Aquatic Ecology Assessment

Proposed Dunoon Dam

Prepared for
Rous Water

9 November 2012

DOCUMENT TRACKING

ITEM	DETAIL	
Project Name	Environmental and Aquatic Flows Assessment – Dunoon Dam	
Project Number	09ARMENV-0005	
File location	S:\Synergy\projects\09ARMENV\09ARMENV-0005 Dunoon Dam Environmental Flows & Aquatic Assessment\Report\Aquatic Ecology Reports\Final Reports	
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External Review by	Prof Martin Thoms, Prof Terry Hillman	
Approved by	Dr Paul Frazier	
Status	FINAL	
Version Number	1	
Last saved on	9 November 2012	
Cover photo	L: Riffle downstream of proposed Dunoon Dam wall; Top R: Large pool in Rocky Creek, downstream of proposed dam wall; Bottom R: Little Rocky Creek	

This report should be cited as 'Eco Logical Australia 2012. *Aquatic Ecology Assessment for the proposed Dunoon Dam*. Prepared for Rous Water.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Rous Water. The input and comment from the Future Water Strategy Project Reference Group is also recognised.

Professor Martin Thoms, Professor Terry Hillman and Dr Keith Bishop are also gratefully acknowledged for their assistance in the preparation of this assessment.

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Abbreviations

ABBREVIATION	DESCRIPTION
ACCC	Australian Competition and Consumer Commission
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AUSRIVAS	Australian River Assessment System
Chl *a*	Chlorophyll *a*
DEWHA	Department of Environment, Water, Heritage and the Arts (now SEWPAC)
DO	Dissolved Oxygen
DPI	Department of Primary Industries
DoPI	Department of Planning and Infrastructure
EAR	Environmental Assessment Requirement
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EP&A Act	*Environmental Planning and Assessment Act 1979*
FM Act	*Fisheries Management Act 1994*
FRP	Filterable Reactive Phosphorus (Ortho phosphorus)
I&I NSW	NSW Department of Industry & Investment
LGA	Local Government Authority
NATA	National Association of Testing Authorities
NES	National Environmental Significance
NOW	NSW Office of Water
NV Act	*Native Vegetation Act 2003*
OEH	Office of Environment and Heritage
RCD	Rocky Creek Dam
ROTAP	Rare or Threatened Australian Plants as determined by the CSIRO
RWRWSSS	Rous Water Regional Water Supply Strategy Study
SEPP	State Environmental Planning Policy
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities

ABBREVIATION	DESCRIPTION
SIGNAL 2	Stream Invertebrate Grade Number – Average Level
SpC	Specific Conductivity
SSD	State Significant Development
SSI	State Significant Infrastructure
TSC Act	*Threatened Species Conservation Act 1995*
TSS	Total Suspended Solids
WM Act	*Water Management Act 2000*

Executive Summary

Rous Water is assessing the viability of a new water storage dam to augment the water supply for four local council areas in the Northern Rivers region of NSW. The proposed Dunoon Dam is an in-stream storage located on Rocky Creek within the Richmond River catchment, with a proposed full storage capacity of 50,000 ML.

Eco Logical Australia (ELA) was commissioned to undertake an aquatic ecology assessment as part of a number of technical studies being undertaken to determine the viability of the proposed storage. The broad aim of this aquatic ecology assessment was to examine the potential impacts of the proposed dam on aquatic habitats and communities upstream, within, and downstream of the proposed dam inundation area.

A detailed program of desktop and field-based survey was undertaken to examine key aspects of the system's aquatic ecology. Desktop surveys included review of previous studies in and around the study area and searches of the relevant databases for potential threatened species presence. Field studies included assessment of aquatic and riparian flora, aquatic and riparian habitat, water quality and fauna surveys including fish, other vertebrates (primarily birds, platypus and amphibians) and macroinvertebrates.

The field survey program was designed and implemented to describe the key elements of the aquatic and riparian ecology in the region and to enable identification of potential impacts from the proposed dam. The sampling program was designed to assess spatial variation along Rocky Creek and Terania Creek, provide data at key times (spring and autumn) and to assess the impacts of a flushing flow on diversity and abundance of aquatic biota. Survey sites were located at five key sites in potential impact zones upstream, downstream and in the inundation area of the proposed dam. A control site was also assessed to allow for comparison of impact against natural system variability, should the dam proceed. Each of these key sites was surveyed to describe its geomorphic character. Two additional sites on Rocky Creek were selected for fish surveys (via electro fishing) and two deep pools (one in Rocky Creek and the other downstream in Terania Creek) were assessed for thermal stratification.

The Desktop assessment, including database searches, found one Endangered Ecological Community, 30 flora, six frog, 24 bird and three mammal species listed as threatened within or around the study area. In addition three fish species, Eastern Freshwater Cod, Purple Spotted Gudgeon and Oxleyan Pygmy Perch were identified as potentially occurring in the study area.

Flora surveys showed variable habitat condition along the reach, with poorer condition generally relating to the level of disturbance or clearing in the immediate catchment surrounding the site. Areas with more intact tree cover showed few exotic species and better overall condition. The number of exotic species showed a general increase downstream from Rocky Creek Dam to the Terania Creek sites. Small-leaved Privet, Camphor Laurel and Lantana were significant weed species found in several riparian zones. Brazilian Watermilfoil was identified as a potentially significant exotic macrophyte.

Water quality assessment identified that the current water quality is good, with most key parameters falling within or below the ANZECC specified range. The large pool below the proposed dam wall remained weakly thermally stratified for the entire survey period and there were several short periods where the temperature difference between the surface and bottom temperatures was greater than 1 ºC,

indicating that stratification is a normal part of the function of that pool. Flows of approximately 20 MLd^{-1} (at Rocky Creek Dam) for several days were sufficient to reduce thermal stratification to less than 1 ºC. Water quality is maintained in this system by low and even base flow levels.

Aquatic macroinvertebrates surveys recorded 5055 individuals from 73 families and 23 orders. SIGNAL2 analysis showed that all sites were moderately impacted in relation to reference conditions. It is assumed that current impacts are a result of the altered catchment land use and Rocky Creek Dam upstream. SIGNAL2 scores, when averaged over the three sampling periods, were highest at Site 5 (downstream of the confluence with Rocky Creek).Vertebrate surveys identified 13 fish species, two frog species and 28 bird species, with no rare or threatened species recorded. No introduced fish species were found. Platypus surveys identified individuals at several sites during various surveys and burrow clusters were found at the three sites surveyed.

ELA (2012) undertook a related study to investigate the environmental flow requirements of the system and develop an environmental flow regime to maintain or improve the current habitat and species diversity. In addition SMEC (2011) assessed the terrestrial ecology in the study area and undertook the associated impact assessment. Impact assessment of the system's aquatic ecology was conducted in consideration of the mitigating effects of the proposed environmental flow regime and the assessment already undertaken for terrestrial species and communities undertaken by SMEC (2011).

Wildlife database searches identified that the Eastern Freshwater Cod, Purple Spotted Gudgeon, Oxleyan Pygmy Perch and Black Necked Stork may occur in the study area, however, these species were not recorded during the field surveys. An assessment of significance determined that the proposed dam is unlikely to have a significant impact on these species. Given records and potential habitat for this species in the area, any additional survey work undertaken for a more detailed impacts assessment should consider the occurrence of these species and whether assessment under the EPBC Act is required.

Field surveys undertaken for this study considered a large potential area of impact from the proposed Dam. Should the project proceed, aspects of the aquatic ecology and environmental flows assessment may require further more detailed assessment to focus on the proposed dam disturbance and inundation area in accordance with the current NSW and Federal guidelines.

Any potential impacts upon aquatic and riparian habitat should be considered in an Offset Strategy that would detail the location of suitable offset sites, restoration needs and on-going management requirements of the conservation areas. The development and implementation of an Offset Strategy prior to dam construction should be considered as part of a broader catchment management program and could also address other compensatory requirements for impacts of the dam, such as impacts to terrestrial biodiversity.

The mitigation measures recommended in this assessment should be incorporated into relevant environmental management plans relating to both construction and operation phases to manage potential impacts to aquatic ecology. These mitigation measures are based on the conceptual dam design and should be refined when the detailed dam design is complete. Monitoring aspects of the existing system such as water quality, fish and deep pool dynamics is recommended as soon as possible to gain a more detailed understanding of the system prior to detailed dam design and associated management plans.

Should the Dunoon Dam project progress, Rous Water will be required to lodge an application with the Department of Planning and Infrastructure (DoPI). A set of the Director-Generals Requirements (DGRs) for an Environmental Impact Statement (EIS) will be issued and as the proponent, Rous Water will be

required to meet these requirements. Assessments undertaken as part of the EIS should be done in accordance with current legislation, publications and guidelines.

1 Introduction

1.1 BACKGROUND

Rous Water is the water supply authority providing bulk potable water to four Local Government Areas (LGA's) in north-eastern NSW, including Lismore (excluding Nimbin), Ballina (excluding Wardell), Byron (excluding Mullumbimby) and the Richmond Valley (excluding land to the west of Coraki). Rous Water's regional supply network includes over 36,000 connections within the reticulation areas of the four LGA's and around 2,100 retail connections to the trunk main system. Rous Water services a population of approximately 95,000 over a 3,000 km^2 area. To safeguard future water supplies Rous Water is assessing the viability of a new water storage, the proposed Dunoon Dam, to augment existing water sources.

The proposed Dunoon Dam would be an in-stream storage with a proposed capacity of 50,000 ML, located on Rocky Creek within the Richmond River Catchment. Rous Water commissioned Eco Logical Australia (ELA) in January 2010 to conduct an aquatic ecology assessment in relation to the proposed Dunoon Dam.

This aquatic ecology assessment has been undertaken for the proposed Dunoon Dam to inform Rous Water of the technical viability of the proposed dam and help determine the likely cost of mitigation measures that would need to be undertaken as a result of any potential impacts upon the aquatic ecology of Rocky Creek should the proposal be further considered.

1.2 AIMS & OBJECTIVES

The broad aim of this aquatic ecology assessment is to examine the potential impacts of the proposed dam on aquatic habitats and communities upstream, within, and downstream of the proposed dam inundation area. The objectives of this study are to:

- Review all known records of aquatic species and communities, and document all species and communities likely to occur within the Rocky Creek system, as listed under relevant state and federal legislation
- Identify potential for threatened species, communities or populations listed under the *Fisheries Management Act 1994* (FM Act)*, Environmental Planning and Assessment Act 1979* (EPA Act)*, Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to occur in the creek system
- Undertake field sampling and surveys that account for seasonal requirements of threatened species likely to occur within the Rocky Creek system, and to help determine the impacts of the proposed dam, on flows, water quality, and aquatic and riparian habitat
- Assess potential impacts on aquatic species and communities, including riparian areas, due to the proposed dam development. The assessment must meet the requirements of a supporting specialist study under the assessment framework for State Significant Infrastructure (SSI) development of the EPA Act 1979
- Assess potential impacts to aquatic ecology in accordance with the EPBC Act 1999, Fisheries Management Act 1994 and relevant publications and policies by NSW Fisheries (now DPI (Fishing and Aquaculture))

- Ascertain impacts on threatened species, communities or populations listed under the FM Act or the EPBC Act. The following schedules under the FM Act are to be taken into consideration where applicable:
    - Schedule 4 – Endangered species, populations and ecological communities
    - Schedule 4a – Critically endangered species and ecological communities
    - Schedule 5 – Vulnerable species and ecological communities
    - Schedule 6 – Key threatening processes
    - Factors under 5A of the EPA Act are to be taken into account when making this assessment of impact and any other relevant guidelines (including the DPI Threatened Species Assessment Guidelines 2008)
- Review the potential for the introduction of aquatic noxious weeds
- Identify mitigation measures to minimise impacts during construction and operation of the dam
- Identify any ecological monitoring requirements prior to and post commissioning of the dam.

1.3 LEGISLATIVE CONTEXT

The following section identifies the statutory requirements relevant to the proposed Dunoon Dam project with reference to aquatic ecology. The following statutory requirements are relevant:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Environmental Planning and Assessment Act 1979* (EP&A Act)
- *Fisheries Management Act 1994* (FM Act)
- *Threatened Species Conservation Act 1995* (TSC Act)
- *Water Act 2007*
- *Water Management Act 2000* (WM Act)
- *Native Vegetation Act 2003* (NV Act).

Consultation with DoPI and other agencies once the project application is submitted will provide further clarification and detail on the approval pathway.

This aquatic ecology assessment has been undertaken in accordance with current legislation, publications and guidelines; however, advice should be sought closer to the time when planning approval for the dam is required.

1.3.1 Environment Protection & Biodiversity Conservation Act 1999

The Commonwealth EPBC Act establishes a process for assessing the environmental impact of activities and developments where 'matters of national environmental significance' (NES) may be affected. Under the Act, any action which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Commonwealth Department of the Sustainability, Environment, Water, Population and the Arts (SEWPaC) which is responsible for administering the EPBC Act.

Actions that may have a significant impact on one or more matters of NES need to be referred to SEWPaC under the EPBC Act. The EPBC Act referrals process can produce one of three outcomes:

i. Non-controlled action: Assessment and approval under the EPBC Act is **not required**. The project may proceed without further approval under the EPBC Act
ii. Non-controlled action – specified manner: Assessment and approval under the EPBC Act is **not required** provided the action is undertaken in a specific way (similar to conditions)

iii. Controlled Action: The project will, or is likely, to have a significant impact on one or more matters of national environmental significance. The project **will require** full assessment and approval before it can proceed.

The EPBC Act lists threatened species, ecological communities, key threatening processes, migratory species and Ramsar areas of national significance.

For the purposes of this report, species listed under the EPBC Act that would potentially be affected by the proposed works are assessed according to the EPBC Act 'Administrative Guidelines on Significance'. The assessments are usually used to assist in determining whether the proposed development should be referred to the Federal Minister of the Environment for a decision on whether approval would be required.

1.3.2 Environmental Planning & Assessment Act 1979

The EP&A Act is the principal planning legislation within NSW, providing a framework for the overall environmental planning and assessment of development proposals. Various legislation and instruments, such as the NSW TSC Act, are integrated with the EP&A Act and have been reviewed separately.

In October 2011, a new assessment system for projects of State significance commenced in New South Wales, replacing the former Part 3A process for major projects under the EP&A Act. The new system established two separate assessment frameworks for State Significant Development (SSD) and State Significant Infrastructure (SSI). Projects that fall within these categories will be assessed by the Department of Planning and Infrastructure (DoPI) and determined by the Minister.

Schedule 3 of *State Environmental Planning Policy* (SEPP) *State and Regional Development 2011* lists the general categories of SSI. Under clause 4(1), the proposed dam would be classified as SSI, as Rous Water is classified as a public authority and the capital investment value would be greater than $30 million.

The proposed dam would be assessed under Part 5.1 of the EP&A Act and requires the approval of the Minister. When an application is made for the Minister's approval for SSI, DoPI will consult with relevant public authorities to provide input to the preparation of the Director-General's Requirements (DGRs) for an Environmental Impact Statement (EIS). Agencies provide their recommended requirements to DoPI which may require the proponent to undertake comprehensive assessments that align with relevant legislation or planning provisions. Assessments undertaken as part of the EIS should be done in accordance with current legislation, publications and guidelines.

It is noted that an SSI proposal is not an integrated development and as such do not require the concurrence of other state agencies. Certain approvals from state agencies are not required and these are listed under section 115ZG and 115 ZH. A permit under sections 201 (dredging or reclamation work), 205 (marine vegetation removal) or 219 (blockage of a fish passage) of the FM Act are not required for an approved SSI. While these approvals are not required, it is recommended that consultation is undertaken with the relevant agencies to ensure that the intent of the relevant Acts are still observed.

DoPI set out the application process for SSI for proponents, and it is recommended that Rous consult with DoPI should they decide to progress the Dunoon Dam project to ensure current planning and approvals pathways are adhered to.

The potential impacts upon aquatic ecology within the proposed dam impact area have been assessed in accordance with the Part 3A *Guidelines for Threatened Species Assessment* (DEC and DPI 2005) in the absence of current guidelines and to meet the requirements of the brief provided by Rous. It is acknowledged that Part 3A of the EP&A Act has been repealed and new laws governing state significant projects are currently being developed. Upon completion of the final dam design, this aquatic ecology impact assessment may need to be updated prior to submission to reflect any changes within the NSW planning system.

1.3.3 Fisheries Management Act 1994

The NSW FM Act and its regulations are administered by the Department of Primary Industries (DPI NSW (Fisheries)), and applies to habitat and aquatic flora and fauna that have the potential to be impacted by the proposed dam. Threatened species, populations and ecological communities identified as 'endangered', 'critically endangered' and 'vulnerable' are listed in Schedules 4, 4A and 5 of the FM Act. The Act also lists 'key threatening processes' and includes provisions for the protection of aquatic habitats and reserves (Part 7).

As noted above, the proposed Dunoon Dam will be assessed under Part 5 of the EP&A Act. Subsequently, a permit to block a fish passage is not required (Section 115ZG). However, it is likely that DGRs issued for the project will require consideration of the FM Act including consideration of impacts and description of measures to avoid, minimise or offset these potential impacts.

Under Part 7 Division 1 of the FM Act, preparation of a habitat protection plan is required if it is determined by the Minister that the habitat is essential for the survival of a species or if it is required to maintain harvestable populations of a species. A habitat protection plan may be determined for the protection of critical habitat as declared under Part 7A – Threatened Species Conservation.

A habitat protection plan:

- May relate to a habitat that is essential for spawning, shelter or other reason
- May apply generally or to particular areas or fish
- Is to describe the importance of particular habitat features to which it applies
- May set out practical methods for the protection of any such habitat features
- May contain any other matter concerning the protection of habitat of fish that the minister considers appropriate.

This current study identified seven fish species that are reliant on open passageway in order to spawn and/or migrate. These species include *Anguilla reinhardtii* (Long-finned Eel), *Maccullochella ikei* (Eastern Freshwater Cod), *Macquaria novemaculeata* (Australian Bass), *Myxus petardi* (Freshwater Mullet), *Mugil cephalus* (Sea Mullet), *Gobiomorphus australis* (Striped Gudgeon) and *Gobiomorphus coxii* (Cox's Gudgeon). In addition to these species previous studies have found open passageway reliant *Anguilla australis* (Short-finned Eel), *Bidyanus bidyanus* (Silver Perch), *Potamalosa richmondia* (Freshwater Herring), *Galaxias olidus* (Mountain Galaxis) and *Galaxias maculatus* (Common Jollytail) occur or have the potential to occur within the Rocky Creek system (Austeco 1994; Bishop 1998).

1.3.4 Threatened Species Conservation Act 1995

The NSW TSC Act, as amended, aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. The TSC Act applies to both terrestrial and aquatic flora and fauna and is administered by the Office of Environment and Heritage (OEH). The interactions between the TSC Act and the EP&A Act requires consideration of whether a development (Part 4), or

an activity (Part 5), is likely to significantly affect threatened species, populations, ecological communities or their habitat.

1.3.5 Water Act 2007

The Water Act commenced on 3 March 2008 and implemented key reforms for water management in Australia. The Water Act establishes a Commonwealth Environmental Water Holder to manage the Commonwealth's environmental water to protect and restore the environmental assets of the Murray-Darling Basin, and outside the Basin where the water is Commonwealth owned. Under The Act the Australian Competition and Consumer Commission (ACCC) has a key role in developing and enforcing water charge and water market rules along the lines agreed in the National Water Initiative (SEWPaC 2012).

1.3.6 Water Management Act 2000

The NSW *Water Management Act 2000* (WM Act) has replaced the provisions of the *Rivers and Foreshores Improvement Act 1948*. The *WM Act* and *Water Act 1912* control the extraction of water, the use of water, the construction of works such as dams and weirs and the carrying out of activities in or near water sources in NSW. *'Water sources*' are defined very broadly and include any river, lake, estuary, or place where water occurs naturally on or below the surface and coastal waters.

As the proposed Dunoon Dam will be SSI under Part 5 of the EP&A Act, approvals under sections 89 (water use), 90 (water management work) or 91 (controlled activity) of the WM Act are not required.

1.3.7 Native Vegetation Act 2003

The NV Act was introduced in 2005 to end broad scale land clearing across the state in order to protect native vegetation for future generations. The NV Act regulates the clearing of vegetation on all land in NSW with the exception of national parks and other conservation areas, state forests and reserves, and urban areas. Native vegetation is classified as species of vegetation that existed in NSW before pastoral settlement, including trees, saplings, shrubs, scrub, understorey, groundcover or wetland plants. Clearing is defined as cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ring barking, uprooting or burning native vegetation (OEH 2012).

As the proposed Dunoon Dam will be SSI under Part 5 of the EP&A Act, authorisation under Section 12 of the NV Act to clear native vegetation or State protected land is not required for an approved SSI.

2 Site Background & Physical Setting

2.1 INTRODUCTION

The proposed Dunoon Dam is located on Rocky Creek within the Richmond River catchment in north-eastern NSW (**Figure 2-1**). This chapter aims to provide background information on the Rocky Creek and its catchment, including climate, hydrology, geological and vegetation.

Rocky Creek drains the Nightcap Range and is a sub-catchment of the Wilsons River, one of the main arms of the Richmond River. Rocky Creek forms part of the Terania Creek sub-catchment that drains to Leycester Creek, Wilsons River and the Richmond River, entering the Pacific Ocean at Ballina. The system is influenced by tidal movements (but not the salt wedge) up to a point 20 km downstream of the Rocky Creek and Terania Creek confluence (DIPNR 2004) although the water in Terania Creek is entirely fresh.

Flows in Rocky Creek have been altered due to the construction of Rocky Creek Dam in the 1940s. The section of creek downstream of Rocky Creek Dam to the confluence with Terania Creek (approximately 17.5 km) has formed a naturalised environment and ecology downstream. The proposed Dunoon Dam wall will be located approximately 15 km downstream of the existing Rocky Creek Dam (**Figure 2-2**).

With a storage capacity of 14,000 ML, Rocky Creek Dam is the primary water source for Rous Water. The secure yield of the dam (under the existing operating rules) is 9,600 $MLyr^{-1}$.

The Terania Creek sub-catchment (which includes Rocky Creek) was identified as being of high conservation value by NPWS and NSW Fisheries due to the presence of significant aquatic fauna and/or flora, and significant native fish species or habitat (NSW DLWC 1998). The Terania Creek sub-catchment was given an overall low stress classification based on indicators that suggested the medium levels of environmental stress in the system were likely to be from factors other than water extraction. However, water extraction is likely to contribute further to environmental stress and was identified as a high priority for river management planning (NSW DLWC 1998).

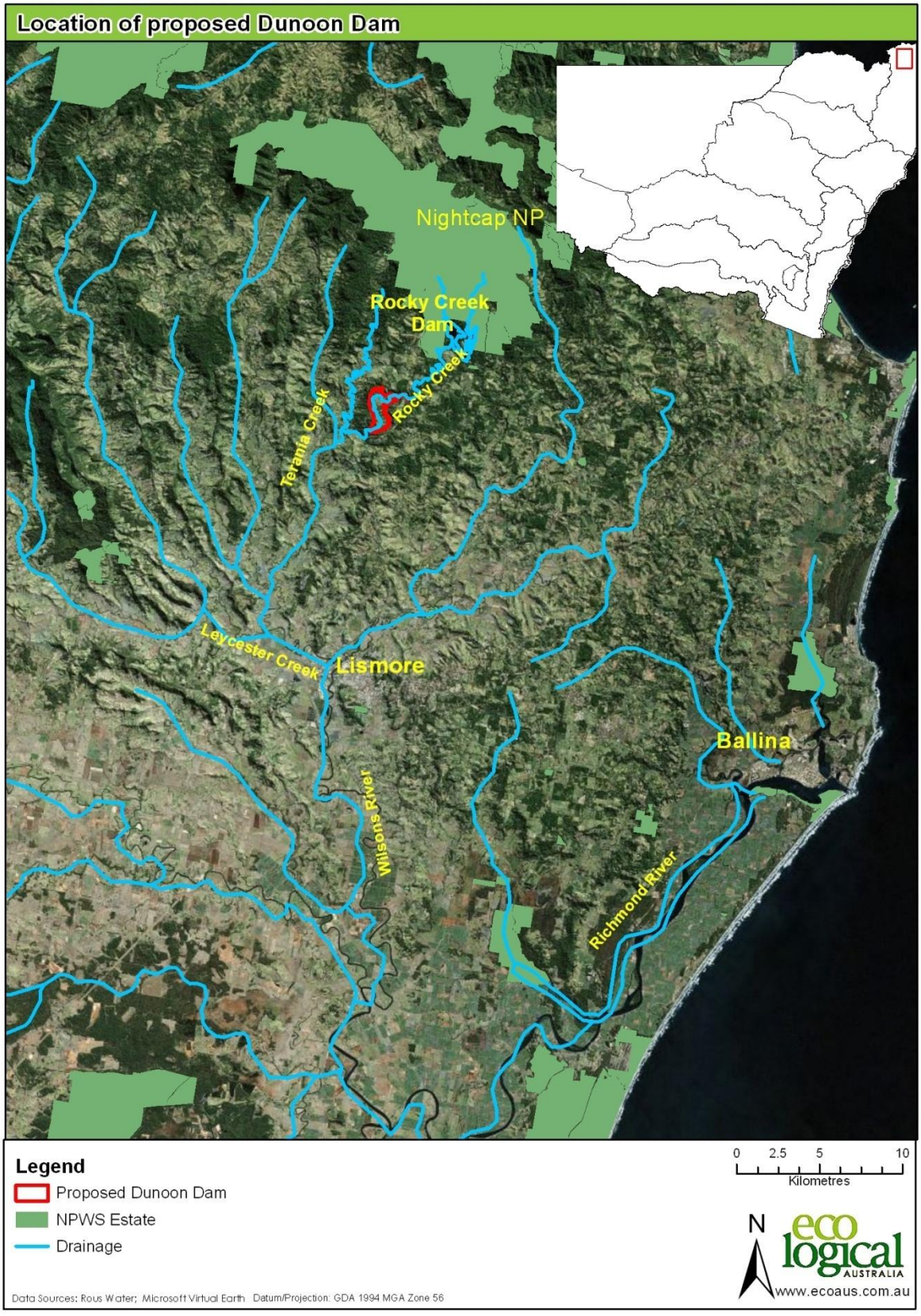

Figure 2-1: Location of the proposed Dunoon Dam in relation to the Richmond River Catchment NSW

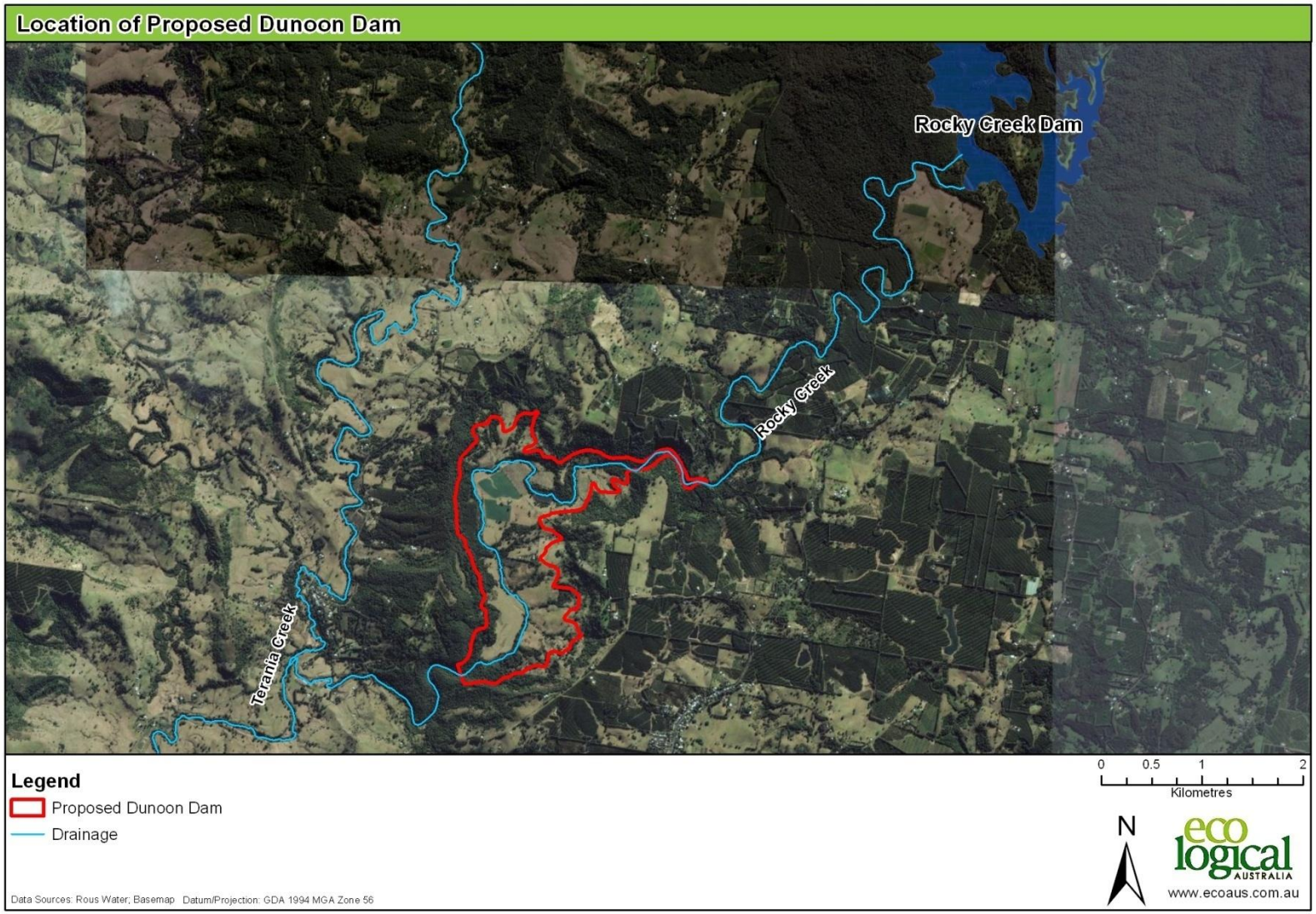

Figure 2-2: Location of the proposed Dunoon Dam in relation to Rocky Creek Dam

2.2 CLIMATE

The nearest long term Bureau of Meteorology station to the project site is Lismore (11 m AHD). Evaporation data were sourced from Alstonville approximately 10 km to the east of Lismore. Lismore experiences subtropical conditions year round with warmer summer months and colder winter months. Average annual rainfall exceeds 1300 mm with a dominant rainy period in summer and early autumn (**Table 2-1**).

Table 2-1: Monthly rainfall and temperature statistics

LISMORE (CENTRE STREET) STATION [058037]					ALSTONVILLE RESEARCH STATION [058131]
MONTH	MEAN MAXIMUM TEMPERATURE (°C) (1907-2003)	MEAN MINIMUM TEMPERATURE (°C) (1907-2003)	MEAN RAINFALL (mm) (1884-2003)	MEAN NUMBER OF DAYS OF RAIN >1 mm (1884-2003)	MEAN DAILY EVAPORATION (mm) (1971-2011)
Jan	29.1	18.8	155.4	10.4	5.7
Feb	29.1	18.8	183.6	11.7	5
Mar	27.9	17.4	188.4	13	4.3
Apr	25.7	14.2	129.2	10	3.5
May	22.6	10.9	115.3	9.3	2.7
Jun	20.2	8.2	97	7.4	2.4
Jul	19.9	6.5	80.3	6.4	2.7
Aug	21.5	7.2	54.9	5.8	3.5
Sep	24.4	9.9	50.4	5.7	4.4
Oct	26.6	13.2	73.2	7.1	5
Nov	28.2	15.8	94.1	8.2	5.4
Dec	29.7	17.8	121.3	9.4	5.9
Annual	**25.5**	**13.2**	**1343.1**	**104.4**	**4.2**

Source: Bureau of Meteorology 2009

2.3 HYDROLOGY

The catchment of Rocky Creek is approximately 59 km^2 with 34 km^2 (60%) of the catchment captured by Rocky Creek Dam (Bishop 1998). The combined catchment area of Rocky Creek Dam and the proposed Dunoon Dam is estimated to be approximately 51 km^2. Little Rocky Creek, the major tributary of Rocky Creek below the proposed dam site, contributes 4.7 km^2 to the Rocky Creek catchment.

The Terania Creek catchment immediately upstream of the confluence with Rocky Creek is approximately 90 km^2 (Bishop 1998). Assuming similar rainfall and runoff throughout the catchments, the Rocky Creek system under natural conditions would have contributed approximately 40% of the total discharge to Terania Creek below the confluence (i.e. based on catchment areas alone). At the confluence, flow from 23% of the combined catchment area is captured and modified via Rocky Creek Dam. Below the confluence with Rocky Creek, the gradient of Terania Creek decreases markedly and there are no significant inflows until the confluence with Leycester Creek.

With a storage capacity of 14,000 ML, Rocky Creek Dam is the primary water source for Rous Water. Rocky Creek Dam was constructed in the 1940s and has resulted in a naturalised system in downstream reaches to the confluence with Terania Creek. There is no capacity for controlled release of water from Rocky Creek Dam and no environmental release regime. Records indicate that Rocky Creek Dam generally spills from February through to April. Rocky Creek Dam has a surface water licence entitlement of 12,358 ML/year (NSW Office of Water 2009). This volume is 80% of the total entitlement of the water source (Terania Creek). Bishop (1998) concluded that the dam has a gross hydrological impact on the system which has implications for geomorphology, water quality, aquatic and riparian vegetation, macroinvertebrates, platypus and fish.

Long-term modelled natural flows indicate that daily flows in Rocky Creek range from 8 MLd^{-1} (95^{th} percentile flow) at the site of the proposed Dunoon Dam up to a maximum flood peak of 17, 280 MLd^{-1}. Discharge is highly variable with the flow regime dominated by rapidly rising and falling limbs associated with flood events. Flows less than 43 MLd^{-1} occur more than 50% of the time and flows greater than 1, 000 MLd^{-1} occur less than 2% of the time.

Under existing flow conditions (i.e. with Rocky Creek Dam operating under current flow rules), flows at the site of the proposed dam range from 3 MLd^{-1} (95^{th} percentile flow) up to 17, 378 MLd^{-1}. Flows less than 17 MLd^{-1} occur more than 50% of the time and flows greater than 1, 000 MLd^{-1} occur less than 2% of the time.

Anecdotal evidence provided by Rous Water suggests that seepage from Rocky Creek Dam during dry weather is relatively constant at 0.7 MLd^{-1} (Rous Water pers. comms. 21 December 2010).

The highly seasonal pattern of natural flows in Rocky Creek reflects the rainfall patterns of the catchment, with peak flows generally in late summer early autumn and lowest flows in the period from August to October.

2.4 LANDFORM & TOPOGRAPHY

The topography of the Rocky Creek catchment consists of high, steep hills (McDonald et al 1990) with average local relief between 90-300 m and a modal slope of between 10 - 32%. Bishop (1998) estimated that 11% of the catchment had slopes steeper than 30% (**Figure 2-3**).

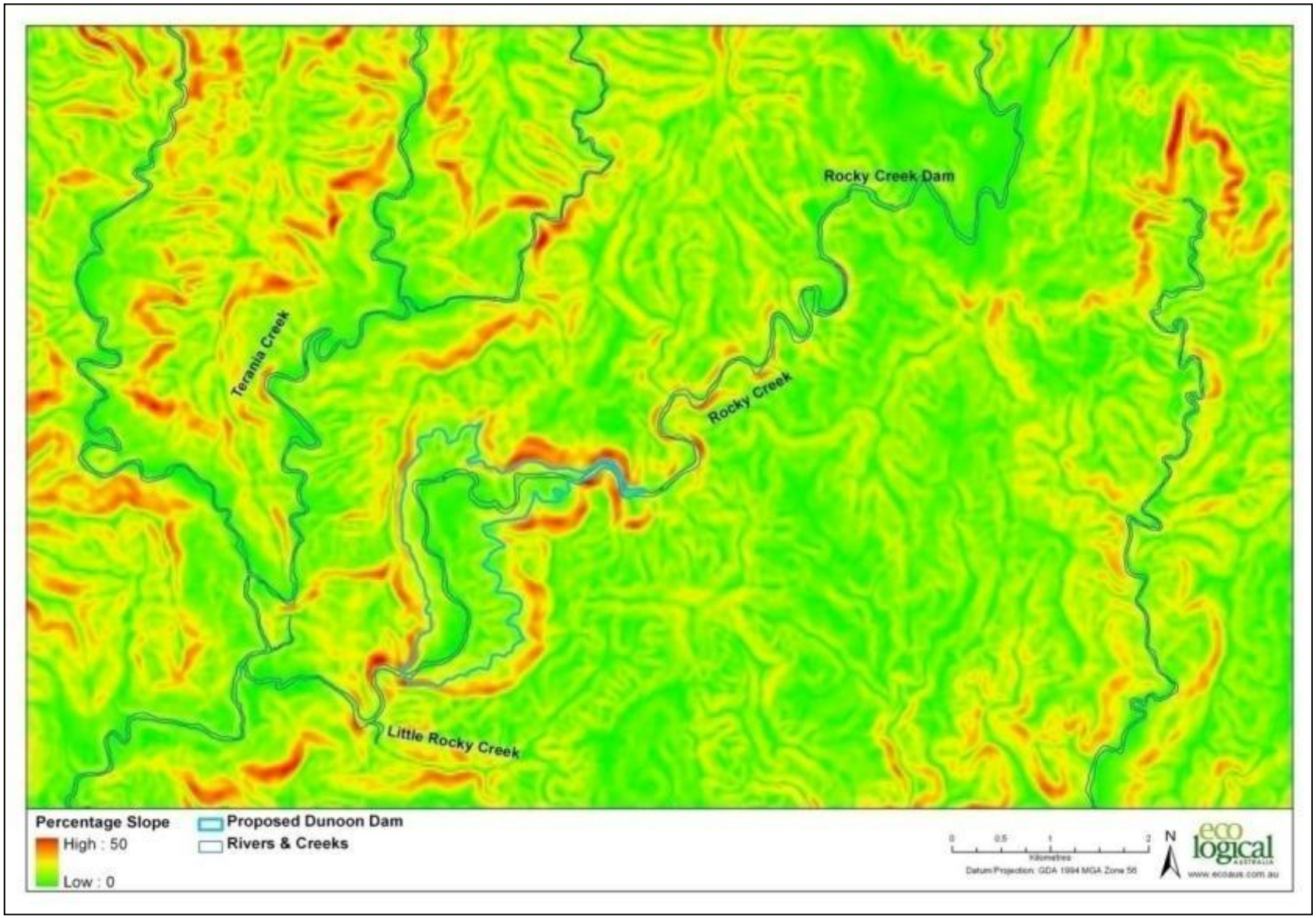

Figure 2-3: Catchment slope

2.5 GEOLOGY & SOILS

The area is made up of a range of sedimentary and volcanic geologic units (DMR 2002) including:

- Lismore Basalt
- Kangaroo Creek Sandstone
- Walloon Coal Measures
- Nimbin Rhyolite.

The Lismore Basalt unit covers the largest area in the Rocky Creek catchment and is predominantly found in the undulating higher ground and outcropping on the valley sides (Allen & Bainbridge 2006). The area within the proposed inundation area, upstream from the proposed dam site, is underlain by the Kangaroo Creek Sandstone (quartz sandstone and conglomerate) while the upper portion is underlain by the Walloon Coal Measures (shales, sandstone and coal). The Nimbin Rhyolite is found in the upper portion of the Rocky Creek catchment.

The soils landscapes along Rocky Creek from Rocky Creek Dam to the upstream extent of the inundation area are the Wollongbar and Rosebank units (Morand 1994). These units are characterised by Ferrosols that range in depth (up to 2 m) depending on their position in the landscape. Shallower and stonier soils typically occur on crests and upper slopes. Self-mulching dark reddish/reddish brown clay loams are generally found in the top horizons of the soil profile and are susceptible to erosion.

Soil landscapes within the proposed inundation area include the Terania unit along the creek line and the Calico, Coolamon and Georgica units occurring higher on the slopes. Soil types within the Terania unit are varied and typically deep (>3 m) and well-drained, with heavier poorly-drained clays found on more recent floodplains. Soils in the Calico and Georgica unit include moderately deep (<1.5 m) Chromosols, Sodosols and Dermosols, with Vertosols occurring on the lower slopes. Alluvial soils occur along drainage lines. The soils of the Coolamon landscape are shallower (<1 m) Dermosols and Ferrosols.

2.6 GEOMORPHOLOGY

Rocky Creek is predominantly a valley confined creek system although some floodplain features occur. Thoms (1998) identified three function process zones between Rocky Creek Dam and the Terania Creek confluence. These zones include two gorge zones, an armoured zone and two mobile zones (**Table 2-2**; **Figure 2-4**).

The proposed dam wall will be located in the gorge/constrained zone located upstream of Robertson Bridge.

Table 2-2: Functional process zones in Rocky Creek (Rocky Creek Dam to Terania Creek confluence) (Thoms 1998)

FUNCTION PROCESS ZONES	LOCATION	KEY CHARACTERISTICS
Gorge / constrained zone	1. Immediately downstream of Whian Whian Falls for approximately 1.5km 2. Lower gorge upstream of Robertson Bridge	- High energy zones - Steep bed slopes - Bedrock, large boulder/cobbles and scour pools dominate - Sediment source zone
Armoured zone	Rocky Creek Dam to Simes Bridge	- High energy zone - High bed slopes - Highly armoured bed sediments (cobble and gravel) - Sediment source area - Some floodplain formations
Mobile zone	1. 2km downstream of Simes Bridge to 5km downstream of Frasers Road 2. Robertson Bridge to Terania confluence	- Relatively mobile bed sediment - Large sediment (silt and sand) storage areas within the channel - Relatively active channel - Floodplain features

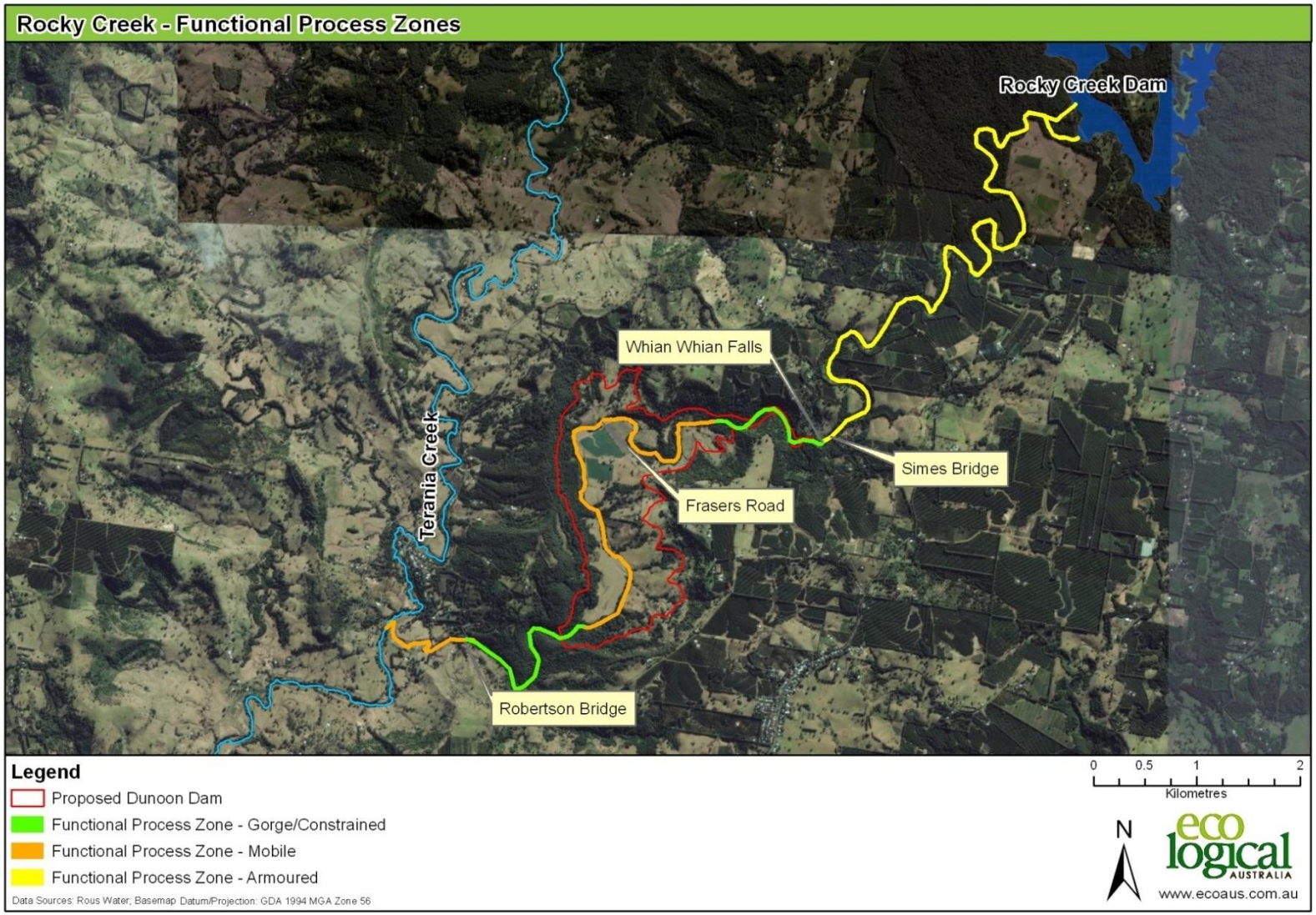

Figure 2-4: Rocky Creek functional process zones

2.7 VEGETATION

The catchment downstream of Rocky Creek Dam has largely been cleared with typical land-uses including cattle grazing, horticulture and nut tree plantations. Bishop (1998) estimated that up to 80% of the catchment has been cleared of native vegetation.

Remnant native vegetation areas are composed of:

- Northern Ranges Dry Tallowwood - tall to very tall forest with a very mixed canopy containing Tallowwood (*Eucalyptus microcorys*) in association with one or several other species and often with a Forest Oak (*Allocasuarina torulosa*) midstorey (NPWS 1999)
- Sub-tropical & Warm Temperate Rainforests. Basalt soils support sub-tropical rainforests with a well-developed multi-layered canopy. Warm temperate rainforests are found on areas with a rhyolitic base (and typically higher in elevation). Species include Coachwood (*Ceratopetalum apetalum*), Soft Corkwood (*Caldcluvia paniculosa*), Crabapple (*Schizomeria ovata*), Yellow Carabeen (*Sloanea woollsii*), *Cryptocarya* spp., Booyongs (*Argyrodendron* spp.) and Rosewood (*Dysoxylum fraserianum*).

Outside of Nightcap National Park, these remnants typically occur on the steeper slopes.

Other woodland/forest areas are composed of:

- Camphor Laurel (*Cinnamomum camphora)* - Introduced trees
- Forestry Plantations - largely relatively recent plantations (< 12 years old) of mostly hardwood plantations (various eucalypt species).

2.8 AQUATIC HABITAT

Bishop (1998) surveyed the physical habitats (pool, riffle, run, cascade, backwater) of Rocky Creek from Rocky Creek Dam to the Terania Creek confluence. This survey identified the creek as a high-energy system with pool-riffle-run sequences (comprising over 95% of physical habitats), several cascades and two subterranean structures (**Table 2-3**).

Table 2-3: Physical habitat of Rocky Creek (Bishop 1998)

HABITAT FEATURE	% OF CREEK LENGTH
Pool	51.1
Run	30.7
Cascade	0.9
Riffle	14.8
Backwater	2.1
Subterranean structures	0.4

3 Methods

3.1 LITERATURE & DATA REVIEW

The aims of the literature and data review were to:

- Review all known records of aquatic species and communities
- Identify and document all species and communities likely to occur within the Rocky Creek system, as listed under relevant state and federal legislation
- Identify potential for threatened species, communities or populations listed under the FM Act, EPA Act, TSC Act and the EPBC Act to occur in the creek system.

3.1.1 Data Audit

The following information and databases were reviewed as part of the aquatic ecology assessment for the proposed Dunoon Dam:

- Atlas of NSW Wildlife (OEH 2011a)
- EPBC Protected Matters Search Tool (SEWPaC 2011a)
- NSE Fisheries Database Search (I&I NSW 2011)
- Northern Rivers CMA Vegetation Mapping (ELA 2005).

Vegetation communities present within the study area were reviewed (ELA 2005) along with aerial photography of the site (LPI, 1998 approx.).

A search using the online EPBC Protected Matters Search Tool and Atlas of NSW Wildlife was performed on 07/03/2011. The EPBC Protected Matters Search Tool was set to a radius of 10 km around coordinates -28.67126, 153.297715 (Datum GDA94). The search of the Atlas of NSW Wildlife covered the area from latitude -28.61128 to -28.71383 and longitude 153.21295 to 153.37416 (Datum GDA94). Director General Requirements typically request a list of threatened species, populations or ecological communities of their habitats, know or likely to occur in the locality for five kilometre radius. It is noted that BioNet (previously Atlas of NSW Wildlife) has been de-natured so sensitive records will be accurate to approximately 10 km). Hence a conservative radius of 10 km was used for desktop database searches.

Aquatic related species from both searches were combined to produce a list of threatened species that may occur within the study area (**Table 4-1**; **Appendix A**). These data were analysed and assessed based on the likely occurrence of each species in the region using 5 likelihood levels. These terms include:

- "yes" = the species was or has been observed on the site
- "likely" = a medium to high probability that a species uses the site
- "potential" = suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely, or unlikely to occur
- "unlikely" = a very low to low probability that a species uses the site
- "no" = habitat on site and in the vicinity is unsuitable for the species.

3.1.2 Literature Review

A review of literature pertaining to the area surrounding the proposed Dunoon Dam site, Rocky Creek Dam (upstream of proposed inundation area), Rocky Creek and Terania Creek was undertaken to gain an understanding of the aquatic flora, fauna and habitat in the region. In particular, three specific studies had been undertaken in the area to assess the potential impact of a new dam or the current impact of Rocky Creek Dam. These studies include:

- Austeco. 1994. *Preliminary Investigations of Flora and Fauna at Two Potential Dam sites near Federal and Dunoon.* Rous Water.
- Bishop. 1998. *Preliminary Assessment of the Effect of Rocky Creek Dam on the Downstream Environment.* Rous Water.
- Ecos Environmental Planning. 2001. *Proposed Dunoon Dam Site Flora and Fauna Survey and Revegetation Concept Plan.* Rous Water.
- Matthews. 1996. *A Baseline Study to Assess the Potential Impact of a Proposed Water Storage dam on the Platypus.* Southern Cross University.
- SMEC. 2011. *Dunoon Dam Terrestrial Ecology Impact Assessment*. Prepared for Rous Water.

3.2 FIELD SURVEY

A field survey program was designed and implemented to describe the key elements of the aquatic and riparian ecology in the region and to enable estimation of potential impacts from the proposed dam. The sampling program was designed to assess spatial variation along Rocky Creek and Terania Creek, provide data at key times from spring 2010 to autumn 2011 and assess the impacts of a flushing flow on diversity and abundance of aquatic biota.

3.2.1 Site Selection

Surveys were undertaken at five representative 100 m long reaches (**Figure 3-1**). Two additional sites (Sites 6 and 9) were included for dedicated fish survey. Site 7 was used for environmental flows survey. Sites were located on Rocky Creek upstream, downstream and within the proposed dam inundation area and on Terania Creek upstream and downstream of the confluence with Rocky Creek. Reaches were selected to cover the range of typical habitat features (pool, riffle, run) and to provide a 'control' site on Terania Creek site, upstream of the confluence. Sites include:

- Site 1 - Rocky Creek - upstream of proposed dam inundation area (baseline impacts of Rocky Creek Dam and potential impacts of changed water operating rules)
- Site 2 - Rocky Creek - in proposed inundation area (localised impacts on aquatic flora, fauna and landscape)
- Site 3 - Rocky Creek - downstream of proposed dam wall (reach of likely largest impact of altered flow regime from proposed dam)
- Site 4 -Terania Creek - upstream of Rocky Creek confluence (un-impacted flow regime, control site for monitoring)
- Site 5 -Terania Creek - downstream Rocky Creek confluence (reach for downstream recovery estimates of hydrological and ecological impacts of proposed dam)
- Site 6 - Rocky Creek - deep pool downstream of proposed dam wall (water quality and stratification assessment plus fish survey)
- Site 8 – Terania Creek - deep pool (water quality and stratification assessment)
- Site 9 - Rocky Creek - long pool in proposed inundation area (fish survey).

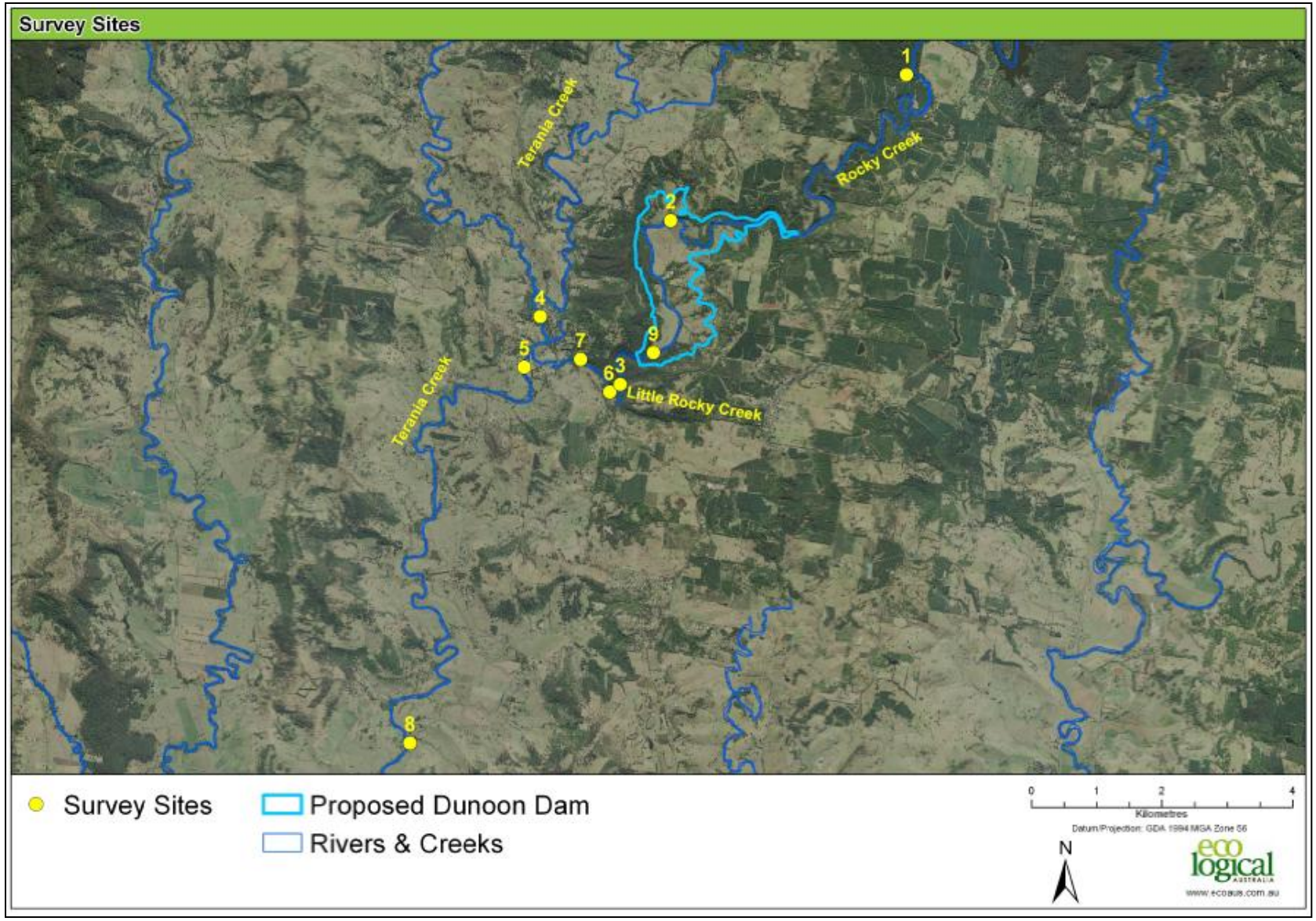

Figure 3-1: Aquatic Ecology field site locations

3.2.2 Survey Regime

Each site (except Site 7) was surveyed for key elements of aquatic ecology and water quality. Further, each site was surveyed at three times, spring 2010, autumn 2011 and October 2010 following a flushing flow event (**Table 3-1**). Fish surveys were conducted separately by DPI NSW on 15 and 16 September 2010. It was initially intended to undertake a survey in mid spring 2010, however, a series of high flow events prevented all but a flushing flow survey in spring so the intended spring survey was conducted in late November 2010 at least 30 days after the last large flow event to allow time for the sample sites to be re-set and recolonised (Boulton et al. 1988, Lake et al. 1989).

Table 3-1: Field sampling regime

SITE	COORDINATE (GDA94, ZONE 56)		AQUATIC ECOLOGY ASSESSMENTS						
	Upstream	Downstream	Water quality	Macro-inverts	Fish	Frogs	Platypus	Birds	Flora
1	E 532746 N 6831769	E 532833 N 6831733	✓	✓		✓		✓	✓
2	E 529199 N 6829529	E 529101 N 6829517	✓	✓		✓	✓	✓	✓
3	E 528347 N 6826988	E 528262 N 6826929	✓	✓		✓	✓	✓	✓
4	E 527136 N 6828016	E 527178 N 6827932	✓	✓				i	✓
5	E 526971 N 6826882	E 526995 N 6826793	✓	✓		✓	✓	✓	✓
6	E 528206 N 6826902		✓		✓				
8	E 525129 N 6821504		✓						
9	E 529288 N 6827912	E 528874 N 6827505	✓		✓				✓

i = incidental records

Sampling effort was directed at the three main potential impact sites (2, 3 and 5) with a reduced sampling regime at Sites 1 and 4. Sites 6 and 9 were selected for fish surveys whilst Site 8 was sampled for water quality only (**Table 3-2**).

Table 3-2: Sampling dates and survey efforts.

SURVEY	DATE	WATER QUALITY	MACRO-INVERTEBRATES	RIPARIAN	BIRD	FROG	PLATYPUS	FISH
Fish	15-16 Sept 2010	✓						✓
Post-Flush	17-22 Oct 2010	✓	✓		i	i	✓	
Spring (2010)	21-26 Nov 2010	✓	✓	✓	i	✓	✓	
Autumn (2011)	27th Mar - 1st Apr 2011	✓	✓		✓	i	✓	

i = incidental records

Fish sampling was undertaken as a separate assessment in September 2010. Water quality sampling and assessment was undertaken during each survey period. Riparian and aquatic flora surveys were undertaken during summer 2010. Macroinvertebrates and platypus were surveyed at each of the main sampling trips. Frog surveys were undertaken on the summer 2010 sampling event, while specific bird surveys were undertaken on the autumn 2011 event. Incidental notes on flora or fauna sightings or evidence of occurrence, were recorded during each survey.

Apart from slightly heavier rainfall in the autumn survey period, weather conditions during the surveys were within the expected long-term range for the region (**Table 3-3; Table 3-4; Table 3-5; Table 3-6**). Rocky Creek Dam spills occurred in early October 2010, prior to post-flush surveys and on several occasions between December 2010 and March 2011. Daily spill exceeded 5000 ML for a short period in January 2011 and was followed by a smaller pulse of just under 1500 MLd^{-1} in mid February 2011 (**Figure 3-2**).

Table 3-3: Weather observations for the September fish survey period*

		SEPTEMBER	
		15th	16th
Temperature (ºC)	Min	15.6	12.5
	Max	25.3	23.2
Rainfall (mm)	Same day	1.8	0
	24hrs prior	0	1.8
	48 hrs prior	0	0
Spills from Rocky Creek Dam (MLd^{-1})		0	0

Table 3-4: Weather observations for the Post-flush survey period *

		OCTOBER POST-FLUSH					
		17th	18th	19th	20th	21st	22nd
Temperature (ºC)	Min	7.1	8.5	10.5	16.2	14	11
	Max	21.6	24.1	24.6	19.8	22.8	24
Rainfall (mm)	Same day	0	0	0	25.4	0.4	0.4
	24hrs prior	10.3	0	0	0	25.4	0.4
	48 hrs prior	0	10.3	0	0	0	25.4
Spills from Rocky Creek Dam (MLd^{-1})		310	200	145	132	186	120

Table 3-5: Weather observations for the spring survey period *

		NOVEMBER - SPRING					
		21st	22nd	23rd	24th	25th	26th
Temperature (ºC)	Min	14.4	16.7	17.2	16.4	14.9	15.4
	Max	24	25.6	24.3	25	26	26.2
Rainfall (mm)	Same day	0.6	1.6	4.4	8	0.6	0.2
	24hrs prior	7.4	0.6	1.6	4.4	8	0.6
	48 hrs prior	12.4	7.4	0.6	1.6	4.4	8
Spills from Rocky Creek Dam (MLd^{-1})		37	22	22	15	37	22

Table 3-6: Weather observations for the autumn survey period *

		MARCH/APRIL AUTUMN						
		26th	27th	28th	29th	30th	31st	1st
Temperature (ºC)	Min	17.1	16.5	16.6	18	18.3	17.8	18.1
	Max	25.6	24	23.6	25	22.6	28	24.4
Rainfall (mm)	Same day	0	0	4	10.8	12.8	1	7.8
	24hrs prior	0	0	0	4	10.8	12.8	1
	48 hrs prior	0	0	0	0	4	10.8	12.8
Spills from Rocky Creek Dam (MLd^{-1})		29	22	15	85	215	277	230

***temperature records from the nearest weather station, Lismore, NSW; BoM 2011; Discharge rates provided by Rous Water.**

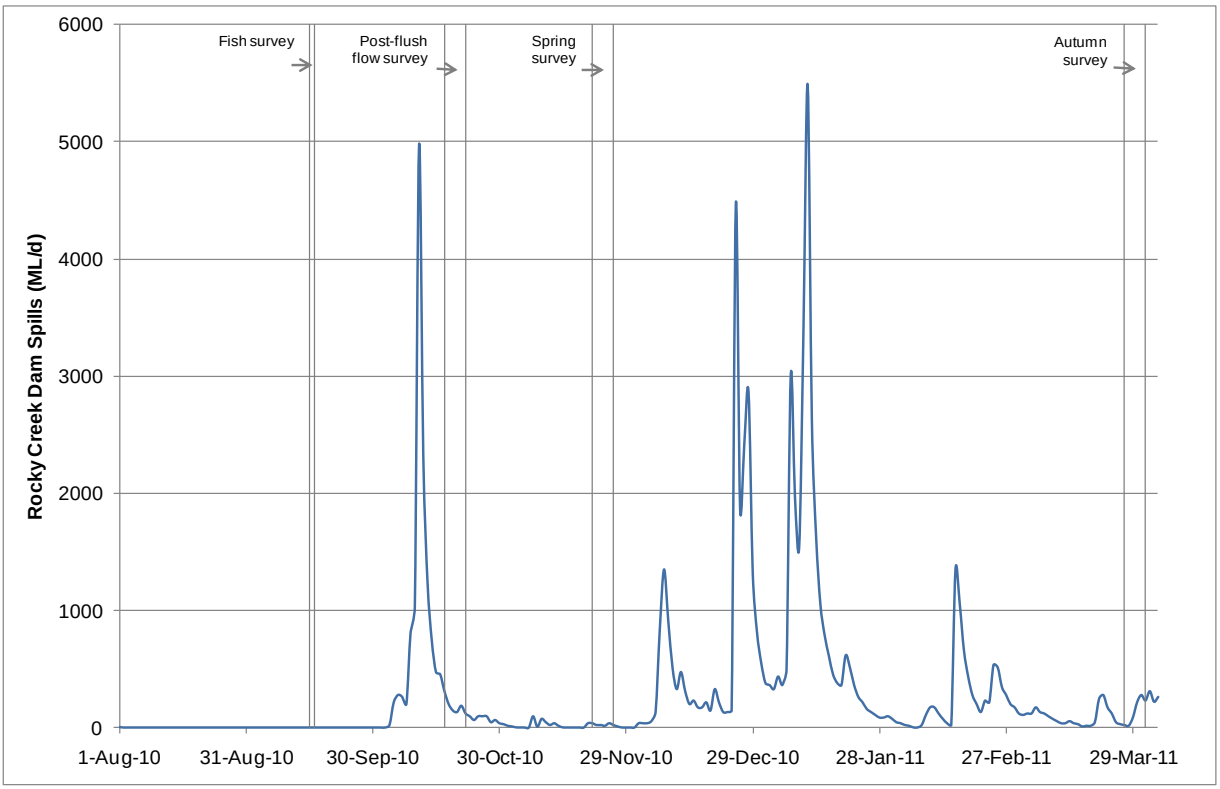

Figure 3-2 Rocky Creek Dam spills at sampling (MLd^{-1})

3.3 FIELD SURVEY METHODS

3.3.1 Riparian & Aquatic Vegetation

At Sites 1 to 5, a 40 x 10 m quadrat was established along the stream bank for a floristic survey. The quadrat was positioned within each site location to encompass riparian zones adjacent to riffle and pool habitats. The survey included all native and weed species within the quadrat and other significant flora within the reach. A cover abundance score (Braun-Blanquett method) was assigned to each species, where: 1 = <5%; 2 = 5–25%; 3 = 25–50%; 4 = 50–75%; and 5 = 75–100% of the projected surface. In-channel aquatic vegetation present during the macroinvertebrate surveys was also noted.

3.3.2 Water Quality

Physical-chemical properties were measured at Sites 1–5 during each survey period. Water temperature (ºC), dissolved oxygen ((DO) mg/L and % saturation), conductivity (mS/cm), pH and turbidity (NTU) were measured with a Hydrolab Quanta during the post-flush and spring field surveys. A Horiba Multi-parameter water quality meter was used during the autumn survey; the variables measured by this unit were the same as that of the Quanta, however, DO was not provided as percent saturation. Duplicate water samples for nutrient analysis were collected in 125 mL polyethylene bottles from flowing water. Duplicate samples for assessment of chlorophyll *a* and total suspended solids (TSS) were collected in 2 x 1 L polyethylene bottles from flowing water. These samples were then filtered through a glass fibre filter in the field. All water and filtered samples were stored on ice in dark conditions until delivery to laboratories. Nutrient samples were analysed at Richmond Water Laboratories (Lismore), and chlorophyll *a* and TSS samples analysed at the University of New England.

At Site 6 a thermister chain with 3 temperature loggers (Tidbit, onset.com) at depths of 0.5 m and 2.5 m below the water surface, and approximately 0.5 m from the bottom (4.5 – 5 m below surface) was installed on the 23rd September 2010 and removed on the 29th March 2011. Loggers were set to record temperature in ºC at 15 minute intervals. Data from the loggers were downloaded and assessed in relation to potential for water column thermal stratification. At Site 8, the portable multi-probe was used to record vertical profiles of DO and temperature during the summer, autumn and flushing flows surveys.

3.3.3 Aquatic Macroinvertebrates

Macroinvertebrates were sampled at Sites 1 to 5 on three occasions (**Table 3-2**) to contribute to an assessment of the long-term river health at each site. Macroinvertebrate collection was undertaken in accordance with a preserved-pick AUSRIVAS style survey in riffle, pool and edge habitats (Turak et al. 2004). Separating riffle and pool-edge samples at three different flow heights will provide an indication of how macro-invertebrate communities response to flow condition. Riffle habitat is defined as an area of broken water with fair to rapid current, with some cobble or boulder substratum. Pool and edge habitats were combined for this survey and are defined as areas along creek banks with little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds, overhanging banks and areas with trailing bank vegetation (Turak et al. 2004).

Using a kick-net (250 µm mesh size), the operator started at the lower end of the riffle and shuffled upstream actively disturbing the substrate with their feet to dislodge animals. The net was placed downstream of their feet and used to collect drifting macroinvertebrates throughout the water column. Riffle habitats were sampled to a total length of 3 m. Samples in the pool-edge habitats were collected using a similar technique by using the sampler's feet and net to disturb the substrate and edge features (roots, macrophytes, logs etc) before sweeping the net through the water column. Pool and edge habitats were swept for a length of 3 m each and composited into one sample.

Net contents were transferred into triple layered zip-lock bags and filled with 70% ethanol for preservation (one sample for riffle, another for pool-edge). Nets were checked for fish and non-target fauna which were released unharmed. Bags were sent to New England Limnology for taxonomic identification.

3.3.4 Fish

Fish surveys were undertaken by NSW Fisheries (DPI) using standard Sustainable Rivers Audit (SRA) protocols, at Sites 6 and 9 (**Table 3-1**), on 15 and 16 September 2010. Two pool habitats were selected for fish survey sites as they provide suitable habitat for endangered and/or iconic species, such as the Eastern Freshwater Cod should any be present. The two pools were located in reaches that would be exposed to the most severe impacts of the proposed dam (i.e. within the inundation zone and immediately downstream of the proposed dam wall). The presence of the alien fish *Gambusia holbrooki* (Mosquito fish) in the catchment is also of interest as predation by this species on native fauna is listed as a Key Threatening Process in NSW.

Site 6 was sampled using standard backpack electrofishing techniques and Site 9 was sampled using a combination of standard backpack and boat electrofishing techniques. Unbaited traps were also used at both locations. Fish species observed and not caught were also recorded. DPI also measured water quality data at the time of sampling.

Electrofishing is a non-lethal active sampling technique that can be undertaken from a boat, portable backpack or from the bank, depending on stream size. A controlled electric current (1000V – DC pulsed) is applied to the water, with the unit adjusted to suit the electrical conductivity of the water so that three to four amps is delivered. The electrical current stuns the fish, they are then netted, counted, identified, measured and released. As the size of this stream was relatively small, the entire section of reach was sampled at each site, covering a range of habitats including pools, runs, undercuts, and macrophytes, across a range of substrates including bedrock, cobbles, sand, and mud/silt. At Site 6, where electrofishing was conducted using the backpack method, eight 150 second shots were fired. Site 9 used a combination of boat and backpack methods, therefore eleven 90 second shots were fired from the boat and one 150 second shot was fired from the backpack. Two people were involved in the sampling effort, one to operate the boat and administer the current, the other to net the stunned fish. A net of 40 cm x 40 cm square opening, 40 cm drop and 5 mm mesh size was used to capture the stunned fish.

Ten unbaited traps were deployed for two hours, across a range of habitats at 0.4 to 1.5m depth at both sites. The traps were oblong in shape (40 cm x 25 cm x 25 cm) with an entrance size of 50 mm and a mesh size of 3–4 mm.

All fish captured from both sampling methods were identified on-site and subsequently released unharmed.

3.3.5 Amphibians

Frog surveys were undertaken at Sites 1, 2, 3 and 5 during the spring 2010 survey (**Table 3-2**). Survey methods included:

- Active habitat searches for 30 minutes at each site on two consecutive days
- Frog chorus census for 30 min at each site on two consecutive nights using acoustic recorders between 10-11pm
- 5 minutes call playback followed by 5 minutes listening and searching at each site on two consecutive nights targeted at threatened frog species potentially occurring within the catchment

- Opportunistic sightings.

3.3.6 Wetland & Migratory Birds

A wetland and migratory bird census was undertaken at Sites 1, 2, 3 and 5 during the autumn 2011 survey (**Table 3-2**). Opportunistic sightings during the November 2010 spring survey were also recorded.

A 20 minute morning and evening census was undertaken at each site, repeated over two days per site. The census included a meandering walk for visual observations and acoustic recordings of bird calls. Opportunistic sightings during all trips were recorded.

3.3.7 Platypus

A platypus census was undertaken at Sites 2, 3 and 5 during each visit (**Table 3-2**). This included a survey for likely habitat, targeted searches at dawn and dusk in potential platypus habitat areas and a survey of banks for burrow structures. Opportunistic sightings were also documented.

3.4 LABORATORY METHODS

3.4.1 Water Quality

Total phosphorus, ortho-phosphorus (FRP), total nitrogen and nitrogen oxides analyses were conducted by Richmond Water Laboratories, accredited by the National Association of Testing Authorities (NATA). Chlorophyll *a* and TSS analyses were conducted by the University of New England (**Table 3-7**). After collection up until delivery to the laboratory all samples were kept in cold and dark conditions.

TSS was measured by filtering 1L of sample water through a 934-AH RTU Glass Microfiber filter paper (1.5 µm), with a known weight, in the field using an EYELA A-35 aspirator. Samples were frozen until analysis was conducted in the laboratory. The filter paper with retained material was then weighed and placed into a foil envelope and dried in an oven at 50 ºC for 48 h. Samples were reweighed after drying to measure the weight of the TSS in each sample. The organic content of the TSS was then analysed by placing the filter paper into the furnace for 4 hours at 500ºC. The filter paper was then reweighed and the organic content calculated.

The concentration of Chlorophyll *a* was measured by filtering 1 L of sample water in the field through 934-AH RTU Glass Microfiber filter paper using an EYELA A-35 aspirator. Samples were frozen until analysis was conducted in the laboratory. The filter paper was then placed in 10 mL of 90% aqueous acetone. The solution was then refrigerated for 24 hours. The samples were then centrifuged for 6 minutes at 3500rpm. The absorption spectra were recorded using a UV-1700 Pharmaspec UV-visible spectrometer at 666 nm and 750 nm.

Table 3-7: Water samples collected in field, methods of collection, laboratory methods and practical quantitation limit.

SAMPLE	FIELD COLLECTION METHOD	LABORATORY METHOD	PRACTICAL QUANTITATION LIMIT
Nitrogen – Total	Unfiltered	RWL 10.04	0.1 mg/L
Nitrogen – Oxidised	Filtered (1.2 µm)	RWL 10.04	0.01 mg/L
Phosphorus – Total	Unfiltered	RWL 10.04	0.05 mg/L
Phosphorus – Ortho	Filtered (1.2 µm)	RWL 10.04	0.01 mg/L
Total Suspended Solids	Filtered (pre-weighed 1.2 µm)	APHA 2000	0. 001 µg/L
Chlorophyll *a*	Filtered (1.2 µm)	APHA 2000	0.01 mg/L

3.4.2 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were analysed by New England Limnology to family level taxonomic identification. Macroinvertebrates were identified using the AUSRIVAS sample processing methods. Each preserved sample was emptied on to a white tray and specimens picked for 40 to 60 minutes.

Macroinvertebrates were then sorted and identified to family level, except for Acarina, Cladocera, Copepoda, Oligochaeta and Ostracoda which were identified to order level as per the NSW AUSRIVAS Method (Turak et al. 2004). One family of Collembola and Neuroptera could not be identified and were therefore also only identified to order level.

3.5 DATA ANALYSIS

3.5.1 Water Quality

Water quality was determined by comparing surveyed values with the trigger values of the ANZECC 2000 guidelines for the protection of aquatic ecosystems in south-east Australian lowland rivers. The Water Quality and River Flow objectives, developed for the Richmond River Catchment by DECCW (2006) use the default trigger values stated within the ANZECC guidelines as an indicator of aquatic health (**Table 3-8**). ANZECC trigger values are either given as a threshold value or as a range of desirable values. These values differ according to water body type. Lowland streams are classified as those that lie below 150 m altitude, therefore all five study sites fall into the lowland river category.

Table 3-8: Default trigger values for physical and chemical stressors for lowland rivers of south-east Australia (ANZECC 2000)

INDICATOR	TRIGGER VALUE/DESIRABLE RANGE
Total Phosphorus	0.025 mg/L
Total Nitrogen	0.35 mg/L
Chlorophyll *a*	0.003 mg/L
Oxidised Nitrogen	0.04 mg/L
Ortho Phosphorus (FRP)	0.02 mg/L
Turbidity	6 - 50 NTU
Salinity	0.125 - 2.20 mS/cm
Dissolved Oxygen	85 - 110 %
pH	6.5 - 8.0

3.5.2 Aquatic Macroinvertebrates

The Stream Invertebrate Grade Number – Average Level (SIGNAL 2) biotic index (Chessman et al. 1997, Chessman 2003) was used to provide an indication of habitat and water quality for each location. Average SIGNAL 2 scores were calculated for each site by summing the pollution sensitivity grades assigned to each macroinvertebrate family and dividing by the number of families. Where a specimen was unable to be identified to family level, the order-class-phylum level SIGNAL 2 grade was used (Chessman, 2003). SIGNAL 2 values range from 1 (most tolerant to pollution) to 10 (most sensitive to pollution). Water quality was defined after Chessman et al. (1997) as:

- Average SIGNAL 2 values greater than 6: clean water;
- Average SIGNAL 2 values between 5 and 6: doubtful or mildly polluted;
- Average SIGNAL 2 values between 4 and 5: moderately polluted; and
- Average SIGNAL 2 values less than 4: severely polluted.

EPT scores (Ephemeroptera, Plecoptera, Trichoptera) were also derived from the macroinvertebrate samples as these families are flow and pollution-sensitive and rheophylic 'flow loving' and therefore would be most impacted by altered flow regimes and loss of turbulent flow in riffles. The EPT score is the percentage of EPT individuals comprised in a sample.

4 Results

4.1 DATABASE SEARCHES

Federal and state databases of Threatened Species, Threatened Populations and Communities and Key Threatening Processes were searched to identify the potential for threatened species, communities or populations to occur in the project area. The complete results from the database searches can be found in **Appendix A** of this report.

4.1.1 Threatened Species

Database searches show that two listed threatened fish species either have been recorded or could potentially occur within the Rocky Creek catchment, including:

- *Maccullochella ikei* (Eastern Freshwater Cod) listed as an endangered species under the FM Act and EPBC Act. Eastern Freshwater Cod were once abundant in both the Clarence and Richmond River systems downstream of tableland waterfalls. Wild fish are now currently considered to be extinct in the Richmond River system. Re-stocking with hatchery-bred cod has been undertaken since 1989. They prefer clear, flowing streams with rocky beds, deep holes, plenty of boulders and/or large woody debris. Riparian vegetation, large boulders and snags provide a complex array of habitats for each stage of the cod life cycle and influence the quality and quantity of food and shelter
- *Morgurnda adspersa* (Purple Spotted Gudgeon) is listed as an endangered species under the FM Act. Purple Spotted Gudgeon occur in inland drainages of the Murray-Darling basin as well as coastal drainages of northern NSW and Queensland. They are found in slow-moving or still waters of rivers, creeks and billabongs, often amongst weeds, rocks or large woody debris.

Twenty four (24) other threatened flora and fauna species and one migratory bird species either previously recorded or likely to occur within the riparian habitat or use Rocky Creek for foraging or breeding purposes (**Table 4-1**) were identified from database searches.

Table 4-1: Threatened flora and fauna species previously recorded or potentially occurring along Rocky Creek.

SCIENTIFIC NAME	COMMON NAME	LOCATION	CONSERVATION SIGNIFICANCE		LIKELIHOOD OF OCCURANCE
			TSC Act	EPBC Act	
Flora					
Baloghia marmorata	Marbled Baloghia/Jointed Baloghia		-	V	Potential
Bosistoa transversa	Three-leaved Bosistoa		-	V	Potential
Corokia whiteana	Corokia		V	V	Potential
Desmodium	Thorny Pea	Whian Whian Falls	V	V	Yes

SCIENTIFIC NAME	COMMON NAME	LOCATION	CONSERVATION SIGNIFICANCE		LIKELIHOOD OF OCCURANCE
			TSC Act	EPBC Act	
acanthocladum					
Elaeocarpus sp. Rocky Creek	Minyon Quandong		E	E	Potential
Hicksbeachia pinnatifolia	Red Boppel Nut		E	V	Potential
Macadamia tetraphylla	Rough-shelled Bush Nut		V	V	Potential
Marsdenia longiloba	Slender Marsdenia	Brush Box Gully	V	V	Yes
Owenia cepiodora	Onion Cedar		V	V	Potential
Syzgium hodgkinsoniae	Red Lily Pilly		V	V	Potential
Tinospora tinosporoides	Arrowhead Vine	Whian Whian Falls	V	-	Yes
Fauna					
Amaurornis olivaceus	Bush Hen	Rocky Creek Catchment	V	-	Potential
Ardea ibis	Cattle Egret		-	M	Potential
Assa darlingtoni	Pouched Frog	Rocky Creek Catchment	V	-	Potential
Dasyurus maculatus	Spotted-tailed Quoll		V	-	Potential
Ephippiorhynchus asiaticus	Black-necked Stork		E	-	Potential
Erythrotriorchis radiatus	Red Goshawk	Rocky Creek Catchment	E4A	V	Potential
Irediparra gallinacea	Comb-crested Jacana		V	-	Potential
Ixobrychus flavicollis	Black Bittern		V	-	Potential
Litoria brevipamata	Green-thighed Frog		V	-	Potential
Mixophyes fleayi	Fleay's Barred Frog		E	E	Potential
Mixophyes iteratus	Giant Barred Frog	Rocky Creek Catchment	E	E	Potential
Myotis macropus	Southern Myotis	Rocky Creek Catchment	V	-	Potential
Nyctophilus bifax	Eastern Long-eared Bat	Rocky Creek Catchment	V	-	Potential

V= vulnerable; E = Endangered; E4A = Critically Endangered; M = Migratory

Two Rare or Threatened Australian Plant (ROTAP) species, *Archidendron muellerianum* (Veiny Lace Flower), category 3RCa, and *Quassia sp. 2,* category 3RC (3 = known from more than one specimen and occupying a range greater than 100 km; R = rare, but not endangered or vulnerable; C = conserved in some sort of reservation; a = adequately reserved), have previously been recorded in the area (Austeco 1994).

4.1.2 Threatened Populations & Communities

Database searches showed there are no listed threatened populations or communities of aquatic flora or fauna (fish or aquatic macroinvertebrates species) known to occur within the proposed study area. However; Lowland Rainforest EEC was identified to be occurring within the proposed inundation area within 10 m either side of Rocky Creek (SMEC 2011). This community is listed under the NSW TSC Act.

4.1.3 Key Threatening Processes

Threatening processes that are listed under the FM Act that are relevant to the proposed Dunoon Dam include:

- The removal of large woody debris from NSW rivers and streams
- The degradation of native riparian vegetation along NSW watercourses
- The installation of in stream structures and other mechanisms that alter natural flow regimes of rivers and streams (NSW DPI 2011).

Threatening processes that are listed under the TSC Act that are relevant to the proposed Dunoon Dam include:

- Predation by *Gambusia holbrooki* (Mosquito fish)
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands (OEH 2011).

4.2 LITERATURE REVIEW

4.2.1 Riparian & Aquatic Vegetation

Riparian Vegetation

Previous studies identified that the condition of the riparian vegetation in the proposed project area was variable. Sections adjacent to forested areas were generally in good condition, while those further downstream and adjacent to agricultural land were in poor and reduced condition with invasive species present (Austeco 1994, Sainty 1998). Between Rocky Creek Dam and the Terania Creek confluence, approximately 20% of the left and 25% of the right banks had a combination of native and exotic riparian vegetation greater than 100 m wide (Sainty 1998). The proposed inundation area contains approximately 12 ha of riparian vegetation, which consists of approximately 0.09 ha of pasture, approximately 8.15 ha of Camphor Laurel Disturbed Woodland/Forest, approximately 1.38 ha of Sub-tropical Rainforest and approximately 0.22 ha of Warm Temperate Rainforest.

Complex subtropical and dry rainforest remnants were found along the riparian zone located within the proposed dam area. The remnant of complex rainforest was small yet significant and in good condition with dense vines. Weeds consisted of localised stands of *Lantana camara* (Lantana) or *Ligustrum sinense* (Small-leaved Privet), (**Figure 4-1**). The dry rainforest had a diverse canopy, but was heavily disturbed and had small sections of Camphor Laurel infestation (Austeco 1994).

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) identified Sub-tropical Rainforest and Warm Temperate Rainforest communities in the proposed inundation area within 10 m either side

of Rocky Creek. These communities are incorporated into the Lowland Rainforest EEC, which is listed under the NSW TSC Act.

Five exotic species were identified in the study area. Of note were Lantana, Small-leaved Privet and Camphor Laurel. Exotic species are prevalent between the Channon Road Bridge and the Terania Creek confluence. In some areas, Small-leaved Privet had dominated the native riparian species. Healthy assemblages of native riparian plants were found to occur in some places, with species including *Tristaniopsis laurina* (Water Gum), *Acmena Smithii* (Narrow-leaf Lilly Pilly), *Callistemon viminalis* (Callistemon) and *Ficus coronata* (Sandpaper Fig) (Sainty 1998).

There have been five species listed as threatened under the TSC Act and/or the EPBC Act, or listed as a ROTAP species previously been recorded in the proposed dam area; they include:

- *Marsdenia longiloba* (Slender Marsdenia) – endangered under the TSC Act, vulnerable under the EPBC Act
- *Tinospora tinosporoides* (Arrowhead Vine) – vulnerable under both the TSC and EPBC Acts
- *Desmodium acanthocladum* (Thorny Pea) - vulnerable under both the TSC and EPBC Acts
- *Archidendron muellerianum* (Veiny Lace Flower) – ROTAP
- *Quassia sp. 2* (Southern Quassia) - ROTAP (Austeco 1994; Ecos Environmental Planning 2001).

Previous studies within the Rocky Creek catchment have also identified eight threatened species which could potentially occur in the proposed Dunoon Dam site:

- *Syzygium hodgkinsoniae* (Red Lily Pilly) – recorded close to project area
- *Floydia praealta* (Ball Nut) – recorded Boatharbour NR and other areas near Lismore
- *Corchorus cunninghamii* (Corchorus/Native Jute) – Bungabee, old record Bexhill
- *Macadamia tetraphylla* (Bush Nut) – occurs in rainforest remnant adjoining Area 1[1]
- *Austromyrtus fragrantissima* (Sweet Myrtle) – recorded from The Channon
- *Sophora fraseri* (Sophora) – recorded Bungabee NP
- *Owenia cepiodora* (Onion Cedar) – once common in the area
- *Hicksbeachia pinnatifolia* (Candle Nut) – Recorded between the existing Rocky Creek Dam and Dunoon (Ecos Environmental Planning 2001).

[1] Area 1 is from the southern end of Munro Rd and the 'gorge' north to Fraser Rd; also referred to by Rous Water as properties 10, 11, 12 and 13 in part.

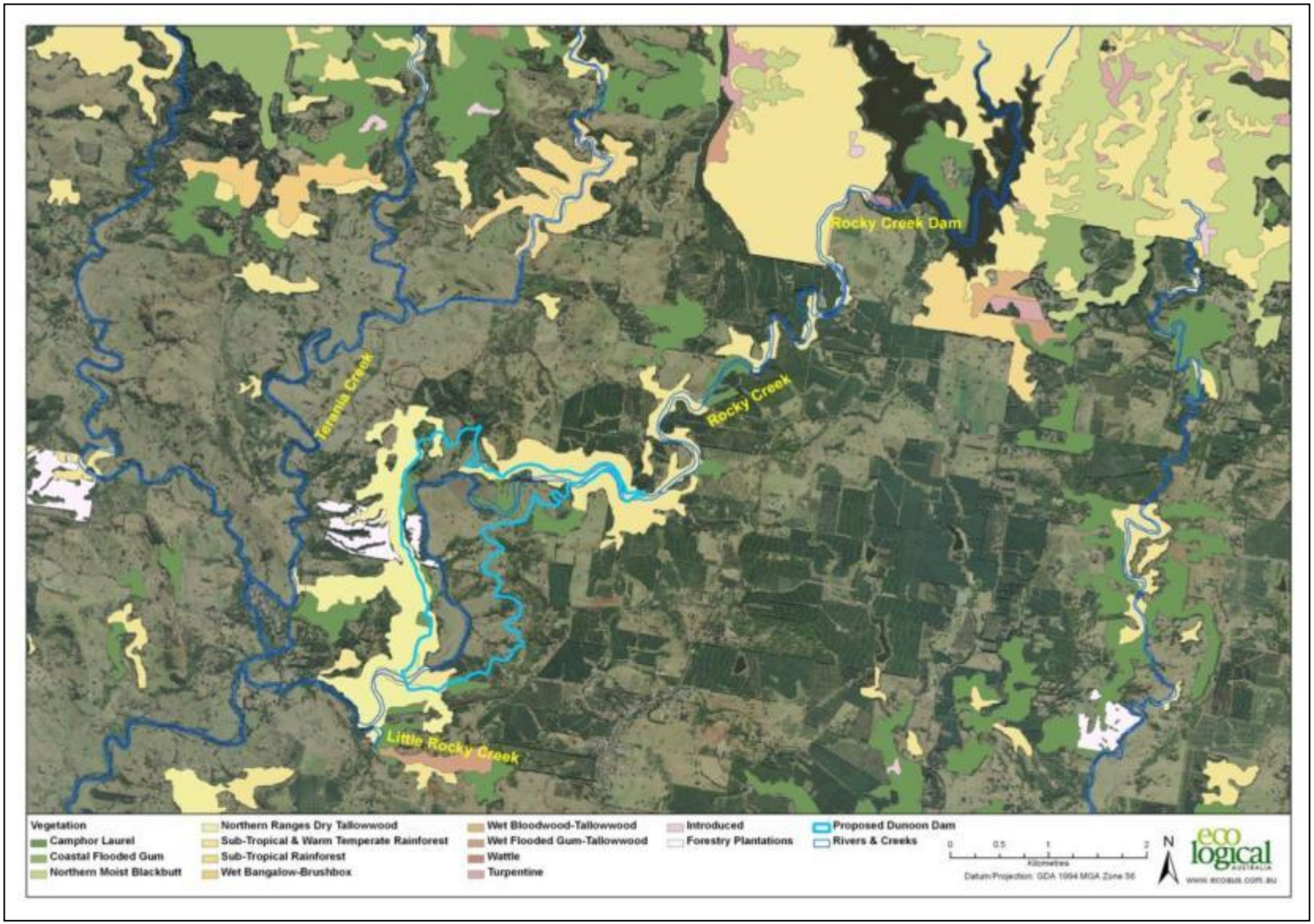

Figure 4-1: Native and forestry vegetation communities found in the area surrounding proposed Dunoon Dam (ELA 2005)

Submerged, Floating & Floating-Attached Flora

Sainty (1998) found 14 species of submerged, floating and floating-attached flora species within Rocky Creek downstream of Rocky Creek Dam. The four dominant flora species present within the Rocky Creek system included *Hydrilla verticillata* (Hydrilla), *Potamogeton javanicus* (Small Pondweed) and *Vallisneria nana* (Native Val). The study identified that due to long periods of low flows, the flora species mentioned above were abundant in all but the steepest parts of Rocky Creek. In locations downstream of Rocky Creek Dam, there were elongated pools that contained large beds of Native Val and *Chara* spp. and occasional dense patches of Small Pondweed. Observations were also made along reference creeks upstream of the existing Rocky Creek Dam and along Terania Creek upstream of any direct disturbance within a National Park. These observations found that the creeks were either totally devoid of or only had very small populations of submerged, floating and floating-attached flora species.

Floating & Attached Algae

Sainty (1998) sampled algae from eight sites along Rocky Creek. Moderate to high densities of diatoms were found on rocks and submerged macrophytes downstream of Rocky Creek Dam. Sainty (1998) suggested that the level of algae species diversity and abundance was assisted by prolonged periods of low flow, with fluctuations in discharge influencing spatial and temporal patterns of abundance and diversity. Only one species of blue-green algae was recorded. The reference sites, upstream from the dam, were found to have a comparatively low abundance of algae; this may have been due to riparian vegetation and steep banks restricting light infiltration to the streambed (Sainty 1998).

Emergent Macrophytes

Sainty (1998) suggested that prior to Rocky Creek Dam being built, high base flows, minor flood flows and occasional large floods would have scoured away sediments, removing habitat required for emergent macrophytes to establish. Field surveys conducted by Sainty (1998) found 28 species of emergent macrophytes and 14 aquatic weed species colonising, in abundance, all but the steepest sections of the creek. The distribution of macrophytes was attributed to prolonged periods of low flow that provided optimal conditions for these plants to colonise in all but the steepest sections. In some areas the density of vegetation was obstructing water flow. The dominant emergent macrophytes were *Carex* spp., *Lomandra* spp., *Cyprus* spp., and *Juncus* spp. None of the weed species were classed as a serious threat at the time of this study. However, the presence and increased abundance of *Rorippa nasturtium aquaticum* (Watercress) and *Myriophyllum aquaticum* (Brazilian Watermilfoil) were indicators that ample nutrients were entering the system.

4.2.2 Water Quality

Bishop (1998) found that water quality recorded in 1977/78 at gauging station 203036 (Rocky Creek at Gibbergunnyah Range Road) was good; however, nutrient data from downstream sites were limited. Sampling undertaken in September 1998 found that total phosphorus and soluble phosphorus levels were very low. Nitrogen concentrations in all forms were found to be low and dominated by the organic fraction rather than agricultural or domestic residues. Nitrogen loading was slightly higher at sites that corresponded to main horticultural areas. It is noted that this assessment was completed during a period of low flow. The water was also found to be non-saline and pH levels tended to be slightly acidic, however, less so than other adjacent Richmond catchments (Kelly 1998).

Bishop (1998) also concluded that stratification was considered likely in the deeper pools and pools with dense submerged vegetation. However, severe dissolved oxygen depletion at depth as a result of this stratification was considered unlikely. The intensity of stratification could be sufficient to stress gill-breathing fauna, particularly during the summer months (Bishop 1998).

Bishop (1998) concluded that the overall condition of Rocky Creek was 'poor', being significantly degraded from its natural condition. While flow regulation from Rocky Creek Dam is a significant contributor to these changes, altered land uses within the catchment and subsequent increased sediment and nutrient loads to the creek would also be casual factors. The study concluded that the general water quality downstream of Rocky Creek Dam (down to the confluence with Terania Creek) was of high quality at the time of the assessment.

4.2.3 Aquatic Macroinvertebrates

An assessment of aquatic macroinvertebrates was undertaken within Rocky Creek and six nearby reference streams (Bishop 1998). The aims of this assessment were to:

- Determine the current macroinvertebrate fauna within Rocky Creek
- Determine the extent of dam-mediated impacts on the macroinvertebrate fauna downstream of Rocky Creek Dam
- Predict the likely effectiveness of suggested environmental flows in relation to macroinvertebrate fauna.

The methodology used during this assessment was based on a modified rapid detection technique developed by Bishop (1990). The methods involved the examination of the macroinvertebrate fauna on rocks from pools by direct observation. Methods were standardised between sites in that rocks were of a similar size, fully submerged and not embedded in the substrate. This was undertaken at two sites within 500 m downstream of the existing Rocky Creek Dam, four sites further downstream along Rocky Creek and six sites along reference streams. Results showed that the sites downstream from Rocky Creek Dam had fewer pollution sensitive macroinvertebrates than the reference sites, likely due to the low food availability and large quantities of sediments and organic matter recorded downstream from the dam.

Although there were no large crayfish recorded at the time of the 1998 survey, burrows were observed at the water's edge. Bishop (1998) discusses that it is likely that two species of large spiny crayfish, *Euastacus sulcatus* (Mountain Crayfish) and *Euastacus valentulus* (Powerful Crayfish) occur in Rocky Creek as it is within their known distribution and there have been historical sightings of crayfish between Rocky Creek Dam and the Gibbergunyah Range Road crossing,

Bishop (1998) determined that it was highly likely that the macroinvertebrate fauna had been impacted by the alteration of the hydrological cycle from flow regulation manifested through low food, sediment deposition and high levels of organic matter. This was shown by the maximum occurrence of sensitive fauna at impact sites less than the minimum recorded at reference-stream sites.

4.2.4 Fish

Data from the Australian Museum, I&I NSW, EPBC records and previous studies were reviewed to obtain an inventory of fish fauna for the proposed Dunoon Dam study area (**Appendix E**). Austeco (1994) identified 26 fish species that had previously been recorded as inhabiting two potential dam sites, Dunoon and Federal, and a further nine that could potentially occur at these sites. Three of the identified species are listed under the FM Act, one of which is also listed under the federal EPBC Act. These species are:

- *Maccullochella ikei* (Eastern Freshwater Cod) – FM Act
- *Morgurnda adspersa* (Purple-spotted Gudgeon) – FM Act
- *Nannoperca oxleyana* (Oxleyan Pygmy Perch) – FM Act and EPBC Act. Likely to have been found in the Federal Valley Area, has the potential to be present in the Rocky Creek Area.

Austeco (1994) also suggested that significant populations of Australian Bass and Eastern Freshwater Cod still inhabited Rocky Creek Dam since their release into the storage between 1988 and 1990; however, there was no evidence of breeding at the time of this report. Bishop (1998) mentions previous recordings of *Tandanus tandanus* (Eel-tailed Catfish) and discusses that there has been a significant hydrological impact on fish downstream of Rocky Creek Dam.

Data provided by Department of I&I NSW indicate that thirty-one fish species have been identified in the Leycester sub-catchment (including Rocky Creek between 1975 and 2006 (**Appendix E**)). Of these species two are introduced, *Cyprinus carpio* (Common Carp) and *Gambusia holbrooki* (Mosquito fish). As these records encompass the entire Leycester sub-catchment, it is unclear which of these species were found within Rocky Creek.

4.2.5 Amphibians

The Richmond River Area Water Sharing Plan – Background Document, developed by the NSW Office of Water (2010), lists six threatened frog species known or expected to occur (**Table 4-1**) within the Terania Creek catchment:

- *Assa darlingtoni* (Pouched Frog)
- *Litoria brevipamata* (Green-thighed Frog)
- *Mixophyes balbus* (Stuttering Frog)
- *Mixophyes fleayi* (Fleay's Barred Frog)
- *Mixophyes iteratus* (Giant Barred Frog)
- *Philoria Loveridgei* (Loveridge's Frog).

None of these threatened species were recorded during a targeted search within the survey area in 2001 that involved spotlighting and call playback. However, there were five native species (*Crinia signifera* (Common Eastern Froglet), *Uperoleia laevigata* (Smooth Toadlet), *Limnodynastes peronii* (Striped Marsh Frog), *Litoria fallax* (Eastern Dwarf Tree Frog) and *Litoria verreauxii* (Whistling Frog)) and one exotic species (*Bufo marinus* Cane Toad) recorded (Ecos Environmental Planning 2001) (**Appendix B**).

4.2.6 Wetland & Migratory Birds

Previous reports have identified several species of threatened wetland birds within Rocky Creek catchment or predicted to occur along Rocky Creek, they include (Bishop 1998):

- Black Bittern (Ixobrychus flavicollis) – dependant on food directly from streams
- Black-necked stork (Ephippiorhynchus asiaticus) - dependant on food directly from streams
- Red Goshawk (Erythrotriorchis radiatus) – inhabits wet habitats near streams
- Bush Hen (Amaurornis olivaceus) - dependant on food directly from streams
- Comb-crested Jacana (Irediparra gallinacea) - dependant on food directly from streams.

4.2.7 Platypus

The area between the Rocky Creek Dam wall and the Terania Creek confluence provides potential platypus habitat. Platypus are reasonably hardy animals able to survive in considerably disturbed habitat (Grant 1998). Platypus observations were recorded during two different studies in the upper sections of the survey area where there was a relatively low level of disturbance and also in the lower reaches of the survey area where land is used for agriculture and the riparian zone is relatively degraded. Matthews (1996) recorded platypus at pools just below Simes Bridge, within the proposed Dunoon Dam footprint and in Terania Creek just upstream from its confluence with Rocky Creek. Grant (1998) observed platypus at three of four sites located between the proposed Dunoon Dam wall and upstream of the Rocky Creek and Terania Creek confluence (**Table 4-2**).

It was suggested that reduced flows and reduced flushing flows could lead to a reduction in platypus numbers. Potential encroachment of invasive species into the channel as a result of the altered flow regime could reduce habitat quality and quantity, and reduce the availability of benthic macroinvertebrate species that are the main food source for platypus. Accumulation of fine sediments and organic matter could also reduce the availability of benthic food species (Grant 1998).

Table 4-2: Observed Platypus locations along Rocky Creek during 1998 survey (Grant 1998)

SITE		OBSERVATIONS				
		DAWN	DUSK	NIGHT	OTHER	TOTAL
1	Downstream of Rocky Creek Dam wall from pontoon bridge	1	0	0	0	1
2	Downstream of Gibbergunyah crossing at Honey Nut Farm crossing	0	3	1	0	4
3	Downstream of Simes Bridge	1	0	0	0	1
4	Upstream of Rocky Creek bridge	0	0	0	0	0
	Incidental sightings	0	0	0	2	2

4.2.8 Bats

Two threatened species of bat that inhabit areas near streams have been recorded within Rocky Creek Catchment (Bishop 1998):

- Southern Myotis (*Myotis macropus*) which is listed as vulnerable under the TSC Act and relies on food directly from streams;
- Eastern long-eared bat (*Nyctophilus bifax*) also listed as vulnerable under the TSC Act and inhabits wet habitats near streams.

Large-footed Myotis were also recorded by SMEC (2011) as part of their Dunoon Terrestrial Ecology Impact Assessment.

4.3 FIELD SITE DESCRIPTIONS

The main sites used for the aquatic ecology survey and assessment were Sites 1 to 5 (**Table 4-3; Figure 4-2; Figure 4-3)**. Sites 1 to 3 were chosen to describe the current aquatic ecology and habitat along Rocky Creek. Site 1 below Rocky Creek Dam and upstream of the proposed dam area was chosen to provide information on the current impacted Rocky Creek system. Site 2 is in the proposed inundation area and provides baseline information on the environment within the inundation area. Site 3 is downstream of the proposed dam wall in the reach mostly likely to be impacted by altered flow regime. Sites 4 and 5 are on Terania Creek. Site 4 is up stream of the confluence with Rocky Creek and will act as a control site for monitoring impacts of altered flow in Rocky Creek. Site 5 is below the confluence with Rocky Creek and will provide evidence for system recovery relative to Site 4.

Table 4-3: Field site summaries

SITE NO	PROCESS ZONE	MEAN BED SLOPE	VALLEY SHAPE	CHANNEL WIDTH (Qbf)	HABITAT FEATURES	BED MATERIAL	BANK MATERIAL	BANKTOP FORM	LARGE WOODY DEBRIS	ADJACENT LANDUSE
1	Armoured zone	2.7 %	Asymmetrical relatively shallow valley (southern valley continuously steeper along reach)	10.9 m	Riffle-run-pool sequence	Coarse gravel – large cobbles d_{50} = 75mm	Medium–coarse gravel	Down sloping top (left hand bank only)	Roots downstream end (1%)	National Park
2	Mobile zone		Shallow valley, asymmetrical (northern side of valley steeper, particularly at upstream extent)	9.3 m	Pool riffle sequence	Coarse gravel – medium boulder d_{50} = 100mm	Sandy loam	Down sloping top	None evident	Agricultural Orchard
3	Gorge zone	1.4%	Asymmetrical valley (steeper northern particularly at downstream extent)	8.0 m	Pool-riffle sequence	Fine gravel - bedrock d_{50} = 150mm	Sandy loam	Down sloping top	5 pieces	Forested
4	Mobile zone		Shallow valley, asymmetrical (northern side of valley steeper, particularly at upstream extent)	12.0 m	Pool riffle sequence	Fine gravel - small cobbles d_{50} = 15mm	Clayey sand with some (fine) gravels	Down sloping top	0	Agricultural
5	Mobile zone		Relatively steep valley, asymmetrical	12.0 m	Pool riffle sequence	Fine gravel – small cobble d_{50} = 15mm	Sand/loamy sandy	Down sloping top	0	Agricultural

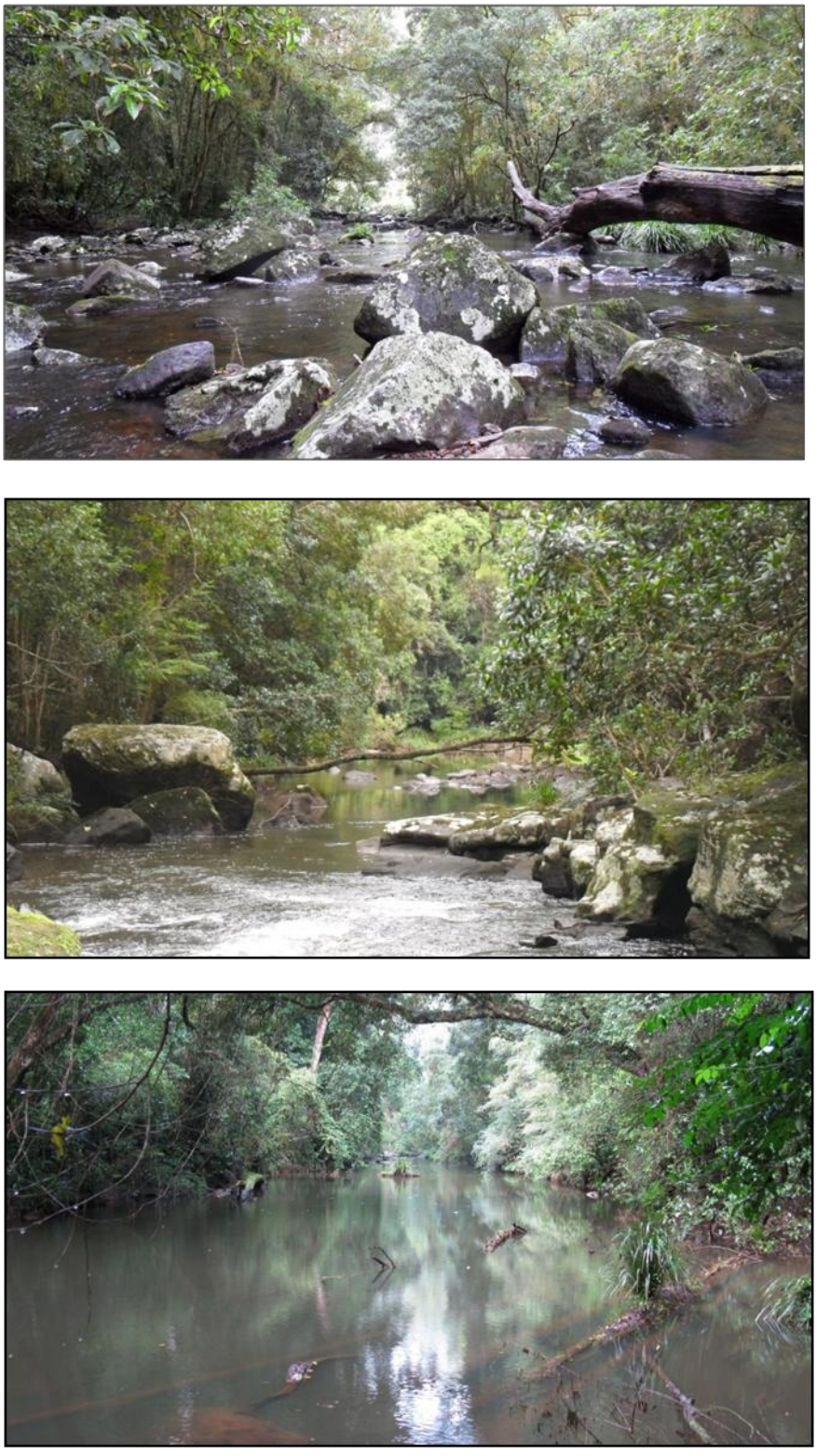

Figure 4-2: Top: Site 1 riffle area; Centre: Site 2 upstream of riffle, downstream of pool; Bottom: Site 3 pool area

Figure 4-3: Top Site 4 run area; Centre Site 5 pool area; Bottom Site 6 large pool

4.4 RIPARIAN & AQUATIC VEGETATION

A riparian flora survey was undertaken at each site within a 40 m by 10 m quadrat running parallel to the channel. Each quadrat was assessed for visible species, including an estimate of cover abundance. Macrophyte species and percent cover were recorded for each study site concurrently with macroinvertebrate sampling. Detailed riparian and aquatic vegetation lists for each site can be found in **Appendix B**.

4.4.1 Site 1

A total of 54 riparian plant species was recorded at Site 1. Twenty-seven canopy species were recorded, all with cover scores of between 1 and 3, except for *Elaeocarpus grandis* (Blue Quandong) which had a cover score of 4. There was less diversity in the shrub layer, with only five species recorded, three of which had cover scores of 1 and the remainder cover scores of 3. Three ground-layer species were recorded, with cover scores of 1, 2 and 3. Vines were represented by eleven species, with cover scores ranging between 1 and 3. There were three species of epiphytes, each with a cover score of 2. There were no exotic species recorded at this site (**Figure 4-4**).

Lomandra sp. was the only semi-aquatic macrophyte identified at Site 1 and was present during the post-flush and autumn sampling periods, with a cover of <5%.

4.4.2 Site 2

A total of 33 riparian plant species was recorded at Site 2. Six canopy species were recorded, Camphor Laurel (exotic species) had the highest cover score (4) of the canopy species. *Acacia melanoxylon* (Blackwood) and *Ficus coronata* (Sandpaper Fig) returned cover scores of 3, with the remainder of the canopy species returning cover scores of 1 or 2. The shrub layer was comprised of two species, *Callistemon viminalis* (Weeping Bottlebrush) and Small-leaved Privet, with cover scores of 3 and 4 respectively. The ground layer was comprised of 25 species, with cover scores ranging from 1 to 3; sixteen species had cover scores of 1. Five of the ground layer species were exotics with a cover score of 1 or 2. No vines or epiphytes were recorded at this site. Five native and three exotic species were recorded outside the quadrat (**Figure 4-4**).

Several species of macrophytes were recorded at this site, with composition changing between sampling periods. *Eleocharis* sp., *Carex* sp., *Sagittaria* sp., *Persicaria strigosa*, *Persicaria hydropiper* and *Isolepis inundatus* were recorded during the post-flush sampling period. Sedge and *Stuckenia pectinata* were recorded during the spring sampling period, both with cover scores of 5%. *Schoenoplectus* sp., *Lomandra* sp. and *Carex* sp. were recorded during the autumn sampling period, with cover of 1%, 5% and 5% respectively.

4.4.3 Site 3

A total of 44 riparian flora species was recorded at Site 3. Fourteen canopy species were recorded, 10 of which had cover scores of 1. One species, *Tristaniopsis laurina* (Water Gum) had a cover score of 5 and the remaining three species had cover scores of 2. Four shrub species were recorded, two of which were native species, *Croton verreauxii* (Green Native Cascarilla) and *Linospadix monostachya* with cover scores of 1 and 2 respectively. The other two shrub species were exotic; Lantana and Small-leaved Privet with cover scores of 1 and 3 respectively. Eighteen ground-layer species were recorded within the quadrat with cover scores ranging between 1 and 3. Three of these species were exotic; of note was the highly invasive Wandering Jew (*Tradescantia fluminensis*) with a cover score of 3. Five native vine species were recorded within the quadrat with cover scores ranging between 1 and 3. Two epiphytes were recorded, *Asplenium australasicum* (Bird's Nest Fern) and *Pothos longipes*. Six native species were recorded outside the quadrat (**Figure 4-4**).

Macrophytes present during the post-flush sampling period included: *Lomandra longifolia* (5% cover), *Carex* sp. (<5% cover) and *Cheilanthes* sp. (1% cover). There were no macrophytes present during the spring 2010 sampling period and only *L. longifolia* was present during the autumn 2011 sampling period with a cover of 5%.

4.4.4 Site 4

A total of 37 riparian flora species was recorded at Site 4. Nine canopy species were recorded, three of which had cover scores of 3, Sandpaper Fig, *Streblus brunonianus* (Whalebone Tree) and *Syzygium australe*, with the remaining vegetation having cover scores of 1. There were three shrub species, *Alectryon subcinereus* and Weeping Bottlebrush with cover scores of 1 and Small-leaved privet with a cover score of 2. Twenty-two ground-layer species were recorded, with cover scores ranging between 1 and 3, except for the exotic plant Wandering Jew with a cover score of 4. Other exotic species within the ground-layer included: *Ageratina adenophora* (Crofton Weed), *Amaranthus* sp., *Drymaria cordata* (Tropical Chickweed), *Rumex crispus* (Curled Dock), *Setaria sphacelata* (South African Pigeon Grass), *Solanum americanum* (Glossy Nightshade) and *S. seaforthianum* (Climbing Nightshade). Two vine species were recorded, both of which are exotic species, *Anredera cordifolia* (Madeira Vine) and *Cardiospermum grandiflorum* (Balloon Vine), both with cover scores of 2. Bird's Nest Fern was the only epiphyte recorded in the quadrat (**Figure 4-4**).

Macrophytes present during the post-flush sampling period included: *Lomandra* sp. (5% cover), *Eleocharis* sp. (5% cover) and *Vallisneria* nana (<5% cover). The only macrophyte present during the spring sampling period was *V. nana* (5% cover). Macrophytes present during the autumn 2011 sampling period, were *V. nana* and *Lomandra* sp., with cover of 10% and 5% respectively.

4.4.5 Site 5

A total of 45 riparian flora species was recorded within Site 5. There were three canopy species within the quadrat, Camphor Laurel and Whalebone Tree with cover scores of 1 and Sandpaper Fig with a cover score of 3. The shrub layer comprised two species, Weeping Bottlebrush with a cover score of 4, and Small-leaved Privet with a cover score of 1. The ground layer had 39 species, 23 of which were exotic species. Cover scores ranged between 1 and 3. One vine species was recorded, exotic Balloon Vine; this species had a cover score of 1. No epiphytes were recorded in the quadrat. Two native species were recorded outside the quadrat (**Figure 4-4**).

Macrophytes present during the post-flush sampling period included: *Myriophyllum papillosum* (<5% cover), *Carex* sp. (<5% cover) and Sedge (1% cover). The only macrophyte present during the spring and autumn sampling periods was *V. nana* with cover being 5% and 8% respectively.

4.4.6 Rare or Threatened Species

There were two listed species identified during the field surveys. *Desmodium acanthocladum* (Thorny pea), listed as 2VC under ROTAP[2] and vulnerable under the TSC Act, was recorded at Site 2 and 3. *Helmholtzia glaberrima* (Flax lily), listed as 2RCa under ROTAP, was recorded at Site 1.

[2] ROTAP definitions: 2 = restricted distribution with a range extending over <100 km; V=vulnerable, at risk over a longer period (20-50 years); R=Rare but with no current identifiable threat; C=Species is known to occur within a proclaimed reserve; a= species is considered to be adequately reserved.

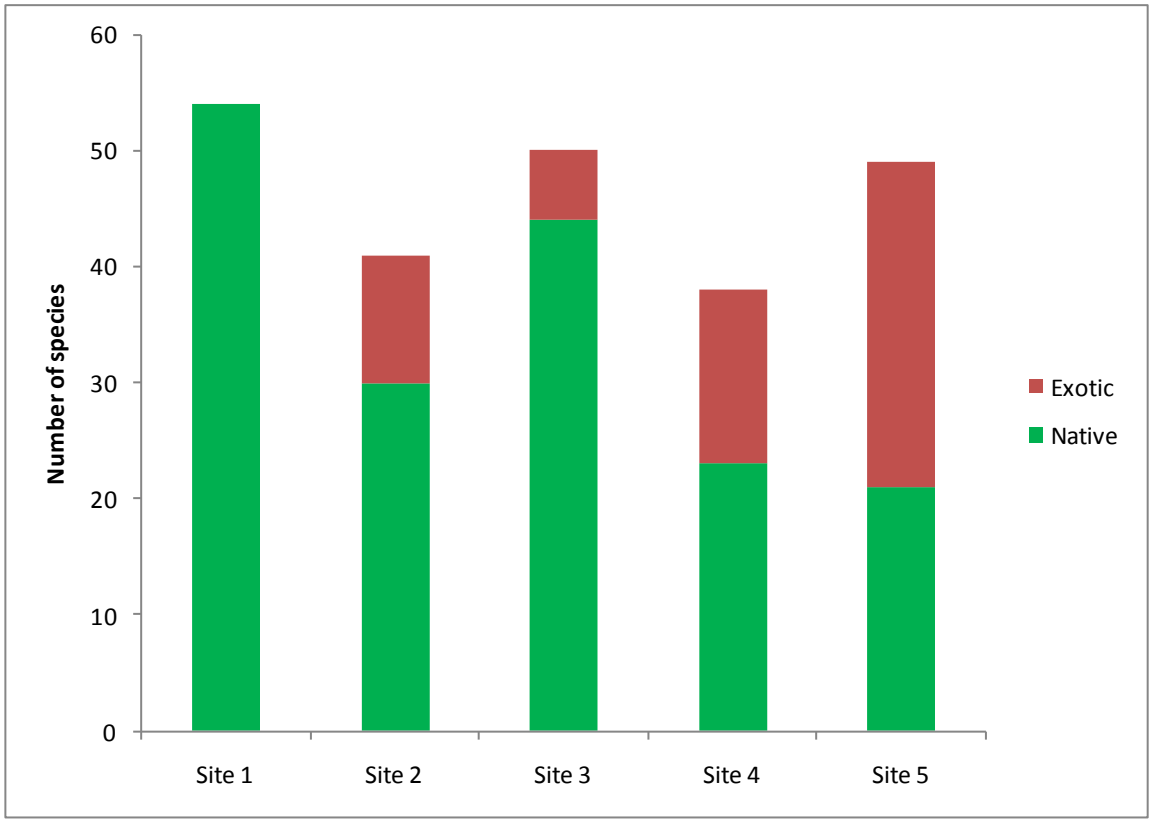

Figure 4-4: Riparian flora species richness recorded November 2010.

4.5 WATER QUALITY

Water quality assessments were undertaken using portable multi-meters, in situ temperature loggers and laboratory analysis. Sampling of in situ parameters was conducted during all field surveys to provide information on the temporal dynamics of water quality parameters.

Detailed water quality results are in **Appendix C**. A summary is provided below.

4.5.1 Physical Chemistry

Water temperature was relatively warm and stable during the sampling period ranging from 16.9 ºC during the post-flush sampling period at Site 2 to 22.5 ºC at Site 1 during the autumn (March) sampling period (**Table 4-4**).

Specific conductivity readings for all sites were below the ANZECC trigger range (2.2 mS/cm) across the entire sampling period (0.05 – 0.097 mS/cm), with readings at each site remaining relatively constant. Conductivity tended to increase slightly down the system, being highest at Sites 4 and 5 (**Table 4-4**).

All sites consistently returned DO (% saturation) of less than 85%, the lower limit of the ANZECC range (85-110%) across the sampling period, with exception of Site 5 during the autumn sampling period (87.4% and 86.2% in the riffle and pool respectively). The lowest recorded percentage was 65.5% within the pool at Site 2 during the spring sampling period. DO tended to be lowest during the spring 2010 sampling and highest in autumn 2011 across all sites. Detrimental impacts on biota generally occur below 20% air saturation, with all sites recording concentrations well above this critical threshold (**Table 4-4**).

Turbidity readings were generally low, ranging from 2 to 19 NTU and were near the lower end or below the ANZECC desirable range (6-50 NTU) for lowland streams. Turbidity was consistently lower in Rocky Creek (maximum value 8 NTU) than Terania Creek (maximum 19 NTU) (**Table 4-4**).

Water column pH was approximately neutral for all sites during the 2010 spring and post-flushing flow surveys, ranging from 6.75 to 7.98. Water column pH was consistently more alkaline at all sites during autumn 2011 sampling ranging from 7.86 to 8.74, and generally exceeded the upper limit of the ANZECC range of 8.0 at all sites (**Table 4-4**). This increased alkalinity may result from reduced surface water flows and greater contribution from localised sources (springs) that have an underlying alkaline geology.

TSS ranged between 0.0002 and 0.0036 g/L for all of the sites on all sampling occasion, with the exception of Site 4 which had 0.01 g/L TSS during the autumn sampling period (**Table 4-4**). These concentrations are exceptionally low for suspended sediment.

Table 4-4: Summary of water quality results from sites 1-5.

		Post-Flush# (19-20 Oct 2010)		Spring# (24-25 Nov 2010)		Autumn* (28-29 Mar 2011)		ANZECC Range
		Riffle	Pool	Riffle	Pool	Riffle	Pool	
Site 1	Temperature (^{0}C) *	19.25	19.7	21.12	20.8	22.5	22.5	-
	Specific Conductivity (mS/cm) *	0.053	0.053	0.055	0.055	0.052	0.053	0.125-2.20
	pH *	6.75	6.80	6.99	6.99	8.07	7.86	6.5-8.0
	Dissolved Oxygen (%) *	73.4	68.7	67	67.3	83.5	82.1	85-110%
	Turbidity (NTU) *	7.6	5.8	3.5	3.3	2	2	6-50NTU
	Total Phosphorus (mg/L)^	<0.05		<0.05		<0.05		0.05mg/L
	Ortho Phosphorus (mg/L) ^	<0.01		<0.01		<0.01		0.02mg/L
	Total Nitrogen (mg/L) ^	0.3		0.33		0.25		0.50mg/L
	Oxidised Nitrogen (mg/L) ^	0.05		0.05		0.09		0.04mg/L
	Total Suspended Solids (g/L) ^	0.0026		0.0015		0.00075		-
	Chlorophyll *a* (mg/L) ^	0.0003		0.0024		.00159		0.005mg/L
Site 2	Temperature (^{0}C)	16.88	16.97	20.14	20.26	20.2	20.2	-
	Specific Conductivity (mS/cm)	0.064	0.064	0.071	0.071	0.069	0.071	0.125-2.20
	pH	6.89	6.90	7.29	7.98	8.4	8.23	6.5-8.0
	Dissolved Oxygen (%)	82.8	76.7	66.6	65.5	83.5	84.4	85-110%

		Post-Flush# (19-20 Oct 2010)		Spring# (24-25 Nov 2010)		Autumn* (28-29 Mar 2011)		ANZECC Range
		Riffle	Pool	Riffle	Pool	Riffle	Pool	
	Turbidity (NTU)	6.3	5.9	3	3.1	7	8	6-50NTU
	Total Phosphorus (mg/L)		<0.05		<0.05		<0.05	0.05mg/L
	Ortho Phosphorus (mg/L)		<0.01		0.01		<0.01	0.02mg/L
	Total Nitrogen (mg/L)		0.37		0.31		0.35	0.50mg/L
	Oxidised Nitrogen (mg/L)		0.16		0.08		0.19	0.04mg/L
	Total Suspended Solids (g/L)		0.0013		0.0002		.0019	-
	Chlorophyll *a* (mg/L)		0.0012		0.0001		.00077	0.005mg/L
Site 3	Temperature (^{0}C)	17.9	17.93	19.96	19.97	20.6	20.7	-
	Specific Conductivity (mS/cm)	0.069	0.069	0.077	0.077	0.072	0.072	0.125-2.20
	pH	6.95	7.01	7.18	7.23	8.7	8.74	6.5-8.0
	Dissolved Oxygen (%)	76.1	75.8	67.2	67.8	84.8	83.3	85-110%
	Turbidity (NTU)	6.2	6.2	5.9	5	5	5	6-50NTU
	Total Phosphorus (mg/L)		<0.05		<0.05		<0.05	0.05mg/L
	Ortho Phosphorus (mg/L)		<0.01		0.02		0.065	0.02mg/L
	Total Nitrogen (mg/L)		0.38		0.3		0.33	0.50mg/L
	Oxidised Nitrogen (mg/L)		0.17		0.08		0.17	0.04mg/L
	Total Suspended Solids (g/L)		0.0007		0.0005		.00175	-
	Chlorophyll *a* (mg/L)		0.0004		0.0001		.00055	0.005mg/L
Site 4	Temperature (^{0}C)	17.71	17.73	21.67	21.67	20.7	20.8	-
	Specific Conductivity (mS/cm)	0.085	0.084	0.098	0.097	0.096	0.097	0.125-2.20
	pH	7.09	7.07	7.35	7.34	8.4	8.31	6.5-8.0
	Dissolved Oxygen (%)	70.7	71.9	70	70.8	85.1	81.7	85-110%
	Turbidity (NTU)	15.3	15	9.1	10.1	19	19	6-50NTU
	Total Phosphorus (mg/L)		<0.05		0.06		0.065	0.05mg/L

		Post-Flush# (19-20 Oct 2010)		Spring# (24-25 Nov 2010)		Autumn* (28-29 Mar 2011)		ANZECC Range
		Riffle	Pool	Riffle	Pool	Riffle	Pool	
	Ortho Phosphorus (mg/L)		0.01		0.04		0.015	0.02mg/L
	Total Nitrogen (mg/L)		0.31		0.33		0.35	0.50mg/L
	Oxidised Nitrogen (mg/L)		0.12		0.07		0.14	0.04mg/L
	Total Suspended Solids (g/L)		0.0036		0.0015		.01	-
	Chlorophyll *a* (mg/L)		0.0001		0.0001		.00149	0.005mg/L
Site 5	Temperature (^{0}C)	18.05	18.03	20.67	20.66	21.4	21.4	-
	Specific Conductivity (mS/cm)	0.08	0.079	0.091	0.09	0.097	0.09	0.125-2.20
	pH	7.00	6.99	7.26	7.2	8.08	8.3	6.5-8.0
	Dissolved Oxygen (%)	74.1	79.5	68.3	69.2	87.4	86.2	85-110%
	Turbidity (NTU)	9.8	9.8	8.6	9	14	14	6-50NTU
	Total Phosphorus (mg/L)		<0.05		0.05		0.05	0.05mg/L
	Ortho Phosphorus (mg/L)		0.01		0.03		0.01	0.02mg/L
	Total Nitrogen (mg/L)		0.37		0.31		0.33	0.50mg/L
	Oxidised Nitrogen (mg/L)		0.16		0.09		0.14	0.04mg/L
	Total Suspended Solids (g/L)		0.0031		0.0027		.00315	-
	Chlorophyll *a* (mg/L)		0.0002		0.0002		.00083	0.005mg/L

* *in situ* measurements; ^ samples taken from riffle habitat only; # Hydrolab Quanta used for field measurements; * Horiba Multi-parameter water quality meter used for field measurements

A thermister chain placed in the deep pool at Site 6 logged the difference between surface and bottom temperatures between 23/9/10 to 29/3/11, a period where it was predicted thermal stratification was most likely to occur. The average temperature difference was 0.33 ºC and the highest recorded was 2.92 ºC. Weak thermal stratification was still present for the majority of the survey period and there were several periods when the surface temperature exceeded the bottom temperature by more than 1 ºC. However, these periods of thermal stratification (temperature difference greater than 1 ºC) were short in duration, generally less than 1 day with flows of approximately 20 MLd^{-1} for several days being sufficient to remix the pool (**Figure 4-5**).

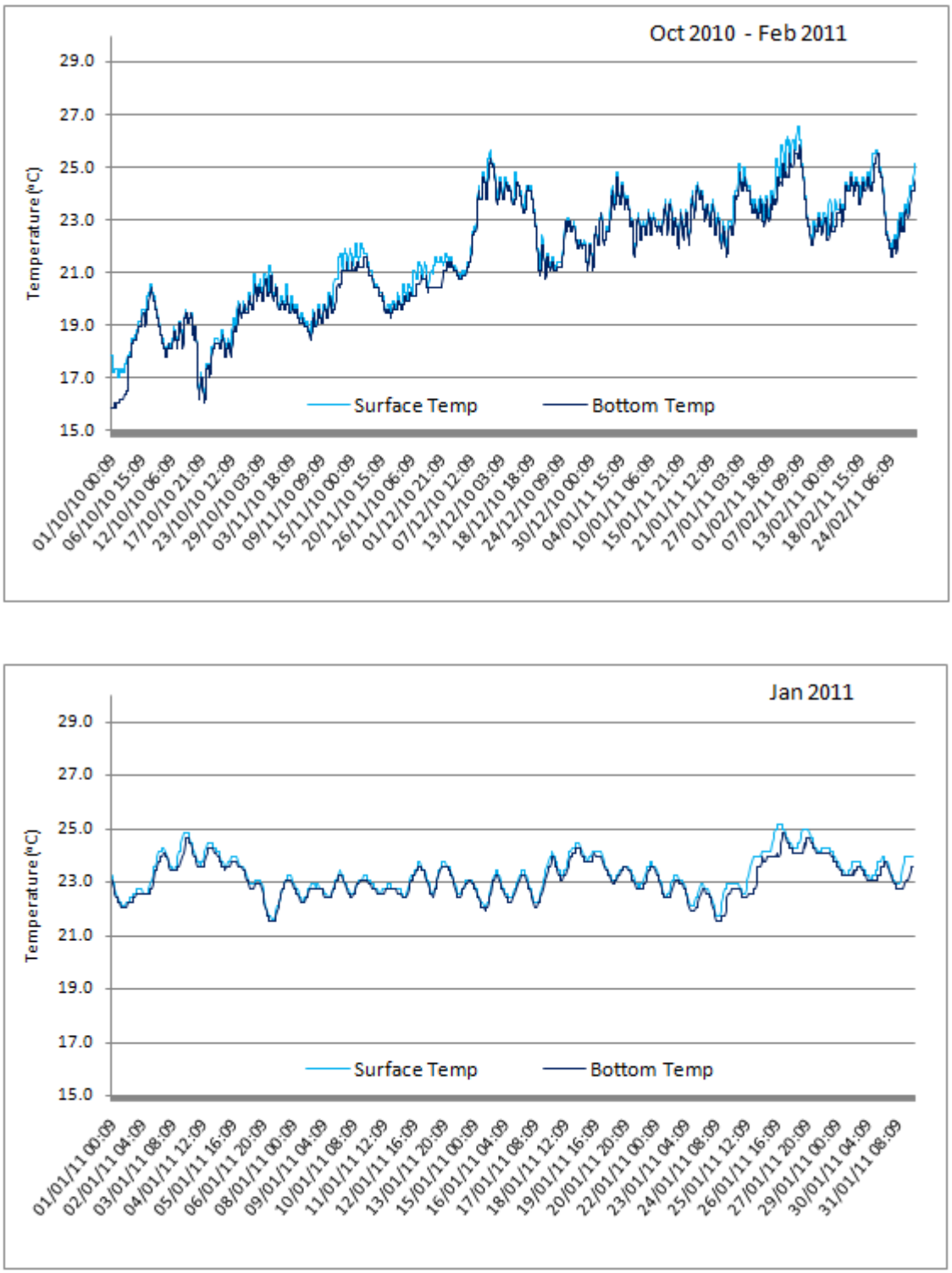

Figure 4-5: Temperature at Site 6 (deep pool, Rocky Creek)

No temperature gradients were observed Site 8 at any time in the sampling period. The largest recorded difference in dissolved oxygen between the water surface and bottom at the deep pool at Site 8 was 1.6% in spring (**Figure 4-6**).

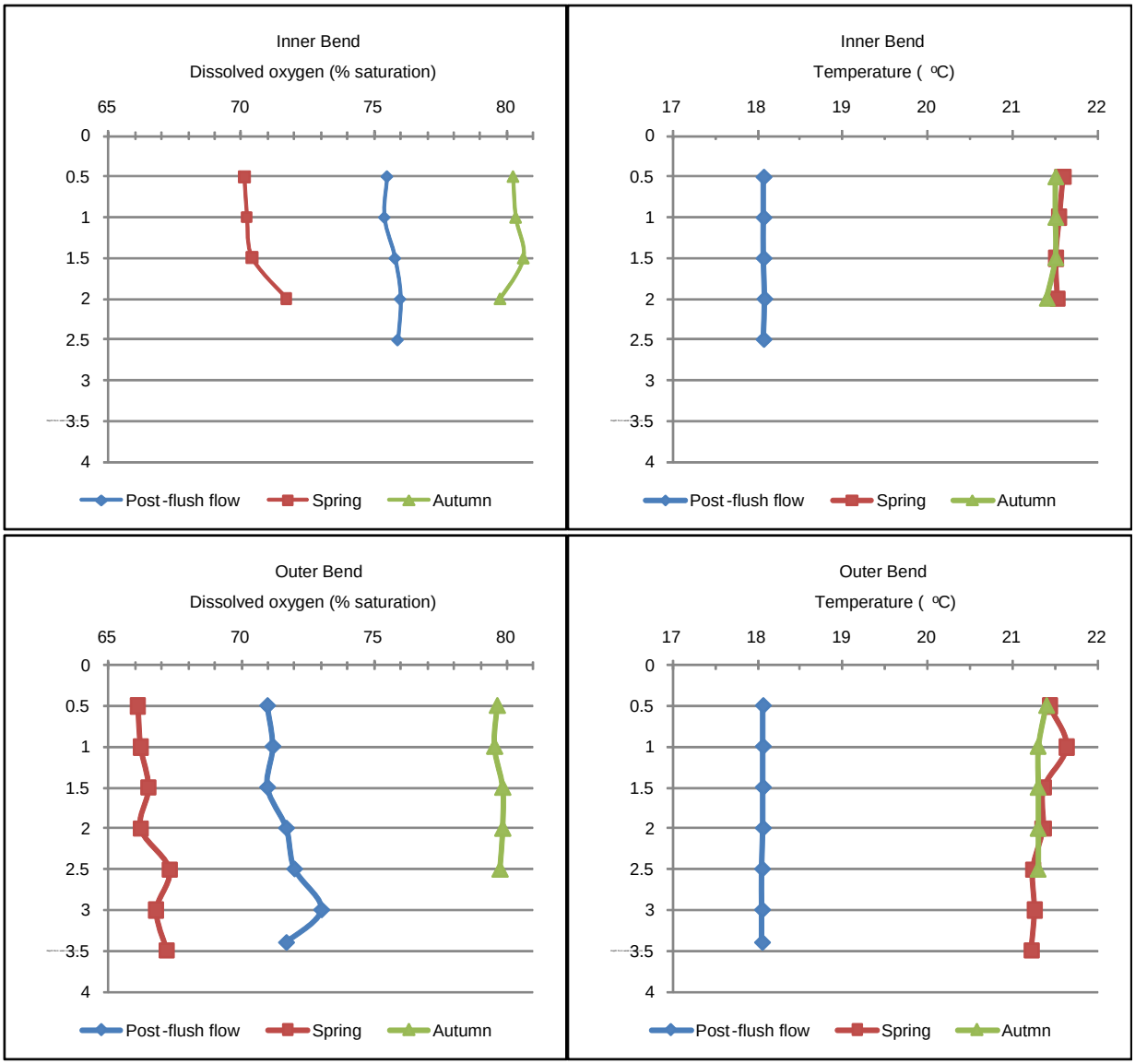

Figure 4-6: DO and temperature profiles from Site 8 (pool, Terania Creek) (Inside bend: above; Outside bend: below)

4.5.2 Nutrients & Chlorophyll *a*

Nutrients (TP, FRP, TN and NOx) and Chlorophyll *a* were consistently low and below the ANZECC recommended thresholds (**Table 4-4**). Chlorophyll *a* concentrations were very low and generally less than 10% of the trigger value, and phosphorus levels were extremely low and near lower detection limits of the methods used. Only NOx was consistently higher than the ANZECC recommendations ranging from 0.07-0.17 mg/L against the ANZECC guideline of 0.04 mg/L.

4.6 AQUATIC MACROINVERTEBRATES

Aquatic macroinvertebrates were sampled during October (post-flush) and November (spring) 2010 and during March (autumn 2011) from a composited pool-edge habitat and a riffle habitat at five sites along Rocky and Terania Creek. Velocity, depth, silt and detritus cover, algal cover, substrate composition and aquatic vegetation of the two sampling habitats were recorded on each sampling occasion (**Appendix D**).

A total of 5055 individual aquatic macroinvertebrates were collected from pool-edge and riffle habitats comprising 73 families distributed across 23 orders (**Appendix D**).

The average abundance-weighted SIGNAL2 scores representing both pool-edge and riffle habitats ranged from 4.84 (Site 1) to 5.22 at Site 5 on Terania Creek over the study period, indicating all sites have mildly to moderately impacted macroinvertebrate communities. As expected, riffle habitats had consistently higher SIGNAL2 scores than the composited pool-edge habitat due to improved habitat and food availability. Average abundance-weighted SIGNAL2 scores were generally higher in autumn following a high rainfall summer period rather than in spring as predicted, suggesting the macroinvertebrates have responded positively to the increased flow variability (**Figure 4-7; Table 4-5**). In most instances the EPT scores reflected the SIGNAL2 scores with the exception of Sites 3 and 5 where the EPT scores would indicate the habitat is of poorer quality than indicated by the SIGNAL2 scores (**Table 4-6**).

Figure 4-7: Abundance weighted SIGNAL2 scores for pool and riffle habitats at the five sampling sites for three sampling periods (Oct 2010 - post-flush; Nov 2010 - spring; March 2011 - autumn).

Table 4-5: Abundance weighted SIGNAL2 scores over three sampling periods (Oct 2010 - post-flush; Nov 2010 - spring; March 2011 - autumn) at five sites along Rocky Creek and Terania Creek, Richmond River Catchment, NSW

SIGNAL2	OCT 2010	NOV 2010	MAR 2011	
	SITE 1			
Riffle	5.03	4.88	5.51	
Pool	4.45	4.21	4.98	
Average	**4.74**	**4.54**	**5.24**	**4.84**
	SITE 2			
Riffle	5.58	5.50	5.60	
Pool	4.57	4.51	4.65	
Average	**5.08**	**5.01**	**5.13**	**5.07**
	SITE 3			
Riffle	5.25	5.72	5.45	
Pool	4.65	3.83	4.42	
Average	**4.95**	**4.78**	**4.94**	**4.89**
	SITE 4			
Riffle	5.78	5.85	5.70	
Pool	4.89	4.25	4.17	
Average	**5.34**	**5.05**	**4.93**	**5.10**
	SITE 5			
Riffle	6.24	4.82	6.27	
Pool	4.03	5.18	4.80	
Average	**5.14**	**5**	**5.54**	**5.22**

Table 4-6: EPT Scores based on abundance for three sampling periods (Oct 2010 - post-flush; Nov 2010 - spring; March 2011 - autumn) at five sites along Rocky Creek and Terania Creek, Richmond River Catchment, NSW

	SITE 1 RIFFLE	SITE 1 PE	SITE 2 RIFFLE	SITE 2 PE	SITE 3 RIFFLE	SITE 3 PE	SITE 4 RIFFLE	SITE 4 PE	SITE 5 RIFFLE	SITE 5 PE
March (autumn 2011)	50.3	40.3	60.2	36.2	46.5	37.8	55.6	9.2	56.5	41.9
Nov (post-flush 2010)	35.6	9.5	25.9	22.9	41.5	9.9	62.8	14.8	29.9	26.7
Oct (spring 2010)	24.3	14.5	45.2	29.5	13.9	25.2	34.7	25.4	30.3	26.2

PE = Pool edge

Site 1

Silt and detritus cover in the riffle habitat was below 5% for both the post-flush and spring sampling periods and no silt/detritus cover was present in the autumn sampling period. The substrate was composed of fine to medium sand, ranging up to small boulders. During the post-flush sampling medium gravel made up 40% of the substrate, whilst during the spring and autumn surveys small cobbles made up the larger proportion with 55% and 50% respectively. Silt and detritus cover in the pool-edge habitat was higher with 5 to 25% cover during the post-flush and autumn sampling periods, and 25 to 50% in the spring period. The substrate was composed of coarse to very coarse sand and ranging up to small boulders. During the post-flush survey very fine to fine gravel made up 50% of the substrate, shifting to 50% large cobbles in the autumn period. The pool-edge habitat had 30% small boulder coverage.

The post-flush sampling period at this site was numerically dominated by the pollution-sensitive Elmidae larvae (Riffle Beetles) in the riffle habitat. However, there were also high numbers of pollution-tolerant Chironominae (SIGNAL2 score of 3) in the riffle and this sub-family was also most abundant in the pool-edge habitat. The SIGNAL2 score (5.03) and EPT score 35.5% for the riffle during this sampling period would indicate that the macroinvertebrate community is mildly impaired relative to an undisturbed site. The SIGNAL2 (4.45) and an EPT score of only 9.5% for the pool-edge during this sampling period would indicate that the macroinvertebrate community is slightly more impacted than the riffle.

The spring sampling period in the riffle was dominated by sensitive and rheophylic Hydropsychidae larvae (net spinning caddis flies); however, more tolerant Chironominae and Orthocladiinae were also recorded in high numbers. The pool-edge habitat was again dominated by the hardy Dipteran larvae (Chironominae and Tanypodinae). The SIGNAL2 score for both the riffle and the pool-edge (4.88 and 4.21 respectively) during this sampling period would indicate that the macroinvertebrate community is moderately impaired relative to an undisturbed site. The EPT scores are considerably higher in the riffle than the pool-edge (24.3 and 14.5% respectively) indicating a higher number of pollution-sensitive macroinvertebrates in the riffle than in the pool.

The riffle habitat in the autumn sampling period was dominated by the pollution-sensitive Hydropsychidae larvae. The pool-edge habitat was dominated by tolerant Dipteran larvae (Tanypodinae). The SIGNAL2 score of (5.51) in the riffle is the highest for this site, and suggests that the macroinvertebrate community in this riffle has responded positively to the high seasonal rainfall in the creek system. The SIGNAL2 for the pool-edge (4.98) has also shown improvement in the autumn period. The EPT scores for both the riffle and the pool-edge (50.3 and 40.3% respectively) during this sampling period were considerably higher than on the previous sampling occasions, indicating that there were a high number of pollution-sensitive macroinvertebrates present.

Site 2

Silt and detritus cover in the riffle was constant at less than 5% over all three sampling periods. The substrate was composed of very fine sand and silt, and ranged up to large cobbles. During the post-flush sampling period small cobbles made up the greater proportion with 50% cover. The composition of the substrate during the post-flush sampling period was made up of 40% coarse gravel to small cobbles. By autumn the dominant substrate was 50% large cobbles. Substrate in the post-flush sampling and spring periods was comprised of fine to medium sand and ranged up to coarse to very coarse gravel, with coarse gravel making up the largest proportion (50%) in the post-flush period. The autumn sampling period returned a substrate composition of very fine sand and silt ranging up to large cobbles. Coarse to very coarse gravel made up 70% of the cover.

Seventy three macroinvertebrate individuals were recorded in the post-flush sampling period in the riffle, dominated by Baetidae nymphs (Mayflies). Thirty-two individuals captured were from pollution-sensitive families (e.g. above a score of 5). Sampling at the pool-edge yielded 183 individuals, the most abundant family being tolerant Dipteran larvae (Tanypodinae and Chironominae). Although there were numerous families of pollution-sensitive macroinvertebrates captured in the pool-edge, they were generally low in abundance. The SIGNAL2 score (5.88) and an EPT score of 25.9% for the riffle and (4.57) and the EPT score of 22.9% for the pool-edge during the post-flush period indicate that the macroinvertebrate community is impaired relative to an undisturbed site.

Both riffle and pool-edge habitats in the spring sampling period were dominated by pollution-tolerant Dipteran larvae (Chironominae, Orthocladiinae and Culicidae). There were several pollution-sensitive families recorded but in low abundance. The SIGNAL2 score (5.50) and an EPT score of 45.2% for the riffle and (4.51) and the EPT an score of 29.5% for the pool edge habitat respectively during this sampling period indicate that the macroinvertebrate community is impaired relative to an undisturbed site.

During the autumn sampling period the riffle at this site was dominated by pollution-sensitive Hydropychidae (net spinning caddis flies), with other pollution-sensitive families also high in abundance. Pollution-tolerant Baetidae nymphs (mayfly) and Simulidae larvae (blackfly) were also abundant. The pool-edge was again dominated by Dipteran larvae (Chironominae and Tanypodinae), with pollution-sensitive Leptophlebiidae nymphs (mayfly) also abundant. The SIGNAL2 score (5.60) and the EPT score of 60.2% for the riffle, and (4.65) and the EPT score of 36.2 for the pool-edge habitat identify this sampling period as the macroinvertebrate community in highest ecological condition (although still relatively low scores) relative to an undisturbed site.

Site 3

Silt and detritus, and algal cover in the riffle during the post-flush and autumn sampling periods were consistently less than 5%, with silt not present and algal cover between 5 and 25% in the spring sampling period. The substrate components ranged in size from very fine sand and silt up to bedrock,

with bedrock the largest fraction at 80%. Silt and detritus, and algal cover during the post-flush sampling period comprised 5 to 50%. During spring and autumn sampling periods, high levels of silt and detritus cover were recorded (75 to 100%) in some locations. During the post-flush sampling period very fine sand and silt made up 60% of the substrate in the pool-edge whilst small boulders made up to 60% of the substrate in the pool, with the pool-edge composed of large cobbles, small boulders and medium boulders at 20%, 20% and 25% respectively.

During the post-flush sampling period only 79 individual macroinvertebrates were recorded in the riffle, with pollution-sensitive Elmidae (riffle beetles) most abundant. The pool-edge habitat yielded 127 individuals numerically dominated by pollution-tolerant Dipterans (Chironominae). The SIGNAL2 score for the riffle (5.25) and (4.65) for the pool-edge during this sampling period indicates that the macroinvertebrate community is impaired relative to an undisturbed site.

Abundance of individuals increased in the spring sampling period again dominated by pollution-sensitive species dominated in the riffle with Elmidae adults and Hydropsychidae larvae relatively high in number. The pool-edge was dominated by Dipterans (Chironominae and Tanypodinae). The SIGNAL2 score (5.72) and the EPT score of 13.9% for the riffle, and (3.83) and an EPT score of 25.2% during this sampling period are some of the lowest values recorded indicating that the macroinvertebrate community is moderately impaired relative to an undisturbed site.

The riffle habitat during the autumn sampling period was dominated by pollution-tolerant Baetidae nymphs (mayfly); however, pollution-sensitive Leptophlebiidae (prong-gilled mayfly) and Hydropsychidae (net spinning caddis fly) were also high in number. The pool-edge was dominate by pollution-sensitive Leptoceridae (long-horned caddisfly), however, pollution-tolerant Chironominae were also high in number. The SIGNAL2 score (5.45) and the EPT score of 45.6% for the riffle, and (4.42) and an EPT score 37.8% for the pool edge during this sampling period are consistent with Sites 1 and 2 that had peak SIGNAL2 scores in autumn.

Site 4

Silt and detritus cover in the riffle during the post-flush sampling period was 5 to 25%, shifting to less than 5% in the other periods. Algal cover was less than 5% during all sampling periods. The substrate ranged in size from fine to medium sand up to large cobbles. During the post-flush and spring sampling periods coarse to very coarse gravel made up the largest proportion of cover at 50% and 40% respectively. During the autumn sampling period this shifted to small cobbles that made up 40% of the substrate cover. Silt and detritus cover for both the pool and pool-edge during the post-flush sampling period ranged from 5 and 25%, with algal cover being less than 5%. During the spring sampling period there was 50 to 75% silt and detritus cover and less than 5% algal cover in the pool. During the autumn sampling period silt and detritus cover was 25 to 50% in the pool and 50 to 75% in the pool-edge. There was no algal cover during this sampling period. Substrate composition in the pool and pool-edge ranged between coarse to very coarse sand up to small cobbles, with coarse to very coarse gravel making up 50% of the substrate. The pool and pool-edge showed little variation in substrate composition during the post-flush and spring sampling periods.

During the spring sampling period the riffle at this site was dominated by pollution-sensitive Elimdae larvae and Leptophlebiidae nymphs. The pool-edge was also dominated by Elmidae larvae (riffle beetles), with pollution-tolerant Simuliidae (blackfly) and Tanypodinae (midge larvae) also abundant. The SIGNAL2 score (5.78) and the EPT score of 34.7% for the riffle, and (4.89) and the EPT score of 25.4% for the pool-edge during this sampling period indicate that the macroinvertebrate community is mildly impaired relative to an undisturbed site.

Pollution-sensitive Hydropsychidae (caddis fly) were dominant in the riffle in the post-flush period, along with abundant Leptophlebiidae nymphs and Elmidae larvae. The SIGNAL2 score (5.85) and the EPT score of 62.8% (the highest relative contribution recorded of EPT taxa) for the riffle during, and (4.25) and the EPT score 14.8% for the pool-edge during this sampling period indicate that the macroinvertebrate community is mildly impaired relative to an undisturbed site.

The riffle habitat in autumn was dominated by Hydropsychidae larvae, Leptophlebiidae nymphs, Elmidae larvae and Philopotamidae larvae (finger-net caddisfly). Elmidae larvae were the dominant family in the pool-edge, however, pollution-tolerant Chironominae were also abundant. The SIGNAL2 score (5.70) and the EPT score of 55.6% for the riffle and (4.17), and the EPT score of only 9.2% for the pool-edge during this sampling period follow the trend from Site 3 in not being the highest SIGNAL2 scores recorded, suggesting the macroinvertebrate communities did not respond as positively to increased flow variability between summer and autumn.

Site 4 was intended to provide data for an unregulated system of similar size to Rocky Creek, hence our prediction this site would have the highest family richness and SIGNAL2 scores. This was not evident in the data and the lower than expected condition of the macroinvertebrate community may reflect changes to land-use in the Terania Creek catchment negatively impacting the stream biota (as seen in the very high silt/detritus cover at this site).

Site 5

Silt and detritus, and algal cover in the riffle were consistently less than 5% during all sampling periods. Substrate ranged in size from fine to medium sand up to small cobbles. During the post-flush sampling period medium gravel made up 50% of the substrate. During the spring sampling period medium gravel, coarse/very coarse gravel and small cobbles made up 20%, 25% and 20% of substrate cover respectively. During the autumn sampling period small cobbles made up the largest proportion of cover at 55%. Silt and detritus cover during the post-flush sampling period was less than 5% for the pool and between 5 and 25% for the pool-edge. Algal cover was less than 5% for both the pool and pool-edge. Both the pool and pool-edge had between 5 and 25% silt and detritus cover and less than 5% algal cover during the spring sampling period. During the autumn sampling period the pool had between 5 and 25% silt and detritus cover, whilst it was between 50 and 75% in the pool-edge. Algal cover was less than 5% for both the pool and pool-edge. Substrate cover ranged from very fine sand and silt up to small cobbles during each of the sampling periods.

During the post-flush sampling period the riffle was dominated by pollution-sensitive Elmidae larvae and the pool-edge dominated by pollution-tolerant Tanypodinae (midge larvae). The SIGNAL2 score (6.24) for the riffle during this sampling period is the highest recorded and indicates the macroinvertebrate community has responded positively to the flushing event. However, the EPT score of 29.9% for the riffle reflects this consistent trend and is higher than that of the pool-edge. The SIGNAL2 score of (4.30) and the EPT score of 26.7% for the pool-edge during this sampling period suggests this habitat did not respond as well to the flushing event.

Elmidae larvae were the most abundant family during the spring sampling period in both the riffle and the pool-edge with an abundance of other pollution-sensitive families present. Pollution-tolerant families such as Chironominae and Ceratopogonidae (biting midges) were also abundant. The SIGNAL2 score of (4.82) and the EPT score of 30.3% for the riffle, and (5.18) and an EPT score of 26.2% for the pool-edge during this sampling period indicate that the macroinvertebrate community is mildly impaired relative to an undisturbed site.

The riffle and the pool-edge were dominated by Elmidae larvae during the autumn sampling period. The riffle also had high numbers of pollution-sensitive families such as Leptophlebiidae, Hydropsychidae and Philopotamidae. At the pool-edge, pollution-tolerant families such as Baetidae and Chironominae were also relatively high in number. The SIGNAL2 score (6.27) and the EPT score of 56.5% for the riffle, and (4.80) and an EPT score of 41.9% for the pool-edge during this sampling period would indicate that the macroinvertebrate community is mildly impaired relative to an undisturbed site, and responded positively to the high summer flow period.

4.7 FISH

A fish survey was conducted on 15 and 16 September 2010 using a combination of backpack and boat electrofishing, and unbaited traps only at Sites 6 and 9. Temperatures recorded at these sites on the 15th ranged from 16 to 25°C with 1.8 mm of rainfall; and on the 16th temperatures ranged from 13 to 23 °C with no rainfall recorded (temperature and rainfall records from the nearest weather station, Lismore NSW; BoM 2011). Water quality was recorded at the time of sampling; all parameters measured were within the ANZECC guideline range (**Appendix H)**.

Electrofishing resulted in 154 individual fish representing eight species being recorded at Site 6, and 59 individual fish representing eight species being recorded at Site 9. The traps yielded 40 individuals representing 4 species at Site 6, and 5 individuals representing 2 species at Site 9.

A total of 13 species were caught with the electrofisher and a total of 4 species were caught in the traps across both sites. All four species that were caught in the traps were also caught with the electro-fisher. Striped Gudgeon were by far the most abundant species contributing almost half of the total individuals caught or observed (160 individuals). Striped mullet were the next most abundant species (72 individuals) although they were only found at Site 9. There were no introduced species and no rare or threatened species caught or observed. A full species list is in **Appendix E**.

4.8 AMPHIBIANS

Frogs were surveyed during the spring sampling period (**Table 3-2**). Two frog calls were identified at Site 1; *Litoria fallax* (Eastern Dwarf Tree Frog) and *Litoria pearsoniana* (Pearson's Green Tree Frog). One frog call was recorded at Site 5, however, it was not identified due to the short duration of the call (<2 seconds). There were no frog calls heard at site 2 or 3 during the survey. No threatened or endangered frog species were recorded during this sampling at any of the sites.

4.9 WETLAND & MIGRATORY BIRDS

Bird surveys were conducted during the autumn survey period and supplemented with opportunistic bird sightings that were recorded during the spring survey. A total of 28 wetland and migratory birds were observed (**Table 4-7**, **Appendix F**).

There were no threatened or endangered species observed.

Table 4-7: Wetland and migratory bird observations at five sites along Rocky Creek and Terania Creek, Richmond River Catchment (November 2010 opportunistic sightings and March 2011 targeted searches)

SCIENTIFIC NAME	COMMON NAME	HABITAT	OPPORTUNISTIC	AUTUMN SURVEY
Acanthiza pusilla	Brown Thornbill	Riparian		✓
Alcedo azurea	Azure Kingfisher	Riparian	✓	✓
Anas superciliosa	Pacific Black Duck	Wetland		✓
Ardea novaehollandiae	White-faced Heron	Wetland		✓
Chalocophaps indica	Emerald Dove	Riparian	✓	
Cisticola exilis	Golden-headed Cisticola	Wetland		✓
Chrysococcyx lucidus	Shining Bronze Cuckoo	Marine	✓	
Colluricincla megarhyncha	Little Shrike Thrush	Wetland		✓
Coracina tenuirostris	Cicadabird	Marine	✓	
Dicrurus bracteatus	Spangled Drongo	Marine	✓	
Eurystomus orientalis	Dollarbird	Marine	✓	✓
Geopelia humeralis	Bar-shouldered Dove	Wetland	✓	✓
Gerygone mouki	Brown Gerygone	Wetland	✓	✓
Ixobrychus flavicollis	Black Bittern	Wetland	Possible	
Lichenostomus chrysops	Yellow-faced Honeyeater	Wetland		✓
Macropygia amboinensis	Brown Cuckoo-dove	Riparian		✓
Megalurus gramineus	Little Grassbird	Wetland		✓
Monarcha trivirgatus	Spectacled Monarch	Marine, riparian, wetland and migratory	✓	✓
Neochmia temporalis	Red-browed Firetail	Riparian		✓
Ninox novaeseelandiae	Southern Boobook	Marine	✓	
Nycticorax caledonicus	Nankeen Night Heron	Marine	Possible	
Orthonyx temminckii	Logrunner	Riparian	✓	✓
Phalacrocorax carbo	Great Cormorant	Wetland	✓	
Phalacrocorax melanoleucos	Little Pied Cormorant	Wetland		✓
Psophodes olivaceus	Eastern Whipbird	Riparian	✓	✓

SCIENTIFIC NAME	COMMON NAME	HABITAT	OPPORTUNISTIC	AUTUMN SURVEY
Todiramphus macleayii subsp. *incinctus*	Forest Kingfisher	Marine, wetland and riparian		✓
Todiramphus sanctus	Sacred Kingfisher	Marine and riparian	✓	
Zosterops lateralis	Silvereye	Marine	✓	

4.10 PLATYPUS

Sites 2, 3 and 5 were surveyed for platypus burrows and sightings of individuals. There were burrow clusters at each site on all sampling occasions with the exception of Site 5 during the autumn survey when no burrows were visible. Platypus sightings were made in the spring and autumn sampling periods at the pool habitat at Site 2, and in the post-flush and spring sampling periods at Site 5. There were no platypus sightings made at Site 3 (**Table 4-8**).

Table 4-8: Platypus and platypus burrow observations from study sites 2, 3, and 5 along Rocky Creek and Terania Creek, Richmond River Catchment, NSW

	SITE 2			SITE 3			SITE 5		
	Oct-10	Nov-10	Mar-11	Oct-10	Nov-10	Mar-11	Oct-10	Nov-10	Mar-11
Burrows (clusters)	9	7	3	3	5	2	1	3	0
Sightings	0	1	1	0	0	0	2	2	0

4.11 BATS

No targeted surveys for bats were undertaken. However, a Southern Myotis (fishing bat) was observed feeding in a pool upstream of Site 3 by the survey team during an early reconnaissance field survey.

5 Assessment of Potential Impacts

The proposed Dunoon Dam is currently in a conceptual phase and detailed design will be informed by technical studies, including this aquatic ecology impact assessment. Based upon the conceptual design and environmental flows impact assessment (ELA 2012), the following activities associated with the proposal have been considered:

- Dam construction (currently preliminary given conceptual phase of proposed dam)
- An approximate dam wall height of 40 m
- Proposed buffer area of 234 ha
- Altered flow, sediment and thermal regime.

This impact assessment considers the likelihood of occurrence of threatened aquatic and riparian flora and fauna species, populations and endangered ecological communities listed under NSW and Commonwealth legislation. This impact assessment considers the potential impacts resulting from the proposed dam upon:

- Riparian vegetation, aquatic vegetation (macrophytes) and associated habitat (instream woody debris, riffles, pools, etc)
- Water quality
- Aquatic macroinvertebrates
- Fauna (non-threatened and threatened)
- Threatened flora.

The impacts assessed within this report are preliminary at this stage and will be finalised upon completion of the detailed dam design.

The potential impacts upon threatened aquatic and riparian flora and fauna species, populations and endangered ecological communities have been assessed in accordance with Part 3A Guidelines for Threatened Species Assessment (DEC and DPI 2005), Aquatic Ecology in Environmental Impact Assessment (DoP 2003) and the Matters of National Environmental Significance - Significant Impact Guidelines under the EPBC Act (SEWPaC 2009) using the methods outlined in **Section 3** of this report to provide an indication of the potential likely impacts from the proposed dam.

5.1 PROJECT DESCRIPTION

A proposed new dam on Rocky Creek near Dunoon has been identified as a potential new source of water to supplement the Rous Regional Water Supply Strategy. Conceptual designs are still being undertaken, however, initial data suggests that the maximum inundation area (high water level) represents the 85 m AHD contour and will cover an area of approximately 253 ha. At full supply level, the dam will have a capacity of around 50,000 ML (including approximately 4,800 ML of dead storage).

Preliminary investigations conducted by NSW Public Works suggest a rock armoured zoned earthfill embankment. Based on conceptual designs to date, the proposed dam wall will be approximately 40 m in height. The proposed buffer area surrounding the dam inundation zone will be another 234 ha.

The construction and operation of the proposed dam would involve three main operational modes, these being construction (when the dam will operate in by-pass mode), filling and standard operation.

Operational rules and impacts to hydrology, geomorphology and water quality are discussed in detail in the *Dunoon Dam Environmental Flow Assessment* (ELA 2012).

5.2 IMPACTS ON RIPARIAN & AQUATIC VEGETATION & ASSOCIATED HABITAT

Riparian vegetation within the proposed dam study area consists of several vegetation communities, including:

- Pasture
- Camphor Laurel Disturbed Woodland/Forest
- Sub-tropical Rainforest
- Warm Temperate Rainforest.

These riparian communities can be found within 10 m either side of Rocky Creek within the proposed inundation area. The vegetation communities, Sub-tropical Rainforest and Warm Temperate Rainforest are included within the Lowland Rainforest Endangered Ecological Community (EEC), which is listed under the NSW TSC Act.

Aquatic vegetation observed during the field survey consisted of low cover abundance upstream of the inundation area, moderate cover abundance within the inundation area and low cover abundance downstream of the inundation area.

Although no noxious aquatic weeds were present at any site during the surveys, there are twelve species known from the Richmond Local Government Area that are listed as priority weeds for aquatic landscapes (**Table 5-1**).

Table 5-1: Priority weeds for Aquatic Landscapes in the Richmond Local Government Area

COMMON NAME	SCIENTIFIC NAME
Alligator weed	*Alternanthera philoxeroides*
Cabomba	*Cabomba caroliniana*
Dense waterweed	*Egeria densa*
Gush weed	*Hygrophila costata*
Olive hymenachne	*Hymenachne amplexicaulis*
Parrot's feather	*Myriophyllum aquaticum*
Salvinia	*Salvinia molesta*
Taro	*Colocasia esculenta*
Water hyacinth	*Eichhornia crassipes*
Water lettuce	*Pistia stratiotes*
Water primrose	*Ludwigia peruviana*
Willow primrose	*Ludwigia longifolia*

Habitat features observed during the field survey included riffle-run-pool sequences and instream woody debris upstream of the inundation area, within the inundation area and downstream of the inundation area.

5.2.1 Upstream of Proposed Inundation Area

The riparian/aquatic vegetation and associated habitat (instream woody debris, riffles, pools, etc) will largely be unaffected by the proposed dam during the construction, filling and standard operating stages upstream of the proposed inundation area.

Altered operating rules as a result of the proposed dam are expected to cause a reduction in the number of days when flows above base levels occur in the reach downstream of Rocky Creek Dam. The *Environmental Flows Assessment* (ELA 2012) has indicated that there are unlikely to be any impacts upon riparian/aquatic vegetation and associated habitat upstream of the proposed inundation area as a result of the altered operating rules.

5.2.2 Proposed Inundation Area

Loss of riparian/aquatic vegetation and associated habitat is likely to occur during the construction stage of the project in the vicinity of the dam wall. Given the proposed dam is still in a conceptual phase, these impacts are not yet known, however, it can be assumed that a total loss of riparian/aquatic vegetation and associated habitat will occur in the footprint of the proposed dam wall. Upon completion of the dam wall, inundation will commence upstream for a length of approximately 6 km. The reaches of Rocky Creek that will incur a total loss of riparian/aquatic vegetation and associated habitat due to the proposed dam contain approximately 12 ha of riparian vegetation, which consists of approximately 0.09 ha of pasture, approximately 8.15 ha of Camphor Laurel Disturbed Woodland/Forest, approximately 1.38 ha of Sub-tropical Rainforest and approximately 0.22 ha of Warm Temperate Rainforest. The reaches also contain aquatic vegetation, with seven species of macrophytes recorded, including *Eleocharis* sp., *Carex* sp., *Isolepis inundata, Lomandra* sp. *Persicaria hydropiper, Persicaria strigosa* and *Schoenoplectus* sp.

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) identified one EEC within the proposed inundation area, Lowland Rainforest EEC, which incorporates the Sub-tropical Rainforest and Warm Temperate Rainforest communities. This EEC is listed under the NSW TSC Act. A Part 3A assessment of this EEC was undertaken by SMEC (2011) where a significant impact was predicted for the Lowland Rainforest EEC. As threats to this EEC have already been considered, they have not been reconsidered within this aquatic ecology impact assessment. The Part 3A assessment of significance for the Lowland Rainforest EEC is located within Appendix 4 SMEC (2011).

The loss of riparian vegetation and instream woody debris are listed as key threatening process under the NSW FM Act. The riparian vegetation along Rocky Creek would act as a buffer, protecting the creekline from the effects of adjacent land use practices and provides shade, cover and organic material. Instream woody debris provides habitat for macroinvertebrates and fish, including refuge from predation, habitat for prey and as damming structures to create pools. The loss of riparian/aquatic vegetation and associated habitat from within the inundation area may result in significant impacts upon threatened fauna species, including fish and amphibians. These impacts are outlined further below and an assessment of significance for species that occur or are likely to occur has been conducted.

Over time, it is expected that riparian/aquatic vegetation may colonise the shallower lake fringes, particularly given that the proposed dam will most likely operate at close to FSL for much of the time. As the dam fills with water, there will be an increase in large woody debris from standing timber, which will provide habitat for fish, macroinvertebrates, and turtles. Standing timber that extends above the water surface can also be important habitat for hollow-dependent bat species.

Once the dam is constructed, there is a chance that the water may become infested with aquatic weeds if a suitable vector is available to establish populations. Such vectors may include birds or other mobile animals that move to the dam from weed-infested waterways. Weeds may also spread to the dam if

they are introduced to upstream sections of the catchment and are able to wash downstream. The inadvertent or deliberate release of aquatic weeds may also occur as a result of human activity in the catchment. Improper washing of boats or vehicles may lead to the spread of weeds to the dam.

The transformation of a lotic environment to a lentic one will increase the suitability of aquatic habitat for some weed species. Increased surface area will favour floating aquatic weeds such as Salvinia and Water Hyacinth, more sunlight will reach and penetrate the water surface, providing enhanced opportunities for photosynthesis, and the relatively constant water levels and more stable temperature will favour weed growth.

If noxious weeds enter the dam, it is critical for the ecological functioning of downstream environments that they be detected early and controlled. Mechanical harvesting or physical removal may be possible for small numbers, which may be supplemented by herbicide use if feasible. However, preventative measures are preferred and should be adopted in the initial stages of dam operation. Such measures should include:

- Diversion of nutrient runoff from the dam;
- Wash-down of vehicles and boats that may have come from weed-infested waterways;
- Controlled access to the water;
- Leaving trees along the shoreline to shade the margins of the water and limit light penetration;
- Regular monitoring of the dam for weeds.

5.2.3 Downstream of Proposed Inundation Area

Impacts on riparian/aquatic vegetation and associated habitat downstream of the proposed inundation area may occur during the construction stage of the project through diversion of water for the construction, or the mobilisation of sediments via major earthworks and run-off from unprotected spoil or cleared land. This would increase the sediment load transported downstream and may result in habitat loss through smothering. This impact would decrease with distance downstream from the inundation area as the sediment is deposited. Runoff may also increase the nutrient content of the water, leading to algal growth. Recommendations to regulate the diversion of flows and standard sediment control procedures during the construction phase have been provided in Section 6 of the report.

In the early stages of dam operation, changes to flow patterns and volume may cause a re-distribution of in-stream sediment with particles up to the size of large pebbles. This may alter the sites available for plants that require substrate for root attachment. The suspension of fine sediments can reduce light penetration of the water, and when they settle can cover leaves and reduce photosynthesis.

The *Environmental Flows Assessment* (ELA 2012) concluded that riparian/aquatic vegetation will be maintained by the proposed environmental flow regime. Limited impact on the extent and composition of vegetation is expected due to the recommended transparency of flows up to 100 MLd^{-1} (base to moderate flows). Little change to the existing velocity, temperature, depth, wetted channel width or flow variability from the current regime is likely. The proposed flow regime should also assist in preventing invasive weed species establishing within this reach of Rocky Creek.

No aquatic weeds are known from Rocky Creek downstream of the proposed dam, but the potential exists for them to spread from the dam if they were to be introduced. This will particularly be the case for floating weeds or those that are able to spread vegetatively. From this perspective, it is best to control weed populations as soon as they are detected in the dam.

5.3 POTENTIAL IMPACTS ON WATER QUALITY

Water quality within the study area was within the range that indicated good condition throughout the survey period. The current water quality is maintained by low and even base flow levels. Nutrients, turbidity and physical-chemical characteristics were all either well within the recommended ANZECC guidelines or where these guide lines were exceeded they were in a range that is not critical to biota, ecological processes or physical function of the creek system.

The deep pool at Site 6 remained weakly thermally stratified during the survey period and surface to bottom temperature differences of greater than 1°C occurred on several, albeit brief occasions indicating that stratification is a normal of the function of that pool.

5.3.1 Upstream of Proposed Inundation Area

The water quality in this reach will largely be unaffected by the proposed dam during the dam construction and filling stages. However, during the post-filling stage the Environmental Flows Assessment (ELA 2012) has indicated that as a result of the proposed dam and the altered operating rules, there may be the following changes to water quality:

- Increased stratification of pools and associated water quality issues
- Increased occurrence of algal blooms
- Less frequent flushing of fines and greater accumulation of silt and detritus cover on substrate and pool-edge habitats.

ELA (2012) has indicated that the unchanged seepage from Rocky Creek Dam is expected to maintain existing base flow levels. The number of days and the volume that Rocky Creek Dam spills will be reduced when the proposed dam comes online. A reduction in the number of flushing flows may increase the likelihood of stratification in the deeper pools and increase the potential for algal blooms and poor water quality to occur (e.g., de-oxygenation and nutrient release).

This reach is a highly altered system given that the upstream Rocky Creek Dam has no provision for controlled flow release. However, existing water quality is general in good condition and within recommended ANZECC guidelines. High water quality is expected to be maintained by the altered flow conditions.

5.3.2 Proposed Inundation Area

Previous assessments undertaken within the proposed dam inundation area indicate that the area has good long-term water quality. While it could be surmised that water quality in the proposed storage will also be of good quality, ongoing monitoring and assessment of water quality in Rocky Creek Dam and hydrodynamic modelling could be used to predict possible water quality concerns such as:

- Eutrophication of the reservoir
- Stratification (temperature and dissolved oxygen) and associated water quality issues such as anoxic conditions
- Algal blooms
- Sediment and nutrient trapping.

The *Environmental Flows Assessment* (ELA 2012) has concluded that the inundation of this reach of Rocky Creek would create a highly altered system with different physico-chemical characteristics to the existing system.

It is noted that the inflows to the proposed dam will be regulated by the upstream Rocky Creek Dam, and therefore it is possible that the dam may stratify in the deep storage zone. The subsequent release

of cold water into the downstream environment can have a detrimental impact on water quality and biota.

Bank erosion from wind action may also contribute to suspended sediment and sediment accumulation within the dam area.

These impacts will need to be considered further during concept development and any formal impact assessment of the proposed Dunoon Dam.

5.3.3 Downstream of Proposed Inundation Area

Water quality in Rocky Creek downstream of the existing dam was consistently of high quality, with general trends (such as conductivity, total phosphorus and turbidity increasing down the system) possibly reflecting an accumulation of catchment wide issues.

The water quality downstream of the proposed inundation area may be impacted during the construction phase of the project through the mobilisation of sediments via major earthworks and run-off over unprotected spoil or cleared land. These mobilised sediments would be transported downstream and may result in an increase sediment load that may cause:

- Loss of instream habitat
- Reduced water quality, including:
    - Increased turbidity may reduce light penetration
    - Increased nutrients
    - Potential for increased contaminants.

Possible changes to the flow regime and water quality downstream of the proposed dam during the filling and standard operation stages may include:

- Cold water pollution and subsequent change to the downstream temperature regime
- Stratification of deep pools and associated water quality issues such as anoxic conditions
- Increased algal blooms
- Less frequent flushing of fines and great accumulation of silt and detritus cover on substrate and pool-edge habitats.

Long term water quality in the system is maintained by low and even base flow levels. Based upon the *Environmental Flows Assessment* (ELA 2012), the proposed flow regime has been designed to protect these base- and low-flows (see **Section 9.2**), thereby maintaining and potentially improving the existing conditions. Provision has been made to maintain a minimum flow of 0.7 MLd^{-1} from Dunoon Dam even when inflows to the proposed dam are negligible.

Studies have indicated that flow is the controlling factor for the development of cyanobacterial blooms in Australian rivers with low flows contributing to the stabilization of the water environment, increased light availability, longer retention times and provision for the release of nutrients from sediments. Flow management strategies such as pulsed and flushing flows and artificial de-stratification have been used to control cyanobacterial blooms in regulated rivers. ELA (2012) had made provision for contingency flows of up to 100 MLd^{-1} and while these are primarily to facilitate fish passage, these flow events will also help provide moderate flows during any extended periods of low flows (when there would otherwise be reduced flow).

Water discharged without consideration of temperature or dissolved oxygen concentration may have a negative impact on downstream water quality and ecological function. Controlled release of water from the proposed dam (specifically to address temperature, dissolved oxygen and blue green algae) is

recommended to reduce any detrimental impacts from controlled discharges from the dam, particularly during the summer months when stratification of the storage is most likely to occur.

The main cause of poor water quality in regulated rivers is not necessarily the flow regulation itself, rather from altered land-use practices and channel management. Water quality parameters such as suspended solids and turbidity may improve due to sediment capture by the proposed dam.

5.4 POTENTIAL IMPACTS ON AQUATIC MACROINVERTEBRATES

The aquatic macroinvertebrate sampling and analysis during the field survey gave SIGNAL2 scores between 4.84 and 5.22, indicating a moderate to mildly polluted system. The macroinvertebrate communities are already impacted by Rocky Creek Dam and sedimentation of fine material from agricultural/horticultural land use in the surrounding catchment. Maintenance of base to moderate flows with disruption from high to flood flows are the primary flow conditions required by the macroinvertebrate communities to maintain habitat and food resource requirements.

5.4.1 Upstream of Proposed Inundation Area

Aquatic macroinvertebrates will largely be unaffected by the proposed dam during the construction and filling stages upstream of the proposed inundation area. However, during the standard operating stage of the proposed dam upstream of the proposed inundation area, the *Environmental Flows Assessment* (ELA 2012) has indicated that as a result of the proposed dam and the altered operating rules, a reduction of spills from Rocky Creek Dam could result in reduced habitat availability and quality for aquatic macroinvertebrates.

There is potential that fine sediments may accumulate between larger particles and reduce habitat and food resource availability through smothering, particularly during periods of prolonged low flows. These interstitial spaces provide protection from extreme flow velocity and habitat for invertebrates and consequently there may be a reduced habitat area.

It is predicted that the regular spill events from Rocky Creek Dam will provide flows with sufficient energy and frequency to flush fine sediments from the reach. Base flows from seepage will maintain continued aquatic habitat (not necessarily all flow habitats) year-round.

5.4.2 Proposed Inundation Area

Aquatic macroinvertebrates that require lotic habitats (rheophylic taxa) will be lost, although it is likely that over time a new assemblage that is adapted to reservoirs (pelagic and planktonic taxa) may establish. The colonisation of macrophytes is dependent on the availability and stability of suitable shallow water and substrate habitat.

5.4.3 Downstream of Proposed Inundation Area

Aquatic macroinvertebrate assemblages downstream of the proposed inundation area are already stabilised in response to the continued impact of the changed flow regime since the construction and operation of Rocky Creek Dam. Flow changes resulting from the proposed dam are unlikely to result in further significant degradation of this modified system. Based upon the *Environmental Flows Assessment* (ELA 2012), the proposed flow regime for the proposed dam has been designed to secure low-medium flows that would protect important habitat variables such as depth, velocity and cover. Consequently, minimal reduction in habitat complexity and macroinvertebrate assemblages is expected.

Under the existing flow regime, the system improves progressively downstream from Rocky Creek Dam. Given that the altered flow regime will largely maintain (or improve with the protection of baseflows and contingency flows), this trend is expected to continue. Other existing patterns, such as

riffle habitats recording consistently higher SIGNAL2 scores than the composited pool-edge habitat thought to be due to improved habitat and food availability, are also expected to persist.

High to flood flows will be largely unaltered. Maintenance of high flows will continue to prevent the detrimental consequences of sedimentation on invertebrate communities. Results also suggested that the macroinvertebrate assemblages generally responded positively to increased flow variability (i.e. after flushing flows) despite initial decreases in abundance.

Research has suggested that although instream disturbances and flow reductions may decrease aquatic invertebrate density and diversity downstream, benthic invertebrates can be highly resilient to these effects. This resilience can be seen by the condition of the sites assessed along Rocky Creek downstream of the existing dam.

We predict no loss or change in the macroinvertebrate assemblages in this reach due to the construction and operation of Dunoon Dam.

5.5 POTENTIAL IMPACTS ON AQUATIC VERTEBRATE FAUNA

Fish

Fish surveys conducted within the proposed impact area (one downstream (Site 6) and one upstream (Site 9) of the proposed dam wall) identified a total of 13 species, none of which are listed under the NSW FM Act or the Commonwealth EPBC Act. The fish species recorded during the field survey were all native species.

The desktop assessment undertaken for this aquatic ecology assessment identified three listed fish species that have been either previously recorded or are likely to inhabit the proposed dam study area. These species include the Eastern Freshwater Cod which is listed as endangered under the FM Act and EPBC Act, the Oxyleyan Pygmy Perch which is listed as vulnerable under both the FM Act and EPBC Act and the Purple-spotted Gudgeon which is listed as vulnerable under the FM Act.

Amphibians

Field survey recorded two frog species at Site 1; neither are listed as a threatened species under the NSW TSC Act or Commonwealth EPBC Act.

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) identified one threatened amphibian species, Loveridges Mountain Frog, listed as an endangered species under the NSW TSC Act. An additional amphibian species has the potential to occur within the proposed study area, Green-thighed Frog, which is listed as a vulnerable species under the NSW TSC Act.

Wetland & Migratory Birds

Field survey identified 28 wetland or migratory birds as either definitely or possibly observed. Of these species Black Bittern, possibly observed, is listed as vulnerable under the NSW TSC Act.

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) identified the migratory Cattle Egret listed under the Commonwealth EPBC Act. This report also listed two other bird species that potentially inhabit wetland and riparian vegetation, including the Black Bittern and Osprey, both listed as vulnerable under the NSW TSC Act.

Platypus

Platypus sightings and burrows were recorded during the field survey at sites within and downstream of the proposed inundation area.

5.5.1 Upstream of Proposed Inundation Area

Fish

The proposed dam wall will form a barrier to fish migrating upstream or downstream of the dam site. The habitat isolated from future migration will include the newly created lake environment and the reach between Rocky Creek Dam and Whian Whian Falls. Currently, both Whian Whian Falls and Rocky Creek Dam create significant barriers to fish migration upstream.

During the standard operation stage of the proposed dam, the *Environmental Flows Assessment* (ELA 2012) has indicated a reduction in spills from Rocky Creek Dam. However, as base flows will be maintained and high energy flushing and flood flows will still occur frequently it is unlikely that altered flow conditions will reduce the long-term quality of habitat for fish in the reach substantially from its already impacted state.

During this assessment, fish species in the reach immediately below Rocky Creek Dam were not targeted as part of the fish survey. However Eastern Freshwater Cod, listed as a vulnerable species under the NSW FM Act and Commonwealth EPBC act, have been recorded in two separate pools in the 1990s (Bishop 1998). It is unclear if these records relate to natural communities (distinct from stocked populations) as Whian Whian Falls at the downstream end of this reach provides a significant natural barrier to fish migration. As such, potential impacts were considered upon the Eastern Freshwater Cod, Oxleyan Pygmy Perch and Purple-spotted Gudgeon through the application of an assessment of significance under State and Federal guidelines. The assessment of significance concluded that the potential impact upon the Eastern Freshwater Cod, Oxleyan Pygmy Perch and Purple-spotted Gudgeon due to the proposed dam and altered operational rules would not have significant impact upon these species in the area upstream of the proposed inundation area (**Appendix G**).

Amphibians

Amphibian species recorded during the field survey would largely be unaffected by the proposed dam during the construction and filling stages upstream of the proposed inundation area. During the standard operations stage of the proposed dam upstream of the proposed inundation area, the *Environmental Flows Assessment* (ELA 2012) has indicated that it is unlikely that the altered operation of Rocky Creek Dam will significantly impact habitat quality or availability for amphibian species, with inundated populations of macrophytes predicted to be maintained.

Wetlands & Migratory Birds

Wetland and migratory birds will largely be unaffected by the proposed dam during the construction filling and standard operating stages upstream of the proposed inundation area. Available habitat for wetland and migratory will not be affected by the altered operation of the Rocky Creek Dam.

Platypus

Platypus burrows recorded during the field survey will largely be unaffected by the proposed dam during the construction and filling stages upstream of the proposed inundation area. Platypus have been observed in the upper reaches upstream of the proposed inundation area, with the current degraded

condition of the Rocky Creek system still providing good platypus habitat (including foraging, burrowing and nesting habitat) (Grant 1998; Matthews 1996).

Changes to the Rocky Creek Dam operating rules are unlikely to reduce habitat quality or availability upstream of the proposed inundation area, as base flows will be maintained and flushing flows will be sufficient to maintain habitat quality and food resources.

The ability of platypus to survive in considerably disturbed habitat (Grant 1998) suggests that the altered flow regime and possible changes to water quality will have little impact on existing platypus distribution within this zone. However, it is also noted that Grant (1998) concluded that no change to the existing naturalised Rocky Creek flows would result in a reduction of platypus numbers.

5.5.2 Proposed Inundation Area

Fish

The impacts upon fish species within the proposed inundation area would involve the replacement of currently flowing habitat with artificial lentic conditions. These new conditions may favour some species of fish which will continue to persist in the new condition. Some species of fish may be reduced in density due to the disturbed environment, unavailability of preferred habitat or lost capacity to migrate upstream.

It is noted that exotic fish species such as goldfish and carp can thrive in disturbed environments, particularly reservoirs with stable water conditions, thereby creating and indirect impact on existing native taxa through competition and predation. Introduction of non-endemic fish species should be actively discouraged.

An assessment of significance of potential impacts of the proposed dam required for the three species that have either been previously recorded or are likely to occur within the proposed dam study area. Additional assessment of significance under the EPBC Act is required for the Eastern Freshwater Cod and Oxleyan Pygmy Perch. The assessment of significance has considered the potential alteration of environmental flow regimes as a result of the proposed dam, altered habitat within the inundation area and downstream and alterations to natural fish passage.

The Part 3A assessment and EPBC Act assessment of significance concluded that the potential impact on the Eastern Freshwater Cod, Oxleyan Pygmy Perch and Purple-spotted Gudgeon due to the proposed dam and altered operational rules will not have significant impact upon these species with the area within the proposed inundation area (**Appendix G**).

Amphibians

Any existing frog populations and/or habitat would be inundated by the storage. However, the lake environment may provide additional habitat areas as the fringing and aquatic vegetation establishes.

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) identified one threatened amphibian species, Loveridges Mountain Frog, which is listed as an endangered species under the NSW TSC Act. An additional amphibian species has the potential to occur within the proposed study area, Green-thighed Frog, which is listed as a vulnerable species under the NSW TSC Act. An assessment on these species was conducted in the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) where it was predicted that a significant impact would be likely for the Loveridges Mountain Frog and potentially significant for the Green-thighed Frog. Given that a significant impact has been predicted, this species has not been considered within this aquatic ecology impact assessment. The Part 3A assessment of

significance for the Loveridges Mountain Frog and Green-thighed Frog is located in Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

Wetland & Migratory Birds

Wetland and migratory birds should be largely unaffected by the proposed dam during the construction, filling and standard operating stages within the proposed inundation area as they are highly mobile. Available habitat for wetland and migratory birds will not be affected by the altered operation of the Rocky Creek Dam.

An assessment of significance of potential impacts of the proposed dam under the Part 3A guidelines is required for the Black Bittern and Osprey. A Part 3A assessment for these species was conducted in the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) where it was predicted that a significant impact would be likely. Given that a significant impact has been predicted, this species has not been considered within this aquatic ecology impact assessment.

One additional wetland and riparian bird species that may occur potentially occur within the proposed dam study area is the Black-necked Stork. This species is listed as a vulnerable species under the NSW TSC Act. An assessment of significance of potential impacts of the proposed dam under the Part 3A guidelines is required for this species that has the potential to occur within the proposed dam study area. The assessment of significance has considered the potential removal of habitat as a result of the proposed dam within the inundation area. The Part 3A assessment concluded that the proposed dam will not have a significant impact upon this species within the proposed inundation area (**Appendix G**).

An assessment of significance under the EPBC Act was conducted in the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) for the Cattle Egret, where it was predicted that no significant impact is likely.

Platypus

Platypus and their habitat (including burrow clusters) were found within the proposed inundation area (upstream of the Frasers Road crossing). All existing platypus habitat within the proposed inundation area will be inundated. However, platypus are known to use artificial lake environments and the proposed dam may provide increased opportunity for habitat and food resources. Negative impacts on platypus may include fragmentation of populations within the system, loss of lotic feeding habitat and increased likelihood of disease (Rohweder and Baverstock 1999, Grant and Temple 2003)

5.5.3 Downstream of Proposed Inundation Area

Fish

Within the *Environmental Flows Assessment* (ELA 2012), careful consideration was given to the hydrological requirements for fish passage downstream of the proposed dam. Significant changes to low to moderate flows could lead to fragmented fish populations and habitats, change to fish passage and disturbance of spawning cues.

Maintaining longitudinal connectivity for fish and other fauna migration/breeding cues was the primary reason for designing an environmental flow regime with transparent flow releases to 100 MLd^{-1}. Field assessment of key barriers along Rocky Creek show that natural flows to 100 MLd^{-1} will facilitate fish passage (adult and juvenile Australian Bass and Eastern Freshwater Cod) between all habitat features upstream to the deep pool at Site 6 (just downstream of the proposed dam). While there are two more key barriers located upstream, between Site 6 and the dam wall, these barriers are located within an

area likely to be highly disturbed and/or altered as a result of dam construction and related infrastructure works.

Further, to enhance habitat availability, flow contingency rules were designed to provide flows that connect habitat and facilitate migration cues in key seasons if no suitable flow events occur during these times. These flow contingencies will provide connecting flows during dry periods where no connecting flows would occur under the current flow regime. For these contingency flows the maximum rate of rise (10^{th} percentile value of all recorded rates of rise) has been specified within the proposed environmental flow regime. Unnatural rapid fluctuations in flow can strand biota and consequently conservative rates of fall were stipulated to protect against stranding of fauna.

The maintenance of flow variability will continue to maintain existing flow-dependant habitat variables in the system, including fine and coarse substrates, food supply and habitat availability.

Amphibians

While no threatened frog species were recorded during field survey conducted for this assessment, seven threatened frog species are expected to occur within the larger Terania Creek catchment.

Many frog species have highly specialised flow requirements in terms of the timing of inundation and frequency of inundation. Flow requirements for frogs include flushing flows for cleaning sediment from substrate, shallow water for tadpole habitat, habitat complexity and./or isolation to protect from fish predation and underwater vegetation for spawning during spring and summer. The maintenance of low to moderate flows and flow variability of high-end flows should avoid any detrimental impacts on amphibians as a result of the environmental flow regime.

Wetland & Migratory Birds

Wetland and migratory birds will largely be unaffected by the proposed dam during the construction filling and standard operating stages downstream of the proposed inundation area. Available habitat for wetland and migratory birds will not be affected by the altered operation of the Rocky Creek Dam.

Platypus

Platypus burrows were observed in this reach, although no platypus were seen. This suggests that the condition of the current system provides suitable platypus habitat (including foraging, burrowing and nesting habitat) (Grant 1998).

Changes to the existing flow regime are unlikely to reduce the quality and/or availability of habitat, particularly feeding habitat. The relatively high transparency levels of flows from the proposed dam will help to ensure that little change to platypus habitat quality or availability is expected. As noted previously, the ability of platypus to survive in considerably disturbed habitat (Grant 1998) suggests that the small alterations within the area downstream of the proposed inundation area as a result of the proposed environmental flow regime for the proposed dam will have little impact on platypus occurrences.

5.6 IMPACTS ON THREATENED FLORA SPECIES

The desktop assessment undertaken for the proposed dam in relation to this aquatic ecology assessment identified three threatened flora species that have been previously recorded within the aquatic and riparian habitat of the study area, and eight threatened flora species that have the potential to occur within the aquatic and riparian habitat of the study area.

Of these species, one was recorded during the field survey within the proposed dam inundation area and downstream of the proposed inundation area, *Desmodium acanthocladum* (Thorny pea), which is listed as a vulnerable species under the TSC Act and EPBC Act.

5.6.1 Upstream of Proposed Inundation Area

No threatened flora species were observed during the field survey upstream of the proposed inundation area and given that no impacts are likely to occur during the construction and filling stages and that only impacts relating to the altered operating rules of Rocky Creek Dam during the standard operations stage, it is considered that no significant impacts are likely to occur to any likely or potential threatened flora species that may occur within the riparian habitat upstream of the proposed inundation area.

5.6.2 Proposed Inundation Area

One threatened flora species was recorded within the proposed inundation area during the field survey, *Desmodium acanthocladum* (Thorny pea), which is listed as a vulnerable species under the TSC Act and EPBC Act.

An assessment of significance of potential impacts of the proposed dam under the Part 3A guidelines is required for *Desmodium acanthocladum.* An assessment of significance for this species was conducted in the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) where it was predicted that a significant impact would be likely. Given that a significant impact has been predicted, this species has not been considered within this aquatic ecology impact assessment. The assessment of significance for *Desmodium acanthocladum* is located within Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

In addition, 19 threatened flora species that were not recorded during the field surveys for the aquatic ecology assessment are considered to have the potential to occur within the impact area. Seven of these species were recorded during the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) and assessments of significance were undertaken. The assessment of significance for these species predicted that a significant impact would be likely from the proposed dam. These flora species include:

- *Arthraxon hispidus* (Hairy-joint Grass)
- *Corokia whiteana* (Corokia)
- *Hicksbeachia pinnatifolia* (Red Boppel Nut)
- *Macadamia tetraphylla* (Rough-shelled Bush Nut)
- *Marsdenia longiloba* (Slender Marsdenia)
- *Ochrosia moorei* (Southern Ochrosia)
- *Tinospora tinosporoides* (Arrow-head Vine).

The assessment of significance for these recorded species is located in Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

An EPBC Assessment of Significance has been prepared within the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) for species that are listed under the EPBC Act and recorded within the proposed impact area. The EPBC Assessment of Significance concluded that the proposed dam is likely to have a significant impact on endangered and vulnerable flora species recorded within the study area, due to the direct removal of individuals and their habitat, as well as the potential for removal of entire populations within the locality as a result of clearing and construction works. A referral to SEWPaC for the proposed dam would be required. The EPBC assessment of significance for these species is located within Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

In addition to those flora species recorded, an additional four species are either likely to occur or have the potential to occur in the impact area, in particular within the riparian habitat of the proposed dam. An assessment of significance for these species was conducted in the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) where it was predicted that a significant impact would be unlikely.

- *Diospyros mabacea* (Red-fruited Ebony, Silky Persimmon, Ebony)
- *Elaeocarpus* sp. *Rocky Creek* (Minyon Quandong)
- *Gossia fragrantissima* (Sweet Myrtle)
- *Syzygium hodgkinsoniae* (Smooth-bark Rose Apple, Red Lilly Pilly).

The assessment of significance for these potential species is located in Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

An EPBC Assessment of Significance has been prepared within the Dunoon Terrestrial Ecology Impact Assessment (SMEC 2011) for species that are listed under the EPBC Act and may potentially occur within the proposed impact area. The EPBC Assessment of Significance concluded that the proposed dam is unlikely to have a significant impact on potential endangered and vulnerable flora species that may occur within the study area. The EPBC Assessment of Significance for these species is located within Appendix 4 of the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011).

5.6.3 Downstream of Proposed Inundation Area

Thorny Pea was observed downstream of the proposed inundation area during the field survey. Given that the downstream area will experience limited impacts, it is not considered that this threatened flora species will be impacted downstream of the proposed inundation area.

6 Management & Monitoring

The objectives of this management and monitoring chapter are to:

- Provide a summary of identified potential issues for each impact area, including upstream of the inundation area, the inundation area and downstream of the inundation area, in regard to the potential impacts upon aquatic ecology and the altered environmental flow regime in on creek hydrology, ecology, process and function
- Identify any management and mitigation measures as they relate to aquatic ecology, flow regime and aquatic system functioning
- Recommend any monitoring requirements prior to and/or post commissioning of the proposed dam.

6.1 POTENTIAL IMPACTS

The potential issues arising from the construction, filling and standard operation of the proposed dam, as identified during the course of this assessment are summarised in **Table 6-1**

Table 6-1 Summary of potential issues within each impact zone

IMPACT AREA	POTENTIAL IMPACTS
Upstream of inundation area	Reduction in number of times Rocky Creek Dam spills each year Reduction in magnitude of low-moderate flows Reduction in frequency and magnitude of high-end flows Increased accumulation of silt and detritus cover Increased colonisation by Typha Possible increased stratification of deep pools
Inundation area	Potential stratification of the storage Blue green algae outbreaks Trapping of sediments and nutrients Permanent barrier for vertebrates Fragmentation of Rocky Creek Loss of riparian and aquatic vegetation and existing macroinvertebrate assemblages Inundation of habitat for vertebrate and amphibians
Downstream of inundation area	Possible sedimentation during construction Reduction of flows Increase in mean daily flow rate Removal of some high end flows, particularly during drought years Potential change to downstream temperature regime Potential release of anoxic water or water high in nutrients Downstream disturbance of channel/bank sediments as result of release of flows

IMPACT AREA	POTENTIAL IMPACTS
	Possible increase in frequency of deep pool stratification

6.2 RECOMMENDED MANAGEMENT & MITIGATION MEASURES

The mitigation measures and monitoring requirements recommended in this chapter address the impacts on aquatic ecology resulting from the altered flow patterns in Rocky Creek as a result of the construction and operation of the proposed dam. Mitigation measures are provided for each of the impact zones. It is noted that these measures are based on the conceptual dam design only.

These mitigation measures should be adopted where relevant into the applicable management plans which will be required, including:

- Construction Environmental Management Plan (CEMP)
- Operational Environmental Management Plan (OEMP)
- Foreshore Management Plan.

These plans should be prepared prior to any on-ground works commencing and most likely will be stipulated in the conditions of approval for the project.

6.2.1 Upstream of Proposed Inundation Area

The Environmental Flows Assessment (ELA 2012) has determined that the altered system operating rules will alter the hydrology of the system downstream of the existing Rocky Creek Dam.

As there are no current provisions for controlled release of water from Rocky Creek Dam, there are few if any flow related management measures that can be implemented in this reach. The channel form and ecological function of impacted reaches has stabilised following the adjustment to the impact of the current operation of Rocky Creek Dam and has an armoured bed, as such this reach is resistant to impacts from change in flow regime including the reduction in spilling flows from Rocky Creek Dam.

Practical management in this reach should focus on improving general catchment and riparian condition to minimise sedimentation processes through stock exclusion and the planting of riparian endemic native species (**Table 6-2**). Minor flow-based management may be achieved through refinement of operating rules to achieve balance between sustainable yield of both dams and minimise hydrological impacts on this reach may be possible.

Table 6-2: Recommended mitigation and management measures – Upstream of Proposed Inundation Area

POTENTIAL IMPACTS	POSSIBLE MITIGATION & MANAGEMENT MEASURES
Sediment loading from catchment	Implement measures to reduce riparian erosion (e.g. stock exclusion, riparian plantings etc) Address more general catchment issues (land management, soil conservation etc) to reduce general sediment loads to the system

6.2.2 Proposed Inundation Area

Potential mitigation measures within the proposed inundation area are outlined below (**Table 6-3**).

Table 6-3: Recommended mitigation and management measures – Proposed Inundation Area

POTENTIAL IMPACTS	POSSIBLE MITIGATION & MANAGEMENT MEASURES
Stratification	Artificial breakdown of stratification (for example via mechanical aeration)
Algae outbreaks	Minimise nutrient levels into the Rocky Creek and the proposed dam proper through reducing sediment input (see below) Physical control (e.g. artificial mixing)
Sediment and nutrient trapping	Reducing sediment loading and nutrient exports from the Dunoon Dam catchment may improve quality of impounded water Reducing foreshore erosion – given the potential for landslip further analysis is required to determine best practice for shoreline erosion to suit soil and landscape conditions. A foreshore management plan should be developed to determine the best practice methods for erosion control and introduction of remnant vegetation to act as a buffer/filter for natural runoff. Addressing broader-scale catchment issues (land management, soil conservation, fertilizer use etc)
Aquatic ecology	Stocking of fish (such as bass) can be a form of compensation for the impact of dams on fish communities (Ecology Lab 2008). However, it is unlikely that these stocked fish will form self sustaining populations A foreshore management plan should also develop best practice methods for re-introduction of amphibian and platypus habitat within the proposed dam. The should plan should also address the management of platypus during the inundation/filling phase of the dam A foreshore management plan will also help develop a strategy for aquatic and riparian weed control Loss of aquatic and riparian habitat within the proposed inundation area should be offset. Offsetting and/or conservation options within the larger Terania Creek catchment are recommended, as outlined within the *Environmental Flows Assessment* (ELA 2012). For example, the exclusion of stock from the riparian zone and the establishment of an endemic native riparian buffer will improve the aquatic and riparian habitat by providing potential habitat for semi-aquatic and riparian species, reducing the inflow of sediment and nutrients to the creek and improving water quality via shading and provision of endemic organic material. Whole-of-catchment solutions will also assist in mitigating impacts of the proposed dam in the impact zones both upstream and downstream of the dam. The conservation of native vegetation riparian zones, including the buffer zone surrounding the dam as well as the creeks that make up the Terania system (i.e. Rocky Creek, Tuntable Creek and Terania Creek) will help to maintain and improve water quality and habitat for aquatic species.

6.2.3 Downstream of Proposed Inundation Area

The *Environmental Flows Assessment* (ELA 2012) has proposed an environmental flow regime for the proposed dam to protect the key aspects of creek hydrology, ecology, process and function. Maintaining (or improving) the environment through the environmental flow regime will largely negate the requirements for further significant mitigation measures (**Table 6-4)**. The low flow contingency releases will act to improve the environment for key species with connecting releases and other habitat provision when the current flow regime would remain unconnected.

The construction of a fish ladder or lift is not recommended for this site as it would likely only provide artificial lake habitat for migrating species as Whian Whian Falls at the upstream end of the proposed dam lake acts as a natural migration barrier to habitats further upstream. If species were able to migrate beyond Whian Whian Falls they could only access the additional reach to the Rocky Creek Dam wall. In this case the potential habitat quantity and quality above the proposed dam wall does not justify the expense of a fish ladder.

In preference to a fish ladder, options to improve the aquatic and riparian habitat in the larger Terania catchment through fencing from stock and establishment of an endemic native riparian buffer are preferred. This buffer will act to improve the riparian and aquatic habitat through the reduction of inflowing sediment and nutrients, improve water quality through shading and provision of endemic organic material and the creation of habitat for riparian and semi-aquatic species.

Table 6-4: Recommended mitigation and management measures – impact zone 3

POTENTIAL IMPACTS	POSSIBLE MITIGATION & MANAGEMENT MEASURES
Hydrology	Implement the specified environmental flow regime
Water quality	During construction, the mobilisation of sediment into Rocky Creek should be minimised through the development of an erosion and sediment control plan during the construction of the proposed dam. This plan should outline procedures for the control and minimisation of potential impacts from sediment downstream of the proposed inundation area. Erosion and sediment controls should be installed prior to any constriction or earth works, potentially including bunding, silt fences, silt curtains, drains and settlement ponds. Install a multi-level off-take structure to control level of intake (i.e. match as much as possible certain physico-chemical parameters such as temperature) (e.g. Krchnak et al. 2008) Allow for rapid level adjustment of the intake to provide response to event based conditions that may adversely impact downstream conditions, combined with ongoing monitoring program of water profile (i.e. vertical variability) to allow selection of suitable depth for offtake. Artificially mix the water column
Fauna passage	Implement the specified environmental flow regime

6.3 MONITORING RECOMMENDATIONS

A monitoring program to assess the potential impacts on aquatic ecology from the environmental flows as indicated in the Environmental Flows Assessment (ELA 2012) for the proposed dam is recommended (**Table 6-5**). Monitoring should be implemented prior to construction of the dam as well as during operation to better understand the impacts of environmental flows on the aquatic ecology of the Rocky Creek system and on a broader scale. Monitoring of the system post-construction will also provide opportunity for ongoing improvements and refinements to the recommended flow regime.

Any monitoring undertaken prior to construction should be able to inform the development of any management plans. More detailed flow modelling will be required for detailed design and it is anticipated the outcome of that modelling will also contribute to the development of management plans. It is appropriate for more detailed performance objectives should be developed during the detailed design phase of the project.

The field survey sites selected for this project were chosen, in part, to provide sites for future monitoring as they include sites in all impact zones and in a control area. We recommend that the same or, if not possible similar, sites are selected for ongoing monitoring of system condition.

An indicative costing for each of the monitoring recommendations has been provided in **Appendix H.**

Table 6-5: Monitoring recommendations for the proposed Dunoon Dam

ASPECT	RECOMMENDED MONITORING
Pre-construction Stage (until construction commences)	
Water quality	Long-term monitoring of deep pools in the upstream and downstream areas of the proposed inundation area to determine occurrences of thermal stratification and impact of different sized flows on stratification. Water quality (primarily suspended sediment and nitrogen) monitoring upstream and downstream of the existing RCD to create a hydrodynamic model on which the impacts on water quality can be determined. This modelling will provide for more detailed consideration of the impact of proposed dam on physico-chemical properties of flow releases downstream. Detailed assessment and consideration of soil profiles within the proposed full supply level and predicted top water levels to determine potential for mass movement/slumping of the soil profile to identify areas where erosion controls may be required.
Aquatic ecology	Monitoring of macroinvertebrate assemblages within the upstream, downstream and in control areas of the proposed inundation area to gain better longer-term understanding of the seasonal variation in the system and resilience to flow disturbance. Monitoring should ideally include AUSRIVAS style assessments in autumn and spring. Monitoring of fish assemblages (Zones 1 and 3 in particular) to gain more detailed understanding of habitat and migration patterns of current assemblages and populations. Monitoring and mapping of platypus population/s and their habitat for adoption and consideration in the Foreshore Management Plan and CEMP/PEMP.
Construction Stage (until dam is operational)	

Water Quality	Monitoring of water quality to determine if erosion and sedimentation control management plan is restricting the mobilisation of sediments in the habitat downstream of the proposed water storage area.
Operation Phase	
Water quality	Monitoring of water quality during the initial filling period to assist in controlled releases during filling (filling period only). Prevention of thermal stratification in the large pool with concomitant prevention of possible algal blooms and fish kills from de-oxygenation. It is recommended that a water quality logger (temperature and dissolved oxygen) is installed and maintained in the large pool downstream of the dam wall. Although it is likely that occurs at present, it may be prudent to prevent these events even if they have occurred in the past (on-going during dam operation). Within-dam water quality monitoring (temperature, dissolved oxygen and algal) to determine vertical variability to allow selection of suitable depth for intake of controlled releases (on-going during dam operation). Monitoring of shoreline erosion to determine if (additional) mitigation measures are required (filling phase and at regular intervals during operation, as to be specified in the Foreshore Management Plan).
Aquatic ecology	On-going monitoring of macroinvertebrate assemblages within the upstream, downstream and in control areas of the proposed inundation area to gain understanding of the impact of the environmental flows on the system. Additional monitoring sites to those used for this assessment would indicate impacts at different points down the system. Monitoring of fish assemblages (upstream and downstream areas of the proposed inundation area in particular) to determine impact of environmental flows and/or the dam on fish assemblages. Methods should target juveniles of key species and commence during the dam filling phase. Monitoring of platypus burrows upstream and downstream of the proposed inundation area should be undertaken to determine impact of environmental flows and/or the dam. Also, monitoring within the proposed inundation area should be undertaken to determine if habitat for platypus is achieved. Monitoring of exotic plants should be undertaken to determine if ongoing management upstream, downstream and along the proposed dam foreshores is required as a result of the proposed environmental flows and/or the dam. All monitoring should be undertaken as per approved management plans. However, fauna monitoring should be undertaken for a minimum of 3 years and then reviewed in detail to determine ongoing monitoring requirements. Exotic plant monitoring should continue for the life of the dam.

7 Conclusions

This project examined the aquatic species, communities and habitats that may be affected by the construction and operation of the proposed Dunoon Dam. In conjunction with this study, ELA (2012) undertook an assessment of the environmental flow requirements, including a proposed environmental flows regime and associated impact assessment. This study found that the proposed environmental flows regime would be sufficient to maintain or improve the aquatic environment downstream of the proposed dam. In addition SMEC (2011) assessed the terrestrial ecology in the study area and undertook the associated impact assessment. SMEC (2011) identified that the creation of the dam would result in significant impacts on 23 threatened flora and fauna species and one endangered ecological community recorded within the study area, with additional potential significant impacts on 16 species that were identified from database and literature searches. The aquatic ecology assessment examined the aquatic species recorded in addition to those identified by SMEC (2011) and assessed the likelihood of significant impact in light of the environmental flows regime and impact assessment detailed in ELA (2012).

In addition to the earlier studies this study found that Eastern Freshwater Cod, Purple Spotted Gudgeon, Oxleyan Pygmy Perch and Black Necked Stork may occur in the study area. Impact assessment in consideration of Part 3A assessment of significance and the EPBC Act found that the proposed dam is unlikely to have a significant impact on these species. However, given the potential significant impacts on other flora and fauna species within the proposed impact area, it is recommended that a referral including these species (from a precautionary principal) be undertaken in accordance with the EPBC Act to the Minister for SEWPaC.

Should the Dunoon Dam project progress, Rous Water will be required to lodge an application with the Department of Planning and Infrastructure (DoPI). A set of the Director-Generals Requirements (DGRs) for an Environmental Impact Statement (EIS) will be issued and as the proponent, Rous Water will be required to meet these requirements. Assessments undertaken as part of the EIS should be done in accordance with current legislation, publications and guidelines.

At this stage the dam design is conceptual only. Should the project proceed aspects of the aquatic ecology and environmental flows assessment may require further study. Following any further assessment we recommend that the aquatic ecology impact assessment be considered in light of the new design and potential impacts

The recommended mitigation measures provided in this assessment should be incorporated into relevant environmental management plans relating to both construction and operation to manage any potential impacts to aquatic ecology. It is noted that these mitigation measures are based on the conceptual design of the dam; further measures may come to light once the detailed design has been completed. Some pre-construction monitoring of the existing system, such as long-term monitoring of deep pools, water quality and fish assemblages are also recommended to gain a more detailed understanding of the system. Outcomes of this monitoring should also be incorporated as necessary into any management plans.

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Appendix A: Threatened species database searches

Threatened flora species found within a 10km radius of the proposed dam site (TSC Act & EPBC Act), and their likelihood of occurrence.

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
Arthraxon hispidus	Hairy-joint Grass	V	V	In Australia, the species has been recorded from scattered locations throughout Queensland and on the northern tablelands and north coast of NSW. In NSW and Queensland, Hairy-joint Grass is found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps as well as woodland. In south-east Queensland, Hairy-joint Grass has also been recorded growing around freshwater springs on coastal foreshore dunes, in shaded small gullies, on creek banks, and on sandy alluvium in creek beds in open forests and also with bog mosses in mound springs.	Potential
Baloghia marmorata	Marbled Baloghia, Jointed Baloghia	-	V	Marbled Baloghia has a geographically disjunct distribution; confined to the Lismore district, in north-east NSW, and the Tamborine Mountains and Springbrook, in south-east Queensland. It is found in subtropical rainforest/notophyll vine forest and wet sclerophyll forest (brush box woodland) with rainforest understorey between 150 and 550 m above sea level. Soils are rich black or dark brown clay and loam derived from basalt.	Unlikely
Bosistoa transversa	Three-leaved Bosistoa	-	V	Three-leaved Bosistoa is known from the Richmond River, NSW, to Mt Larcom near Gladstone, Queensland. Three-leaved Bosistoa grows in wet sclerophyll forest, dry sclerophyll forest and rainforest up to 300 m in altitude.	Unlikely
Bulbophyllum globuliforme	Miniature Moss-orchid	-	V	Miniature Moss-orchid occurs in the McPherson Range of north-east NSW and south-east Queensland. This species occurs within the Northern Rivers (NSW), Burnett Mary,	Unlikely

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
				Fitzroy, Burdekin and South East Queensland Natural Resource Management Regions. The species grows only on Hoop Pines (*Araucaria cunninghamii*), colonising the upper branches of mature trees in upland rainforest.	
Corchorus cunninghamii	Native Jute	E		Corchorus cunninghamii occurs in the upper Richmond River valley at Bungabbee and Toonumbar. It grows in ecotones between wet eucalypt forest and dry to dry-subtropical rainforest on sheltered slopes and gullies, and in grassy, open forest on exposed slopes and ridges (DEC 2005).	Unlikely
Clematis fawcettii	Stream Clematis	V	V	Stream Clematis occurs from the Richmond River in north-east NSW to the Bunya Mountains in south-east Queensland. It prefers canopy gaps on loam soils derived from basalt and mixed volcanic rocks usually near streams. Associated vegetation communities include dry rainforest, complex notophyll vine forest (warm and cool subtropical rainforest), on the margins of semi-evergreen vine thickets and, at one site, in eucalypt open forest with scattered vine forest species.	Unlikely
Corokia whiteana	Corokia	V	V	*Corokia whiteana* has a restricted distribution in north-east NSW *Corokia whiteana* occurs at altitudes of 10–800 m above sea level in ecotones between wet sclerophyll forest and Coachwood (*Ceratopetalum apetalum*) warm-temperate rainforests, or in Brush Box (*Lophostemon confertus*) open forest with littoral rainforest understorey. The species usually occurs on substrate derived from rhyolite and basalt, and also on quartzite sands.	Likely
Cryptocarya foetida	Stinking Cryptocarya	V	V	Stinking Cryptocarya is known from Iluka, NSW, to Fraser Island and east of Gympie, southern Queensland. Stinking Cryptocarya grows in littoral rainforest, usually on sandy soils, with mature trees also growing on basalt soils. This species occurs within the Northern Rivers (NSW), Burnett Mary and South East Queensland Natural Resource Management Regions	Unlikely
Davidsonia johnsonii	Smooth Davidsonia	E1	E	The Smooth Davidsonia is distributed from the Tallebudgera and Numinbah Valleys in Queensland to Tintenbar, near Ballina in NSW. Most locations are close to the coast,	Potential

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
				but two isolated locations are 25–30 km inland at Nimbin and Terania Creek. Smooth Davidsonia is found mainly in wet sclerophyll forests, with a smaller number of sites known from subtropical rainforest (complex notophyll vine forest)	
Desmodium acanthocladum	Thorny Pea	V	V	The Thorny Pea occurs mainly in the Lismore area of north-eastern NSW, but there are also records of the species from near Grafton, Coraki, Casino and the Mount Warning area. The Thorny Pea occurs on basalt-derived soils at low elevations, mainly along rivers, in dry rainforest and on the fringes of riverine subtropical rainforest	Yes
Diospyros mabacea	Red-fruited ebony, Silky Persimmon, Ebony	-	E	Occurs only in north-east NSW. It is found in a few stands on the Tweed and Oxley Rivers, upstream from Murwillumbah, on Stotts Island in the lower Tweed River and one other small population west of Mullumbimby on the Brunswick River. The largest population is in Limpinwood Nature Reserve. Usually grows as an understorey tree in lowland subtropical rainforest, often close to rivers in soils that are generally basalt-derived or alluvial.	Potential
Eidothea hardeniana	Nightcap Oak	E1	CE	The Nightcap Oak is known from a very limited area in the Nightcap Range on the upper north coast of NSW, north east of Lismore. The Nightcap Oak grows in simple notophyll/microphyll vine forest (warm temperate rainforest) on rhyolite geology.	Unlikely
Elaeocarpus sp. *Rocky Creek*	Minyon Quandong	E1	E	*E.* sp. Rocky Creek is endemic to New South Wales and is known from only four locations, all on the southern edge of the Mt Warning caldera in north-eastern New South Wales. More specifically, these locations are: Whian Whian State Forest, Rocky Creek Dam, Snows Gully Nature Reserve, and at Koonyum Range within Nullum State Forest. *E.* sp. Rocky Creek occurs at warm temperate rainforest/wet sclerophyll forest ecotones on rhyolite and/or basalt derived soils.	Likely
Elaeocarpus williamsianus	Hairy Quandong	-	E	Hairy Quandong is known from nine populations in far north-east NSW, extending from the Tweed Valley south to the Byron Bay area. The known range covers an area of approximately 50 km north-south by 30 km east-west. Hairy Quandong is confined to regrowth subtropical/warm temperate	Unlikely

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
				rainforest on Palaeozoic metamorphics on old landslips on steep hillsides. The species is typically found on steep and eroding slopes at low altitude in gullies, toe slopes, steep drops adjacent to creeks and the headwater areas of creeks	
Endiandra floydii	Crystal Creek Walnut	-	E	The Crystal Creek Walnut is known from Pimpama, just north of the Queensland Gold Coast, south to Byron Hills, 6 km south of Cape Byron, NSW. The Crystal Creek Walnut occurs in subtropical (including littoral) rainforest or wet sclerophyll forest, often with *Lophostemon confertus* (Brush Box) in the canopy and occasionally with *Araucaria cunninghamii* (Hoop Pine) emergents. Disturbed and regrowth sites may include *Cinnamomum camphora* (Camphor Laurel) and *Lantana camara* (Lantana) as weed components.	Unlikely
Floydia praealta	Ball Nut	V	V	The Ball Nut occurs in small, scattered populations from Gympie, Queensland, southwards to the Clarence River in north-east NSW, where it inhabits riverine and subtropical rainforest, usually on soils derived from basalt or in coastal scrub	Unlikely
Fontainea australis	Southern Fontainea	V	V	Southern Fontainea is known from the Tweed Valley and a few locations in the upper reaches of the Richmond Valley in NSW. Southern Fontainea occurs in lowland subtropical rainforest and complex notophyll vine forest on basaltic alluvial flats and well drained, bright reddish-brown alluvial clay loam.	Unlikely
Gossia fragrantissima	Sweet Myrtle	E1	E	Occurs in south-east Queensland and in north-east NSW south to the Richmond River. Mostly found on basalt-derived soils. Found in dry subtropical and riverine rainforests. As it can coppice from roots left in the ground when rainforest is cleared, it is found at several sites as isolated plants in paddocks or regrowth.	Potential
Grammitis stenophylla	Narrow-leaf Finger Fern	E1	-	Occurs in eastern Queensland and eastern NSW. In NSW it has been found on the south, central and north coasts and as far west as Mount Kaputar National Park near Narrabri. Found in moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest.	Unlikely

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
Hicksbeachia pinnatifolia	Red Boppel Nut	V	V	Monkey Nut occurs from Tamborine Mountain, south-east Queensland, to the Bellinger and Nambucca Valleys, in north-east NSW. It occurs in and on the margins of subtropical rainforest from near sea level to 700 m altitude and sometimes extends into wet sclerophyll forest.	Likely
Isoglossa eranthemoides	Isoglossa	E1	E	A very restricted distribution in north-east NSW from the Tweed to the Lismore area, with a single uncertain historical report from south-east Queensland. Understorey of lowland subtropical rainforest, in moist situations on floodplains and slopes. Underlying soils are derived from basalt, metasediments or gabbro.	Unlikely
Macadamia tetraphylla	Rough-shelled Bush Nut	V	V	Rough-shelled Bush Nut occurs from north-east New South Wales (chiefly in the Richmond & Tweed River areas) to south-east Queensland (Mt Glorious, near Brisbane). Rough-shelled Bush Nut occurs in subtropical rainforest and notophyll vine forest in near coastal areas. It is often found on steep slopes, especially at ecotones.	Likely
Marsdenia longiloba	Slender Marsdenia	E	V	Subtropical and warm temperate rainforest, lowland moist eucalypt forest adjoining rainforest and, sometimes, in areas with rock outcrops (DECC 2007). Moist open forest with a fern-grass understorey and occasional small rainforest trees, often on hillslopes adjacent to gully rainforest (Ecos Environmental Pty Ltd, 2005). It appears to prefer soils of medium fertility formed on substrates such as metasediment (Ecos Environmental Pty Ltd, 2005).	Yes
Ochrosia moorei	Southern Ochrosia	E1	E	Southern Ochrosia is known from north-east NSW and south-east Queensland. The range of this species extends from Richmond River in NSW through to the McPherson Ranges, Queensland. Southern Ochrosia grows in riverine and lowland warm subtropical rainforest and complex notophyll vine forest in soils of volcanic origin. This species is often found on hillsides near drainage lines, at elevations of 100–1000 m above sea level. Soils are deep, alluvial or basalt derived, well-drained, and reddish-brown to dark brown	Potential

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
Owenia cepiodora	Onionwood, Bog Onion, Onion Cedar	V	V	Onionwood occurs in the border region of north-east New South Wales and south-east Queensland, within both the Northern Rivers (NSW) and South East Queensland Natural Resource Management Regions. Onionwood grows in complex notophyll vine forest, dry Araucarian vine forest and wet sclerophyll or subtropical rainforest at altitudes ranging from 30 to 420 m.	Unlikely
Randia moorei	Spiny Gardenia	E1	E	Spiny Gardenia is found from Lismore in north-east NSW north to the Logan River in south-east Queensland. Sparsely distributed, with most records in the Tweed and Brunswick areas. Subtropical, riverine, littoral and dry rainforest. In NSW, Hoop Pine and Brush Box are common canopy species.	Unlikely
Sophora fraseri	Brush Sophora	V	V	*Sophora fraseri* is found north of Casino in northern NSW, where it is very rare, and into south-east Queensland, where it is widespread but not common. It grows in moist habitats, often in hilly terrain at altitudes from 60–660 m on shallow soils along rainforest margins in eucalypt forests or in large canopy gaps in closed forest communities	Unlikely
Syzygium hodgkinsoniae	Smooth-bark Rose Apple, Red Lilly Pilly	V	V	Smooth-bark Rose Apple occurs in riverine rainforest on rich alluvial or basaltic soils, from the Richmond River in NSW to Gympie, Queensland, with a disjunct occurrence in north. The species occurs mostly as scattered individuals along watercourses, where the habitat is frequently limited and degraded.	Likely
Syzygium moorei	Rose Apple, Coolamon, Robby, Durobby, Watermelon Tree, Coolamon Rose Apple	-	V	Rose Apple occurs in warm, protected, fertile soils in riverine and gully rainforests at low altitudes, along sections of the Richmond, Brunswick and Tweed Rivers in NSW, as well as at three sites in Upper Mudgeeraba Creek and Upper Tallebudgera Creek in south-east Queensland.	Unlikely
Tinospora tinosporoides	Arrow-head Vine	V	V	Arrow-head Vine occurs near the coast at Richmond River in northern NSW to Burleigh Heads National Park (NP) in Queensland. Arrow-head Vine is locally common in	Yes

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
				rainforest on basalt and also occurs in complex notophyll vine forest.	

***TSC Act Status**: CE – Critically Endangered; E – Endangered; V – Vulnerable*

***EPBC Act Status**: CE – Critically Endangered; E – Endangered; V – Vulnerable*

Threatened fauna species found within a 10km radius of the proposed dam site (TSC Act & EPBC Act), and their likelihood of occurrence.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
FROGS					
Litoria brevipalmata	Green Thighed Frog	V	-	Wet sclerophyll forest along the northern coast of NSW to Ourimbah (Anstis 2002). Also in a variety of habitats including dry to wet sclerophyll forest, rainforests and shrubland with a healthy understorey (DECC 2007). Breeding aggregations occur in still water habitats such as grassy temporary to semi-permanent ponds and flooded ditches in late spring and summer (Cogger 2000; Anstis 2002; DECC 2007).	Potential
Assa darlingtoni	Pouched Frog	V	-	Occurs mainly in the coolest, most moist sites within subtropical, warm temperate and cool temperate rainforests and wet sclerophyll forests (DECC 2007; Ehmann 1997). It favours the highlands and uplands of the eastern Great Dividing Range (300 to 1180 MASL) (Ehmann 1997).	Yes
Mixophyes balbus	Stuttering Frog	E	V	A variety of forest habitats from rainforest through wet and moist sclerophyll forest to riparian habitat in dry sclerophyll forest (DECC 2007) that are generally characterised by deep leaf litter or thick cover from understorey vegetation (Ehmann 1997). Breeding habitats are streams and occasionally springs. Not known from streams disturbed by humans (Ehmann 1997) or still water environments (NSW Scientific Committee 2002).	Unlikely
Mixophyes iteratus	Giant Barred Frog	E	E	Found on forested slopes of the escarpment and adjacent ranges in riparian vegetation, subtropical and dry rainforest, wet sclerophyll forests and swamp sclerophyll forest (DECC 2007; Ehmann 1997). This species is associated with flowing streams with high water quality, though habitats may contain weed species (Ehmann 1997). This species is not known from riparian vegetation disturbed by humans (NSW Scientific Committee 1999). During breeding eggs are kicked up onto an overhanging bank or the streams edge (DECC 2007).	Potential

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Mixophyes fleayi	Fleay's Barred Frog	E	E	Known only from a series of disjunct moist forest blocks in the Border Ranges, Tooloom Scrub, Yabbra National Park, Mt Warning and the Nightland Ranges (NSW Scientific Committee 2000). Associated with rainforest, however is not known to be limited by vegetation structure or altitude (NSW Scientific Committee 2000). Known only from areas where water is flowing and of high quality (Ehmann 1997).	No
Philoria loveridgei	Loveridge's Frog	E	-	A rainforest frog known from two large areas of rainforest, Border Ranges / Lamington National Park and the Mt Warning / Caldera area (Ehmann 1997).	Potential
BIRDS					
Anseranas semipalmata	Magpie Goose	-	M	Now confined to northern Australia, principally the Fitzroy River and east Kimberley, WA, northern Northern Territory, coastal Cape York Peninsula and patchily through eastern Queensland. Small numbers have returned to north-east New South Wales, and re-introduced successfully to Victoria, where populations expanding in south-west and on the Gippsland Plain, and South Australia (Marchant and Higgins, 1990, P. Menkhorst). Magpie Geese live in shallow swamps and associated grassland, feeding on seeds or tubers and green grass (Frith and Davies, 1961, Whitehead and Tschirner, 1992, Wilson, 1997). During the wet season, the geese usually nest in extensive colonies. They move hundreds of kilometres to perennial swamps in the dry season (Frith and Davies, 1961, Bayliss, 1989, Bayliss and Yeomans, 1990).	Unlikely
Amaurornis olivaceus	Bush-hen	V	-	Densely overgrown margins of permanent terrestrial freshwater wetlands, such as creeks and rivers, billabongs, ponds, swamps, dams, lakes and roadside ditches (Marchant & Higgins 1993). Also found on flooded grassland and rainforest (Simpson & Day 1999).	Potential
Ardea alba	Great Egret	-	M	The Great Egret is common and widespread in Australia (McKilligan, 2005). It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats (McKilligan, 2005).	Potential

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Ardea ibis	Cattle Egret	-	M	Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan, 2005). Some individuals stay close to the natal heronry from one nesting season to the next, but the majority leave the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recorded west of the Great Dividing Range (McKilligan, 2005).	Yes
Coracina tenuirostris	Cicadabird	-	M	Cicadabird inhabits the foliage canopy of diverse woodlands and forests, mangrove and paperbark swamps. Arboreal feeder and works in pairs to find insects. In south-eastern Australia this species is a migratory breeding visitor between August and October (Morcombe 2003).	Yes
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5 m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; DECC 2007).	Potential
Erythrotriorchis radiatus	Red Goshawk	E4A	V	Associated with forests and woodlands with a mosaic of vegetation types, an abundance of birds and permanent water. In NSW, this species is thought to favour mixed subtropical rainforest, Melaleuca Swamp Forest, and open eucalypt forest along rivers, often in rugged terrain (Marchant & Higgins 1993; DECC 2005). Across northern Australian south through eastern Queensland to far north-east NSW. The species is very rare in NSW. Most records are from the Clarence River Catchment, with a few about the lower Richmond and Tweed Rivers. (DECC 2005, Threatened Species Website Profiles. NSW Dept. of Environment and Climate Change).	Unlikely

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Gallinago hardwickii	Latham's Snipe	-	M	A variety of permanent and ephemeral wetlands, preferring open fresh water wetlands with nearby cover (Marchant and Higgins 1999). Occupies a variety of vegetation around wetlands (Marchant and Higgins 1999) including wetland grasses and open wooded swamps (Simpson and Day 1999).	Unlikely
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	M	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993).	Potential
Hirundapus caudacutus	White-throated Needletail	-	M	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993).	Potential
Irediparra gallinacea	Comb-crested Jacana	V	-	Freshwater wetlands, such as lagoons, billabongs, swamps, lakes and reservoirs, generally with abundant floating aquatic vegetation (Marchant and Higgins 1999).	Unlikely
Ixobrychus flavicollis	Black Bittern	V	-	Occurs in both terrestrial and estuarine wetlands generally in areas of permanent water and dense vegetation (DECC 2007). In areas with permanent water it may occur in flooded grassland, forest, woodland, rainforest and mangroves (DECC 2007).	Yes
Merops ornatus	Rainbow Bee-eater	-	M	Resident in coastal and subcoastal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March, some occasionally present April to May (Pizzey and Doyle 1988). Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs (ibid). Nest is a chamber a the end of a burrow, up to 1.6 m long, tunnelled in flat or sloping ground, sandy back or cutting (*ibid*).	Potential
Monarcha trivirgatus	Spectacled Monarch	-	M	Wet forests, mangroves (Simpson and Day 1999).	Yes

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Myiagra cyanoleuca	Satin Flycatcher	-	M	Wetter, denser forest, often at high elevations (Simpson & Day 2004).	Unlikely
Pandion haliaetus	Osprey	V	-	Associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers (Schodde and Tidemann 1986; Clancy 1991; Olsen 1995). Osprey may nest on the ground, on sea cliffs or in trees (Olsen 1995). Osprey generally prefer emergent trees, often dead or partly dead with a broken off crown (Olsen 1995).	Potential
Rostratula australis (a.k.a. R. benghalensis)	Painted Snipe (Australian subspecies)	E1	V	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (DECC 2007). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (ibid.). Breeding is often in response to local conditions; generally occurs from September to December (DECC 2007). Roosts during the day in dense vegetation (NSW Scientific Committee 2004). Forages nocturnally on mud-flats and in shallow water (DECC 2007). Feeds on worms, molluscs, insects and some plant-matter (ibid.).	Unlikely
MAMMALS					
Dasyurus maculatus	Spotted-tailed Quoll	V	-	The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; DECC 2007j), more frequently recorded near the ecotones of closed and open forest. This species requires habitat features such as maternal den sites, an abundance of food (birds and small mammals) and large areas of relatively intact vegetation to forage in (DECC 2007). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000).	Unlikely
Myotis macropus	Southern Myotis	V	-	The Southern Myotis inhabits the coastal band from the north-west of Australia, across the top-end and south to western Victoria. If found more than 100 km inland, it is generally along major rivers. They roost in groups of between 10 – 15 individuals, close to water in caves, mine-shafts, storm water drains, hollow-bearing trees etc. They forage for insects and small fish by raking their feet over the surface of streams and pools (DECCW 2011).	Yes

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Nyctophilus bifax	Eastern Long-eared Bat	V	-	This species prefers wetter habitats, ranging from rainforest and monsoon forest to riverine forests of paperbark, but may be found in open woodland, tall open forest and dry sclerophyll woodland (Churchill 1998). These forest bats have been recorded roosting under peeling bark, among epiphytes, in tree hollows and in foliage (Churchill 1998). Individuals are likely to change roost sites nightly (DECC 2007).	Potential

***TSC Act Status**: CE – Critically Endangered; E – Endangered; V – Vulnerable*

***EPBC Act Status**: CE – Critically Endangered; E – Endangered; V – Vulnerable; M - Migratory*

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Appendix B: Flora results

Riparian vegetation recorded within 40 x 10 m quadrats along the stream bank

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Acanthaceae							
	Pseuderanthemum variabile	Pastel Flower			✓		
Adiantaceae							
	Adiantum diaphanum	Filmy Maidenhair			✓		
	Adiantum hispidulum	Rough Maidenhair Fern		✓			
Amaranthaceae							
	**Amaranthus sp.*					✓	✓
Annonaceae							
	Melodorum leichhardtii	Zig-Zag Vine	✓				
Apiaceae							
	**Cyclospermum leptophyllum*	Slender Celery				✓	✓
Apocynaceae							
	Melodinus australis	Southern Melodinus			✓		
Araceae							
	Alocasia brisbanensis	Cunjevoi, Spoon Lily		✓			
	**Colocasia esculenta*	Taro				✓	
	Pothos longipes		✓		✓		
Araliaceae							
	Polyscias elegans	Celery Wood			✓		
Arecaceae							
	Archontophoenix cunninghamiana	Bangalow Palm	✓				
	Calamus muelleri	Southern Lawyer Cane	✓				
	Linospadix monostachya		✓		✓		
Aspleniaceae							
	Asplenium australasicum	Bird's Nest Fern	✓		✓	✓	
Asteraceae							
	**Ageratina adenophora*	Crofton Weed		E		✓	✓

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
	**Ageratina riparia*	Mist Flower		✓	✓		
	**Ageratum houstonianum*			✓			✓
	**Artemisia sp.*					✓	✓
	**Cirsium vulgare*	Spear Thistle		E			
	**Conyza sp.*	Conyza		✓		✓	✓
	**Crassocephalum crepidioides*	Thickhead				✓	✓
	Sigesbeckia orientalis						✓
	**Sonchus sp.*						✓
Basellaceae							
	**Anredera cordifolia*	Madeira Vine				✓	
Bignoniaceae							
	Pandorea jasminoides	Bower Vine	✓		✓		
Blechnaceae							
	Doodia aspera	Prickly Rasp Fern			✓		
	Doodia caudata	Small Rasp Fern	✓	✓		✓	✓
	Doodia caudata var. caudata	Small Rasp Fern			✓		
Caesalpinioideae							
	Caesalpinia subtropica	Corky Prickle-vine	✓				
Caryophyllaceae							
	**Drymaria cordata*	Tropical Chickweed				✓	
Commelinaceae							
	Aneilema biflorum				✓		
	Commelina cyanea	Native Wandering Jew					✓
	**Tradescantia fluminensis*	Wandering Jew		✓	✓	✓	✓
Cunoniaceae							
	Ceratopetalum apetalum	Coachwood			✓		
Cyperacea							
	Fimbristylis sp.						✓
	Carex inversa			✓			
	Carex maculata			✓			
	**Cyperus brevifolius*						✓
	Cyperus enervis			✓			

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
	**Cyperus eragrostis*			✓	✓		✓
	Cyperus exaltatus			E			
	Cyperus gracilis	Slender Flat-sedge				✓	
	Cyperus mirus			✓			
	**Cyperus rotundus*	Nutgrass					✓
	Isolepis cernua	Nodding Club-rush		✓			
	Schoenoplectus validus			E			
Dennstaedtiaceae							
	Dennstaedtia davallioides	Lacy Ground Fern			✓		
Dryopteridaceae							
	Lastreopsis acuminata	Creeping Shield Fern	✓				
Ebenaceae							
	Diospyros pentamera	Myrtle Ebony			✓		
	Diospyros pentamera	Myrtle Ebony	✓				
Elaeocarpaceae							
	Elaeocarpus grandis	Blue Quandong	✓				
	Sloanea australis	Maiden's Blush	✓				
	Sloanea woollsii	Yellow Carabeen	✓				
Euphorbiaceae							
	Croton verreauxii	Green Native Cascarilla			✓		
	Mallotus philippensis	Red Kamala				✓	
Eupomatiaceae							
	Eupomatia laurina	Copper Laurel	✓				
Fabaceae - Faboideae							
	Austrosteenisia glabristyla	Giant Blood Vine			✓		
	Callerya megasperma	Native Wisteria			✓		
	Castanospermum australe	Black Bean					E
	#^Desmodium acanthocladum	Thorny Pea		✓	✓		
	**Trifolium repens*	White Clover					✓
Fabaceae - Mimosoideae							
	Acacia melanoxylon	Blackwood		✓	E		
Juncaceae							

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
	Juncus subsecundus			✓			✓
Lamiaceae							
	Plectranthus parviflorus	Cockspur Flower		✓			
Lauraceae							
	Beilschmiedia elliptica	Grey Walnut			✓		
	Beilschmiedia obtusifolia	Blush Walnut	✓				
	**Cinnamomum camphora*	Camphor Laurel		✓	✓		✓
	Cinnamomum oliveri	Oliver's Sassafras	✓				
	Cryptocarya glaucescens	Jackwood			✓		
	Cryptocarya obovata	Pepperberry	✓				
	Endiandra discolor	Rose Walnut	✓		✓		
	Endiandra muelleri	Green-leaved Rose Walnut	✓				
	Endiandra pubens	Hairy Walnut				✓	
	Litsea australis	Brown Bolly Gum	✓				
	Neolitsea dealbata	Hairy-leaved Bolly Gum	✓				
Lobeliaceae							
	Pratia purpurascens	Whiteroot					✓
Lomandraceae							
	Lomandra hystrix		✓	✓	✓	✓	✓
Lythraceae							
	**Cuphea carthagenensis*						✓
Malvaceae							
	**Sida rhombifolia*	Paddy's Lucerne					✓
Meliaceae							
	Melia azedarach	White Cedar				✓	
Menispermaceae							
	Carronia multisepalea		✓				
Monimiaceae							
	Doryphora sassafras	Sassafras	✓				
	Palmeria scandens	Anchor Vine	✓				
	Wilkiea austroqueenslandica	Smooth Wilkiea	✓				

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Moraceae							
	Ficus coronata	Sandpaper Fig	✓	✓	✓	✓	✓
	Ficus watkinsiana	Strangling Fig	✓				
	Maclura cochinchinensis	Cockspur Thorn				✓	
	Streblus brunonianus	Whalebone Tree				✓	✓
Myrsinaceae							
	**Anagallis arvensis*	Scarlet Pimpernel					✓
	Embelia australiana		✓				
	Myrsine subsessilis		✓		✓		
Myrtaceae							
	Acmena smithii	Lilly Pilly	✓	✓	✓		E
	Callistemon viminalis	Weeping Bottlebrush		✓		✓	✓
	Corymbia intermedia	Pink Bloodwood			E		
	Gossia acmenoides	Scrub Ironwood			✓		
	Lenwebbia prominens		✓		✓		
	Lophostemon confertus	Brush Box			E		
	Rhodamnia rubescens	Scrub Turpentine	✓				
	Syncarpia glomulifera	Turpentine			E		
	Syzygium australe	Brush Cherry		✓		✓	
	Syzygium crebrinerve	Rose Satinash	✓				
	Tristaniopsis laurina	Water Gum	✓		✓		
Oleaceae							
	**Ligustrum sinense*	Small Leaved Privet		✓	✓	✓	✓
Onagraceae							
	Ludwigia peploides subsp. montevidensis	Water Primrose		E			
Oxalidaceae							
	Oxalis exilis			✓		✓	✓
Philydraceae							
	Helmholtzia glaberrima	Flax Lily	✓				
Phormiaceae							
	Dianella caerulea	Blue Flax-lily			✓		

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Phyllanthaceae							
	Actephila lindleyi	Actephila	✓				
	Glochidion ferdinandi	Cheese Tree			✓		
Pittosporaceae							
	Pittosporum undulatum	Native Daphne		✓			
Poaceae							
	**Axonopus compressus*	Broad-leafed Carpet Grass					✓
	**Bromus catharticus*	Prairie Grass					✓
	Cynodon dactylon	Couch					✓
	Echinopogon ovatus	Forest Hedgehog Grass					✓
	**Microlaena stipoides*	Weeping Grass					✓
	Oplismenus aemulus				✓	✓	✓
	Oplismenus imbecillis				✓		
	Oplismenus undulatifolius			✓			
	Paspalum distichum	Water Couch		E			
	**Paspalum mandiocanum*	Broad Leaf Paspalum		✓			✓
	**Setaria sphacelata*	South African Pigeon Grass				✓	✓
Polygonaceae							
	Persicaria hydropiper	Water Pepper		✓		✓	✓
	Persicaria orientalis	Princes Feathers		E			
	Persicaria strigosa	Spotted Knotweed		✓	✓		✓
	Rumex brownii	Swamp Dock					✓
	**Rumex crispus*	Curled Dock				✓	✓
Polypodiaceae							
	Dictymia brownii	Strap Fern	✓				
	Microsorum scandens	Fragrant Fern	✓		✓		
	Platycerium superbum	Staghorn	✓				
	Pyrrosia confluens	Robber Fern				✓	
	Pyrrosia rupestris	Rock Felt Fern		✓			
Proteaceae							

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
	Triunia youngiana	Spice Bush	✓				
Pteridaceae							
	Pteris tremula	Tender Brake				✓	
Ranunculaceae							
	**Ranunculus repens*	Creeping Buttercup					✓
Ripogonaceae							
	Ripogonum album	White Supplejack	✓				
Rubiaceae							
	Atractocarpus benthamianus				✓		
	Morinda jasminoides	Sweet Morinda	✓		✓		
Rutaceae							
	Acronychia octandra	Doughwood	✓				
	Flindersia schottiana	Cudgerie			E		
	Sarcomelicope simplicifolia		✓				
Sapindaceae							
	Alectryon subcinereus	Native Quince				✓	
	**Cardiospermum grandiflorum*	Balloon Vine				✓	✓
	Castanospora alphandii	Brown Tamarind	✓		✓		
	Diploglottis cunninghamii	Native Tamarind	✓				
	Guioa semiglauca	Guioa	✓				
	Sarcopteryx stipata	Steelwood	✓				
	Toechima dasyrrhache		✓				
Sapotaceae							
	Planchonella australis	Black Apple				✓	
Solanaceae							
	Solanum americanum	Glossy Nightshade		✓		✓	✓
	**Solanum mauritianum*	Wild Tobacco Bush		E			
	**Solanum seaforthianum*	Climbing Nightshade				✓	
Sterculiaceae							
	Brachychiton acerifolius	Flame Tree				✓	
	Commersonia bartramia	Brown Kurrajong			E		
	Heritiera trifoliolata	White Booyong	✓			✓	

FAMILY	SPECIES	COMMON NAME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Thelypteridaceae							
	Christella dentata	Binung		✓	✓	✓	
Urticaceae							
	Urtica incisa	Stinging Nettle					✓
Verbenaceae							
	**Lantana camara*	Lantana			✓		
	**Verbena bonariensis*	Purpletop					✓
	**Verbena officinalis*	Common Verbena					✓
Vitaceae							
	Cissus antarctica	Kangaroo Vine	✓				
	Tetrastigma nitens				✓		
Winteraceae							
	Tasmannia insipida	Brush Pepperbush	✓				

* - Denotes exotic species

'E' - Denotes extra species identified outside quadrant

- Denotes ROTAP species

^ - Denotes species listed under the TSC Act

Vegetation cover scores for 40 x 10 m quadrats at five sites along Rocky Creek and Terania Creek, Richmond River Catchment (NSW)

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
CANOPY SPECIES																										
Acacia melanoxylon	Blackwood								✓																	
Acmena smithii	Lilly Pilly		✓					✓					✓													
Acronychia octandra	Doughwood	✓																								
Actephila lindleyi	Actephila		✓																							
Archontophoenix cunninghamiana	Bangalow Palm			✓																						
Atractocarpus benthamianus												✓														
Beilschmiedia elliptica	Grey Walnut											✓														
Beilschmiedia obtusifolia	Blush Walnut	✓																								
Brachychiton acerifolius	Flame Tree																✓									
Castanospermum australe	Black Bean																									
Castanospora alphandii	Brown Tamarind	✓										✓														
Ceratopetalum apetalum	Coachwood											✓														
**Cinnamomum camphora*	Camphor Laurel									✓		✓										✓				
Cinnamomum oliveri	Oliver's Sassafras		✓																							
Corymbia intermedia	Pink Bloodwood																									
Cryptocarya glaucescens	Jackwood											✓														
Cryptocarya obovata	Pepperberry	✓																								

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Diospyros pentamera	Myrtle Ebony		✓									✓														
Diploglottis cunninghamii	Native Tamarind		✓																							
Doryphora sassafras	Sassafras	✓																								
Elaeocarpus grandis	Blue Quandong				✓																					
Endiandra discolor	Rose Walnut	✓										✓														
Endiandra muelleri	Green-leaved Rose Walnut		✓																							
Endiandra pubens	Hairy Walnut																✓									
Eupomatia laurina	Copper Laurel		✓																							
Ficus coronata	Sandpaper Fig			✓					✓				✓						✓					✓		
Ficus watkinsiana	Strangling Fig	✓																								
Flindersia schottiana	Cudgerie																									
Glochidion ferdinandi	Cheese Tree												✓													
Gossia acmenoides	Scrub Ironwood											✓														
Guioa semiglauca	Guioa	✓																								
Heritiera trifoliolata	White Booyong		✓														✓									
Litsea australis	Brown Bolly Gum	✓																								
Lophostemon confertus	Brush Box																									
Mallotus philippensis	Red Kamala																✓									
Melia azedarach	White Cedar																✓									

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Neolitsea dealbata	Hairy-leaved Bolly Gum	✓																								
Pittosporum undulatum	Native Daphne						✓																			
Planchonella australis	Black Apple																✓									
Polyscias elegans	Celery Wood											✓														
Rhodamnia rubescens	Scrub Turpentine	✓																								
Sarcomelicope simplicifolia		✓																								
Sarcopteryx stipata	Steelwood		✓																							
Sloanea woollsii	Yellow Carabeen	✓																								
Streblus brunonianus	Whalebone Tree																		✓			✓				
Syncarpia glomulifera	Turpentine																									
Syzygium australe	Brush Cherry							✓											✓							
Syzygium crebrinerve	Rose Satinash	✓																								
Tristaniopsis laurina	Water Gum			✓												✓										
SHRUB SPECIES																										
Alectryon subcinereus	Native Quince																✓									
Callistemon viminalis	Weeping Bottlebrush								✓								✓								✓	
Commersonia bartramia	Brown Kurrajong																									
Croton verreauxii	Green Native Cascarilla											✓														
**Lantana camara*	Lantana											✓														

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Lenwebbia prominens				✓																						
**Ligustrum sinense*	Small Leaved Privet									✓				✓				✓				✓				
Linospadix monostachya				✓									✓													
Tasmannia insipida	Brush Pepperbush	✓																								
Triunia youngiana	Spice Bush	✓																								
Wilkiea austroqueenslandica	Smooth Wilkiea	✓																								
GROUND LAYER																										
Adiantum diaphanum	Filmy Maidenhair												✓													
Adiantum hispidulum	Rough Maidenhair Fern							✓																		
**Ageratina adenophora*	Crofton Weed																	✓						✓		
**Ageratina riparia*	Mist Flower						✓						✓													
**Ageratum houstonianum*							✓																✓			
Alocasia brisbanensis	Cunjevoi, Spoon Lily						✓																			
**Amaranthus sp.*																	✓					✓				
**Anagallis arvensis*	Scarlet Pimpernel																						✓			
Aneilema biflorum												✓														
**Axonopus compressus*	Broad-leafed Carpet Grass																						✓			
**Bromus catharticus*	Prairie Grass																						✓			
Carex inversa							✓																			

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Carex maculata									✓																	
Christella dentata	Binung, Binung						✓					✓						✓								
**Cirsium vulgare*	Spear Thistle																									
**Colocasia esculenta*	Taro																✓									
Commelina cyanea	Native Wandering Jew																						✓			
**Conyza sp.*	Conyza						✓											✓				✓				
**Crassocephalum crepidioides*	Thickhead																	✓				✓				
**Cuphea carthagenensis*																							✓			
**Cyclospermum leptophyllum*	Slender Celery																✓							✓		
**Cynodon dactylon*	Couch																							✓		
**Cyperus brevifolius*																							✓			
Cyperus enervis								✓																		
**Cyperus eragrostis*							✓						✓										✓			
Cyperus exaltatus																										
Cyperus gracilis	Slender Flat-sedge																✓									
Cyperus mirus							✓																			
**Cyperus rotundus*	Nutgrass																					✓				
Dennstaedtia davallioides	Lacy Ground Fern											✓														
Desmodium acanthocladum	Thorny Pea						✓							✓												

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Dianella caerulea	Blue Flax-lily											✓															
Dictymia brownii	Strap Fern	✓																									
Doodia aspera	Prickly Rasp Fern												✓														
Doodia caudata	Small Rasp Fern		✓				✓											✓				✓					
Doodia caudata var. caudata	Small Rasp Fern												✓														
**Drymaria cordata*	Tropical Chickweed																✓										
Echinopogon ovatus	Forest Hedgehog Grass																					✓					
Fimbristylis sp.																						✓					
Helmholtzia glaberrima	Flax Lily			✓																							
Isolepis cernua	Nodding Club-rush						✓																				
Juncus subsecundus							✓																✓				
Lastreopsis acuminata	Creeping Shield Fern	✓																									
Lomandra hystrix				✓					✓					✓				✓				✓					
Ludwigia peploides subsp. montevidensis	Water Primrose																										
Maclura cochinchinensis	Cockspur Thorn																✓										
**Microlaena stipoides*	Weeping Grass																						✓				
Microsorum scandens	Fragrant Fern	✓										✓															
Myrsine subsessilis			✓									✓															
Oplismenus aemulus													✓						✓					✓			

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Oplismenus imbecillis													✓													
Oplismenus undulatifolius								✓																		
Oxalis exilis								✓									✓						✓			
Paspalum distichum	Water Couch																									
**Paspalum mandiocanum*	Broad Leaf Paspalum							✓																✓		
Persicaria hydropiper	Water Pepper						✓											✓					✓			
Persicaria orientalis	Princes Feathers																									
Persicaria strigosa	Spotted Knotweed							✓				✓											✓			
Plectranthus parviflorus	Cockspur Flower						✓																			
Pratia purpurascens	Whiteroot																						✓			
Pseuderanthemum variabile	Pastel Flower											✓														
Pteris tremula	Tender Brake																✓									
Pyrrosia confluens	Robber Fern																	✓								
Pyrrosia rupestris	Rock Felt Fern						✓																			
**Ranunculus repens*	Creeping Buttercup																						✓			
Rumex brownii	Swamp Dock																						✓			
**Rumex crispus*	Curled Dock																	✓					✓			
Schoenoplectus validus																										
Setaria sphacelata	South African Pigeon Grass																	✓						✓		

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
**Sida rhombifolia*	Paddy's Lucerne																						✓			
Sigesbeckia orientalis																							✓			
Sloanea australis	Maiden's Blush			✓																						
Solanum americanum	Glossy Nightshade						✓											✓					✓			
**Solanum mauritianum*	Wild Tobacco Bush																									
**Solanum seaforthianum*	Climbing Nightshade																✓									
**Sonchus sp.*																						✓				
**Tradescantia fluminensis*	Wandering Jew							✓						✓						✓				✓		
**Trifolium repens*	White Clover																						✓			
Urtica incisa	Stinging Nettle																						✓			
**Verbena bonariensis*	Purpletop																						✓			
**Verbena officinalis*	Common Verbena																									
VINES																										
**Anredera cordifolia*	Madeira Vine																	✓								
Austrosteenisia glabristyla	Giant Blood Vine											✓														
Caesalpinia subtropica	Corky Prickle-vine	✓																								
Calamus muelleri	Southern Lawyer Cane		✓																							
Callerya megasperma	Native Wisteria												✓													
**Cardiospermum grandiflorum*	Balloon Vine																	✓				✓				

SPECIES	COMMON NAME	COVER SCORES																									
		SITE 1					SITE 2					SITE 3					SITE 4					SITE 5				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Carronia multisepalea		✓																								
Cissus antarctica	Kangaroo Vine			✓																						
Embelia australiana			✓																							
Melodinus australis	Southern Melodinus											✓														
Melodorum leichhardtii	Zig-Zag Vine	✓																								
Morinda jasminoides	Sweet Morinda		✓										✓													
Palmeria scandens	Anchor Vine		✓																							
Pandorea jasminoides	Bower Vine		✓											✓												
Ripogonum album	White Supplejack	✓																								
Toechima dasyrrhache		✓																								
EPYPHYTES																										
Asplenium australasicum	Bird's Nest Fern		✓									✓						✓								
Platycerium superbum	Staghorn		✓																							
Pothos longipes			✓										✓													

*Denotes exotic species, ‘E’ denotes extra species identified outside quadrant.

Appendix C: Water quality

Water quality data taken in-field during October 2010, November 2010 and March 2011 at 5 sites along Rocky Creek and Terania Creek, Richmond River Catchment (NSW)

		OCT 2010 #		NOV 2010#		MAR 2011*	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
SITE 1	Temperature (°C)	19.25	19.7	21.12	20.8	22.5	22.5
	Specific Conductivity (mS/cm)	0.053	0.053	0.055	0.055	0.052	0.053
	Dissolved Oxygen (mg/L)	6.03	5.65	5.35	5.36	8.67	8.53
	pH	6.75	6.80	6.99	6.99	8.07	7.86
	Dissolved Oxygen (%)	73.4	68.7	67	67.3	83.5	82.1
	Oxygen Reduction Potential (mV)	281	283	248	252	na	na
	Turbidity (NTU)	7.6	5.8	3.5	3.3	2	2
	Time	9:00	8:40	12:00	11:17	15.10	14.40
SITE 2	Temperature (°C)	16.88	16.97	20.14	20.26	20.2	20.2
	Specific Conductivity (mS/cm)	0.064	0.064	0.071	0.071	0.069	0.071
	Dissolved Oxygen (mg/L)	7.18	6.62	5.35	5.29	8.67	8.76
	pH	6.89	6.90	7.29	7.98	8.4	8.23
	Dissolved Oxygen (%)	82.8	76.7	66.6	65.5	83.5	84.4
	Oxygen Reduction Potential (mV)	278	249	249	255	na	na
	Turbidity (NTU)	6.3	5.9	3	3.1	7	8
	Time	10:00	10:30	12:40	13:00	8.47	9.15
SITE 3	Temperature (°C)	17.9	17.93	19.96	19.97	20.6	20.7
	Specific Conductivity (mS/cm)	0.069	0.069	0.077	0.077	0.072	0.072
	Dissolved Oxygen (mg/L)	6.47	6.41	5.44	5.5	8.81	8.65
	pH	6.95	7.01	7.18	7.23	8.7	8.74
	Dissolved Oxygen (%)	76.1	75.8	67.2	67.8	84.8	83.3
	Oxygen Reduction Potential (mV)	270	312	230	263	na	na
	Turbidity (NTU)	6.2	6.2	5.9	5	5	5
	Time	3:30	3:55	10:00	10:30	9.30	9.48
SITE 4	Temperature (°C)	17.71	17.73	21.67	21.67	20.7	20.8
	Specific Conductivity (mS/cm)	0.085	0.084	0.098	0.097	0.096	0.097
	Dissolved Oxygen (mg/L)	6	6.09	5.48	5.55	8.84	8.48
	pH	7.09	7.07	7.35	7.34	8.4	8.31
	Dissolved Oxygen (%)	70.7	71.9	70	70.8	85.1	81.7
	Oxygen Reduction Potential (mV)	242	264	234	252	na	na
	Turbidity (NTU)	15.3	15	9.1	10.1	19	19
	Time	10:25	10:40	14:30	14:20	10.30	10.45
SITE 5	Temperature (°C)	18.05	18.03	20.67	20.66	21.4	21.4
	Specific Conductivity (mS/cm)	0.08	0.079	0.091	0.09	0.097	0.09
	Dissolved Oxygen (mg/L)	6.24	6.7	5.46	5.53	9.08	8.95
	pH	7.00	6.99	7.26	7.2	8.08	8.3
	Dissolved Oxygen (%)	74.1	79.5	68.3	69.2	87.4	86.2
	Oxygen Reduction Potential (mV)	246	246	232	240	na	na
	Turbidity (NTU)	9.8	9.8	8.6	9	14	14
	Time	17.30	18:00	11:15	11:15	16.24	16.46

# Denotes measurements taken using Quanta Hydrolab; * measurements taken using Horiba; ~ measurement converted from DO mg/L to DO %

Post flush data – Total phosphorus and Total nitrogen, ortho-phosphorus and oxidised nitrogen

RICHMOND WATER LABORATORIES
ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia
Address: P.O. Box 1927
Armidale NSW 2350
Contact: Emma Garraway

Report no: 10/01691
Date sampled: 20/10/2010
Date received: 20/10/2010
Date reported: 2/11/2010
No. of samples: 10
Revision no: 02

Analysis results apply to sample as received.

PARAMETER	Unit	1 FN-1A-201010	2 FN-1B-201010	3 FN-2A-191010	4 FN-2B-191010	5 FN-3A-191010	6 FN-3B-191010	7 FN-4A-201010	8 FN-4B-201010	9 FN-5A-191010
Phosphorus - Ortho	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	0.010	0.010
Nitrogen - Oxidised	mg/L	0.050	0.050	0.16	0.16	0.17	0.17	0.11	0.12	0.16

PARAMETER	Unit	10 FN-5B-191010
Phosphorus - Ortho	mg/L	<0.010
Nitrogen - Oxidised	mg/L	0.16

RICHMOND WATER LABORATORIES
ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia
Address: P.O. Box 1927
Armidale NSW 2350
Contact: Emma Garraway

Report no: 10/01690
Date sampled: 20/10/2010
Date received: 20/10/2010
Date reported: 29/10/2010
No. of samples: 10
Revision no: 00

Analysis results apply to sample as received.

PARAMETER	Unit	1 TN-1A-201010	2 TN-1B-201010	3 TN-2A-191010	4 TN-2B-191010	5 TN-3A-191010	6 TN-3B-191010	7 TN-4A-201010	8 TN-4B-201010	9 TN-5A-191010
Phosphorus - Total	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrogen - Total	mg/L	0.32	0.27	0.38	0.36	0.38	0.38	0.31	0.31	0.34

PARAMETER	Unit	10 TN-5B-191010
Phosphorus - Total	mg/L	<0.050
Nitrogen - Total	mg/L	0.34

Spring data - Total phosphorus and Total nitrogen, ortho-phosphorus and oxidised nitrogen

RICHMOND WATER LABORATORIES

ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia
Address: PO Box 1927
Armidale NSW 2350
Contact: Ian Dixon

Report no: 10/01938
Date sampled: 24/11/2010
Date received: 26/11/2010
Date reported: 9/12/2010
No. of samples: 20
Revision no: 01

Analysis results apply to sample as received.

PARAMETER	Unit	1 1A-FN-241110	2 1B-FN-241110	3 2A-FN-241110	4 2B-FN-241110	5 3A-FN-241110	6 3B-FN-241110	7 4A-FN-241110	8 4B-FN-241110	9 5A-FN-241110
Phosphorus - Ortho	mg/L	<0.010	<0.010	0.010	0.010	0.020	0.020	0.030	0.040	0.030
Nitrogen - Oxidised	mg/L	0.050	0.050	0.080	0.080	0.080	0.080	0.070	0.070	0.070

PARAMETER	Unit	10 5B-FN-241110	11 1A-TN-24110	12 1B-TN-241110	13 2A-TN-24110	14 2B-TN-241110	15 3A-TN-24110	16 3B-TN-24110	17 4A-TN-24110	18 4B-TN-24110
Phosphorus - Ortho	mg/L	0.030	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]
Nitrogen - Oxidised	mg/L	0.10	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]	[NA]
Nitrogen - Total	mg/L	[NA]	0.31	0.35	0.31	0.30	0.30	0.30	0.31	0.34
Phosphorus - Total	mg/L	[NA]	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.060	0.060

RICHMOND WATER LABORATORIES
ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia **Report no:** 10/01938

PARAMETER	Unit	19 5A-TN-24110	20 5B-TN-24110
Nitrogen - Total	mg/L	0.31	0.30
Phosphorus - Total	mg/L	0.050	0.050

Autumn data - Total phosphorus and Total nitrogen, ortho-phosphorus and oxidised nitrogen

RICHMOND WATER LABORATORIES

ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia
Address: PO Box 1927
Armidale NSW 2350
Contact: Emma Garraway

Report no: 11/00587
Date sampled: 29/03/2011
Date received: 1/04/2011
Date reported: 13/04/2011
No. of samples: 10
Revision no: 00

Analysis results apply to sample as received.

PARAMETER	Unit	1 T1-S1-300311	2 T2-S1-300311	3 T1-S2-290311	4 T2-S2-290311	5 T1-S3-280311	6 T2-S3-280311	7 T1-S4-300311	8 T2-S4-300311	9 T1-S5-290311
Phosphorus - Total	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.070	0.060	0.050
Nitrogen - Total	mg/L	0.25	0.25	0.36	0.34	0.33	0.32	0.35	0.35	0.32

PARAMETER	Unit	10 T2-S5-290311
Phosphorus - Total	mg/L	0.050
Nitrogen - Total	mg/L	0.33

Comments:

A. Hawthorne
Laboratory Manager
NATA Signatory

RICHMOND WATER LABORATORIES

ENVIRONMENTAL ANALYSIS • WATER SAMPLING • DATA MANAGEMENT

CERTIFICATE OF ANALYSIS

Client: Eco Logical Australia
Address: PO Box 1927
Armidale NSW 2350
Contact: Emma Garraway

Report no: 11/00588
Date sampled: 29/03/2011
Date received: 1/04/2011
Date reported: 13/04/2011
No. of samples: 10
Revision no: 00

Analysis results apply to sample as received.

PARAMETER	Unit	1 F1-S1-300311	2 F2-S1-300311	3 F1-S2-290311	4 F2-S2-290311	5 F1-S3-280311	6 F2-S3-280311	7 F1-S4-300311	8 F2-S4-300311	9 F1-S5-290311
Phosphorus - Ortho	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	0.12	0.010	0.020	0.010
Nitrogen - Oxidised	mg/L	0.090	0.090	0.19	0.18	0.17	0.17	0.13	0.15	0.14

PARAMETER	Unit	10 F2-S5-290311
Phosphorus - Ortho	mg/L	0.010
Nitrogen - Oxidised	mg/L	0.14

Comments:

A. Hawthorne
Laboratory Manager
NATA Signatory

Appendix D: Macroinvertebrates

Macroinvertebrates

Aquatic macroinvertebrates captured at Site 1, Rocky Creek during each sampling period.

		OCT-10		NOV-10		MAR-11	
ORDER	FAMILY	RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Individuals		**144**	**124**	**180**	**136**	**188**	**144**
Acarina (Freshwater Mites)					2		
Amphipoda (Side Swimmers)							
	Talitridae						1
Bivalvia (Snails, Mussels, Clams)							
	Corbiculidae	11	10	23		16	
	Sphaeriidae		5	3	3	1	5
Cladocera (Water Fleas)							1
Coleoptera (Beetles)							
	Dyticidae		1		1	2	
	Elmidae L	39	6	10	3	15	4
	Elmidae A				1		
	Gyrinidae				7		2
	Hydrophilidae L						1
	Psephenidae	3	1	2	1	7	1
	Scirtidae L	1	2	2	10		8
Decapoda (Shrimp, prawns, crabs and crayfish)							
	Atyidae		5		8		7
	Palaeomonidae	1				2	
	Parastacidae		1	1	2		
	Shrimp larvae (Atyidae/Palaeomonidae)		6				
Diptera (Flies, true flies)							
	Athericidae					1	
	Ceratopogonidae		3				
	Chironominae (sub family)	29	32	29	40	3	8

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Orthocladiinae (sub family)	5	1	28		1	
	Tanypodinae (sub family)	7	26	7	38	31	43
	Simuliidae	12		4		5	1
	Tipulidae		1	1	1		
Ephemeroptera (Mayflies)							
	Baetidae	1		2		1	
	Caenidae	4	9	13	5	5	16
	Leptophlebiidae		5	4	2	9	22
Gastropoda (Freshwater Limpets)							
	Ancylidae					1	
Hemiptera (True Bugs)							
	Notonectidae		1		1		
Lepidoptera (Aquatic caterpillars)							
	Pyralidae				1		
Megaloptera (Toebiters)							
	Corydalidae	1		1		1	
Odonata (Dragonflies and damselflies)							
	Gomphidae		2				3
	Synlestidae		2				
	Epiproct juvenile		1		1		
	Zygoptera juvenile				3		1
	Diphlebiidae					3	
Oligochaeta (Segmented worms)				5		4	
Plecoptera (Stoneflies)							
	Gripopterygidae			3		3	
Tricoptera (Caddisflies)							
	Calamoceratidae		3	2	4	6	12
	Ecnomidae		1				1
	Hydrobiosidae	1		2		2	
	Hydropsychidae	29		38		68	
	Leptoceridae				2	1	7

Aquatic macroinvertebrates captured at Site 2, Rocky Creek during each sampling period.

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Individuals		**73**	**183**	**224**	**135**	**264**	**150**
Acarina (Freshwater Mites)			1		2		
Bivalvia (Snails, Mussels, Clams)							
	Corbiculidae			1	1		1
	Sphaeriidae				6		2
Coleoptera (Beetles)							
	Elmidae L	10	6	23	10	16	15
	Elmidae A	2		8	2	5	1
	Hydrophilidae L						1
	Hydrophilidae A		1				2
	Psephenidae	2		1		4	2
	Scirtidae L			3	1	4	
Decapoda (Shrimp, prawns, crabs and crayfish)							
	Atyidae		13		8		2
	Shrimp larvae (Atyidae/Palaeomonidae)		1				
Diptera (Flies, true flies)							
	Ceratopogonidae				3		
	Chironominae (sub family)	5	36	43	47	5	30
	Orthocladiinae (sub family)	6	2	32	1	6	2
	Tanypodinae (sub family)	5	51	5	11	16	20
	Culicidae			39			
	Simuliidae		1	1		25	
	Tipulidae	4		8		2	
Ephemeroptera (Mayflies)							
	Baetidae	16	4		7	40	4
	Caenidae	1	13		4	2	11
	Leptophlebiidae	9	19	25	9	30	23
Gastropoda (Freshwater Limpets)							
	Hydrobiidae						2
	Lymnaeidae						1

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Hemiptera (True Bugs)							
	Belostomatidae		1				
	Veliidae		1				
Isopoda (Water slaters)							
	Cirolanidae		1				
Lepidoptera (Aquatic caterpillars)							
	Pyralidae		1			2	1
Megaloptera (Toebiters)							
	Corydalidae	2		1		5	1
Odonata (Dragonflies and damselflies)							
	Austrocorduliidae	1					
	Gomphidae		7	1	1	1	4
	Libellulidae						1
	Synlestidae				1		
	Isosticidae				1		
	Corduliidae	1					1
	Epiproct juvenile		2			2	2
	Zygoptera juvenile		1		3		
	Diphlebiidae					6	
	Telephlediidae					3	
Oligochaeta (Segmented worms)		1	3		4		5
Plecoptera (Stoneflies)							
	Gripopterygidae	1	1	5		3	
Tricoptera (Caddisflies)							
	Calamoceratidae		2	2	1	3	1
	Conoesucidae						
	Ecnomidae		1		4		7
	Glossosomatidae	2		1		2	
	Helicopsychidae						
	Hydrobiosidae			8		8	
	Hydropsychidae	4		16		60	1

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Hydroptilidae						
	Leptoceridae		12		6		6
	Philopotamidae			1		11	
	Polycentropodidae		2				1
Turbellaria (Flatworms)							
	Dugesiidae	1			2	3	

Aquatic macroinvertebrates captured at Site 3, Rocky Creek during each sampling period.

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Individuals		**79**	**127**	**147**	**131**	**202**	**148**
Acarina (Freshwater Mites)					4		1
Bivalvia (Snails, Mussels, Clams)							
	Corbiculidae			2		6	1
	Sphaeriidae				1		1
Coleoptera (Beetles)							
	Elmidae L	17	9	14	4	29	15
	Elmidae A	23		23	1	23	1
	Gyrinidae				1		
	Hydrophilidae L				1		3
	Hydraenidae				1		
	Psephe0idae		1	2		3	1
	Scirtidae L		2	5	3		5
Collembola (Springtails)							
	Entombryidae				2		
Copepoda					1		
Decapoda (Shrimp, prawns, crabs and crayfish)							
	Atyidae			1	2		7
	Palaeomonidae				1		
	Shrimp larvae (Atyidae/Palaeomonidae)						2
Diptera (Flies, true flies)							

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Ceratopogonidae		1		2		1
	Chironominae (sub family)	12	42	12	45	5	26
	Orthocladiinae (sub family)	5	5	2	2		2
	Tanypodinae (sub family)		20	5	25	7	16
	Culicidae				2		
	Dixidae				1		
	Simuliidae	1	9	1		4	
	Tipulidae	7	1	10			
Ephemeroptera (Mayflies)							
	Baetidae	7	3	20	3	39	3
	Caenidae	1	22		2	1	11
	Leptophlebiidae	1	3	12	5	22	11
Gastropoda (Freshwater Limpets)							
	Hydrobiidae	2	1	1		3	1
	Ancylidae				1	1	
Hemiptera (True Bugs)							
	Gelastocoridae				1		
	Notonectidae				1		
	Veliidae				1		
Hirudinea (Freshwater leech)							
	Glossiphonidae		1				
Isopoda (Water slaters)							
	Cirolanidae						1
Lepidoptera (Aquatic caterpillars)							
	Pyralidae	1	2		2	6	1
Megaloptera (Toebiters)							
	Corydalidae			5		10	
Odonata (Dragonflies and damselflies)							
	Gomphidae			2		1	
	Synlestidae				2		
	Corduliidae				1		

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Epiproct juvenile						4
	Zygoptera juvenile				7		1
	Diphlebiidae					1	
Oligochaeta (Segmented worms)			1	1	1	8	2
Ostracoda (Seed shrimp)					2		
Plecoptera (Stoneflies)							
	Gripopterygidae		1				
Tricoptera (Caddisflies)							
	Ecnomidae				2		1
	Glossosomatidae					2	
	Hydrobiosidae			7		7	
	Hydropsychidae	1		22		21	1
	Hydroptilidae	1					
	Leptoceridae		3		1		29
	Polycentropodidae					2	
Turbellaria (Flatworms)							
	Dugesiidae					1	

Aquatic macroinvertebrates captured at Site 4, Terania Creek during each sampling period.

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Individuals		**173**	**185**	**258**	**128**	**232**	**174**
Acarina (Freshwater Mites)					2		
Amphipoda (Side Swimmers)							
	Talitridae						1
Bivalvia (Snails, Mussels, Clams)							
	Sphaeriidae						1
Coleoptera (Beetles)							
	Dyticidae		2	2			
	Elmidae L	65	39	45	26	36	87
	Elmidae A	8	12	20	3	7	

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Hydrophilidae L	2	2				4
	Hydrophilidae A		6		12		
	Hydraenidae				3		
	Psephenidae	3	3	3		4	1
	Scirtidae L			2		1	
	Staphylinidae						1
Collembola (Springtails)							1
	Entombryidae		3				
Decapoda (Shrimp, prawns, crabs and crayfish)							
	Atyidae		2		4		
	Palaeomonidae		1		1		
	Shrimp larvae (Atyidae/Palaeomonidae)		1		2		
Diptera (Flies, true flies)							
	Ceratopogonidae		1		8	1	
	Chironominae (sub family)	4	12	7	13	5	47
	Orthocladiinae (sub family)		8	5	6	5	3
	Tanypodinae (sub family)	11	18	4	13	21	4
	Empididae		1		1		
	Simuliidae	10	21				
	Tipulidae					12	3
Ephemeroptera (Mayflies)							
	Baetidae	6		8	3	8	8
	Caenidae	2	27	1	4	6	5
	Leptophlebiidae	39	11	38	2	34	1
Hemiptera (True Bugs)							
	Corixidae				2		
Hirudinea (Freshwater leech)							
	Erpobdellidae						1
Lepidoptera (Aquatic caterpillars)							
	Pyralidae						1
Megaloptera (Toebiters)							

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Corydalidae	1				2	
Neuroptera (Spongefly larvae, lacewing larvae)							1
Odonata (Dragonflies and damselflies)							
	Gomphidae	3	5	6		5	
	Libellulidae				3		
	Isosticidae				4		
	Zygoptera juvenile				4		
Oligochaeta (Segmented worms)		5	1	1	2	1	2
Plecoptera (Stoneflies)							
	Gripopterygidae	1					
Tricoptera (Caddisflies)							
	Calamoceratidae		5		1		
	Conoesucidae				1		
	Ecnomidae		1	1			
	Glossosomatidae	1		6		1	
	Hydrobiosidae	4				1	
	Hydropsychidae	3		92	5	51	
	Leptoceridae		2	2	3	5	2
	Philopotamidae	4		14		23	
	Polycentropodidae		1				
Turbellaria (Flatworms)							
	Dugesiidae	1		1		3	

Aquatic macroinvertebrates captured at Site 5, Terania Creek during each sampling period.

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Individuals		**145**	**191**	**211**	**176**	**209**	**193**
Acarina (Freshwater Mites)				1	1	1	
Bivalvia (Snails, Mussels, Clams)							
	Corbiculidae					1	
	Sphaeriidae		1				

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
Coleoptera (Beetles)							
	Dyticidae	2	1				
	Elmidae L	70	12	59	59	48	40
	Elmidae A	13	6	9	7	12	2
	Hydrophilidae L		6				1
	Hydrophilidae A		5	3	2		1
	Hydraenidae			2			
	Psephe0idae	3		3	3		5
	Scirtidae L						4
Collembola (Springtails)							
	Entombryidae			1			
Decapoda (Shrimp, prawns, crabs and crayfish)							
	Atyidae		4				7
	Palaeomonidae					1	
	Shrimp larvae (Atyidae/Palaeomonidae)		8				
Diptera (Flies, true flies)							
	Ceratopogonidae		4	14	14		
	Chironominae (sub family)	3	31	18	18	10	18
	Orthocladiinae (sub family)	1		4	3		4
	Tanypodinae (sub family)		35	18	12	10	16
	Culicidae		1				
	Simuliidae	7					
	Muscidae			1			
	Nematoda			1			
	Tipulidae		2			2	4
Ephemeroptera (Mayflies)							
	Baetidae	11	29	1	1	11	28
	Caenidae		6	13	10		6
	Leptophlebiidae	19	7	32	25	39	29
Gastropoda (Freshwater Limpets)							
	Hydrobiidae		1				1

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Ancylidae						1
Hemiptera (True Bugs)							
	Corixidae		1				
	Gerridae		4				1
	Veliidae			2	2		
Isopoda (Water slaters)							
	Cirolanidae		2				1
Lepidoptera (Aquatic caterpillars)							
	Pyralidae				1		1
Megaloptera (Toebiters)							
	Corydalidae					3	
Neuroptera (Spongefly larvae, lacewing larvae)							
	Sisyridae						1
Odonata (Dragonflies and damselflies)							
	Gomphidae	2	7	1	1		
	Libellulidae			1			2
	Synlestidae			1			
	Coenagrionidae		4				
	Epiproct juvenile			1			1
	Zygoptera juvenile			1	1		1
Oligochaeta (Segmented worms)			6	7	5	1	
Plecoptera (Stoneflies)							
	Gripopterygidae			1	1		
Tricoptera (Caddisflies)							
	Calamoceratidae				1		
	Conoesucidae	1		1			
	Ecnomidae			4	2		2
	Glossosomatidae	5		3	2	11	1
	Helicopsychidae	2					
	Hydrobiosidae	2		1	1	3	
	Hydropsychidae	4	3	3	3	28	5

ORDER	FAMILY	OCT-10		NOV-10		MAR-11	
		RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
	Hydroptilidae		2				
	Leptoceridae		3	2	1		10
	Philopotamidae					26	
	Polycentropodidae			2			
Turbellaria (Flatworms)							
	Dugesiidae					2	

Water velocity and depth

Average Velocity and maximum depth of water at five sites along Rocky Creek and Terania Creek, Richmond River Catchment, NSW taken at time of macroinvertebrate surveys (October 2010, November 2010, March 2011)

OCTOBER 2011			SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Riffle	Velocity (m/s)	Max	0.70	0.30	0.60	0.70	0.50
		Min	0.70	0.70	0.80		0.60
		Ave	0.70	0.50	0.70		0.55
	Depth (m)	Min					
		Max	0.40	0.40	0.45	0.75	0.50
Pool	Velocity (m/s)	Max	0.30	0.05	0.20	0.30	0.00
		Min	0.30	0.15	0.00		0.20
		Ave	0.30	0.10	0.10		0.10
	Depth (m)	Min					
		Max	0.70	1.00	0.50	0.90	0.60
NOVEMBER 2010							
Riffle	Velocity (m/s)	Max	0.30	0.35	0.40	0.60	0.65
		Min	0.75	0.85	1.20	0.60	1.10
		Ave	0.55	0.60	0.80	0.60	0.90
	Depth (m)	Min	0.10	0.20	0.05	0.25	0.15
		Max	0.15	0.35	0.30	0.40	0.30
Pool	Velocity (m/s)	Max	0.00	0.00	0.00	0.00	0.00
		Min	0.00	0.05	0.00	0.00	0.10
		Ave	0.00	0.01	0.00	0.00	0.01
	Depth (m)	Min	0.35	0.40	0.20	0.30	0.30
		Max	0.45	0.70	0.70	0.40	1.10
MARCH 2011							
Riffle	Velocity (m/s)	Max	0.50	0.20	0.30	0.90	1.00
		Min	1.10	1.20	1.10	1.00	1.00
		Ave	0.70	0.70	0.70	0.95	1.00
	Depth (m)	Min	n/a	0.20	0.15	0.35	0.25
		Max	n/a	0.30	0.30	0.40	0.35
Pool	Velocity (m/s)	Max	0.00	0.00	0.00	0.00	0.00
		Min	0.05	0.05	0.01	0.10	0.20
		Ave	0.00	0.00	0.00	0.02	0.01
	Depth (m)	Min	0.15	0.40	0.30	0.40	0.60
		Max	0.40	0.50	0.45	0.60	1.00

Macroinvertebrate habitat characteristics

Habitat characteristics of Site 1, upstream of inundation area, Rocky Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SITE 1		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Silt/detritus (% cover)		<5	5-25	5-25	<5	25-50	25-50	0	5 - 25	5 - 25
Algae (% cover)		<5	<5	<5	<5	<5	<5	0	<5	<5
Substrate (% cover)	**size (mm)**									
Very fine sand/silt	<0.125									3
Fine/medium sand	0.125-0.5	5			5	5	8			2
Coarse/very coarse sand	0.5-2	5	10	10	10	5	8	5		5
Very fine/fine gravel	2-8	20	50	50		30	8	5		5
Medium Gravel	8-16	40	20	20		20	8	20		15
Coarse/very coarse gravel	16-64	20	15	15	20	20	8	20		10
Small cobble	64-128	10	5	5	55	20	10	50		10
Large cobble	128-250				10		20		20	50
Small boulder	250-500						30			

Macrophytes of Site 1, upstream of inundation area, Rocky Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SCIENTIFIC NAME	COMMON NAME	OCT-10	NOV-10	MAR-11
Lomandra		<5	-	5

Habitat characteristics of Site 2, within proposed inundation area, Rocky Creek, Richmond River Catchment, NSW

SITE 2		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Silt/detritus (% cover)		<5	5-25	5-25	<5	75-100	75-100	<5	75 - 100	75 - 100
Algae (% cover)		<5	<5	5-25	<5	<5	<5	<5	<5	<5
Substrate (% cover)	**size (mm)**									
Very fine sand/silt	<0.125							2	2	2
Fine/medium sand	0.125-0.5	2	5	5	5	5	5	3	3	3
Coarse/very coarse sand	0.5-2	2	20	20	5	10	10	2	5	5
Very fine/fine gravel	2-8	2	20	20	10	20	20	3	5	5
Medium Gravel	8-16	2	5	5	15	20	20	5	5	5
Coarse/very coarse gravel	16-64	5	50	50	20	20	20	5	70	70
Small cobble	64-128	50			20	20	20	30		
Large cobble	128-250	37			20	5	5	50	10	10
Small boulder	250-500				5					

Macrophytes of Site 2, within proposed inundation area, Rocky Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SPECIES	COMMON NAME	OCT-10	NOV-10	MAR-11
Eleocharis sp.		5		
Carex sp.		5		5

SPECIES	COMMON NAME	OCT-10	NOV-10	MAR-11
Persicaria strigosa	Arrowhead	1		
Persicaria hydropiper	Bird Cane	10		
Isolepis inundatus	Wavy Hair	2		
	Sedge		5	
Stuckenia pectinata	Sago Pondweed		5	
Schoenoplectus sp.	Club-rush			1
Lomandra sp.				5

Habitat characteristics of Site 3, downstream of proposed inundation area, Rocky Creek, Richmond River Catchment, NSW

SITE 3		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Silt/detritus (% cover)		<5	5-25	25-50	0	75-100	75-100	<5	75 - 100	75 - 100
Algae (% cover)		<5	5-25	<5	5-25	<5	<5	<5	<5	<5
Substrate (% cover)	**size (mm)**									
Very fine sand/silt	<0.125			60				5		
Fine/medium sand	0.125-0.5	2							5	10
Coarse/very coarse sand	0.5-2	4	5		2				5	5
Very fine/fine gravel	2-8	6	5	20	2			5	5	5
Medium Gravel	8-16	6		20	2	5		5		

SITE 3		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Coarse/very coarse gravel	16-64	4	10			5				
Small cobble	64-128				2	10		5	5	15
Large cobble	128-250		30		2	15			10	20
Small boulder	250-500		50		10	60			20	20
Medium boulder	500-1000	25				5			50	25
Large/very large boulder	1000-4000	53								
Bedrock	-				80			80		

Macrophytes of Site 3, downstream of proposed inundation area, Rocky Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SCIENTIFIC NAME	COMMON NAME	OCT-10	NOV-10	MAR-11
Lomandra longifolia		5		5
Carex sp.		<5		
	Fern	1		
Cheilanthes sp.	Rock Fern	1		

Habitat characteristics of Site 4, Terania Creek, Richmond River Catchment, NSW

SITE 4		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Silt/detritus (% cover)		5-25	5-25	5-25	<5	50-75	0	<5	25 - 50	50 - 75
Algae (% cover)		<5	<5	<5	<5	<5	0	<5		
Substrate (% cover)	**size (mm)**									
Very fine sand/silt	<0.125	15	15	15	5	15	15		20	40
Fine/medium sand	0.125-0.5	10	10	10	5	10	10	10	10	10
Coarse/very coarse sand	0.5-2	15	15	15	10	5	5	10	10	10
Very fine/fine gravel	2-8	50	50	50	15	30	30			
Medium Gravel	8-16	10	10	10	40	30	30	30	25	25
Coarse/very coarse gravel	16-64				20	10	10	10	5	5
Small cobble	64-128				5			40	30	10

Macrophytes of Site 4, Terania Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SCIENTIFIC NAME	COMMON NAME	OCT-10	NOV-10	MAR-11
Lomandra sp.		5		5
Eleocharis sp.		5		
Vallisneria nana	Ribbonweed	<5	5	10

Habitat characteristics of Site 5, downstream of proposed inundation area, Terania Creek, Richmond River Catchment, NSW

SITE 5		OCT-10			NOV-10			MAR-11		
		RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL	RIFFLE	POOL-EDGE	POOL
Silt/detritus (% cover)		5-25	5-25	5-25	<5	5-25	5-25	<5	5 - 25	50 - 75
Algae (% cover)		<5	<5	<5	<5	<5	<5	<5	<5	<5
Substrate (% cover)	**size (mm)**									
Very fine sand/silt	<0.125								20	80
Fine/medium sand	0.125-0.5				10	10	10	5	5	10
Coarse/very coarse sand	0.5-2	15	15	15	10	15	15	10	5	5
Very fine/fine gravel	2-8	10	10	10	15	30	30	10	5	5
Medium Gravel	8-16	15	15	15	20	30	30	10	5	
Coarse/very coarse gravel	16-64	50	50	50	25	10	10	10	5	
Small cobble	64-128	10	10	10	20	5	5	55	55	

Macrophytes of Site 5, downstream of proposed inundation area, Terania Creek, Richmond River Catchment, NSW (% cover of 100 m reach)

SCIENTIFIC NAME	COMMON NAME	OCT-10	NOV-10	MAR-11
Myriophyllum papillosum	Common Watermilfoil	<5		
Carex sp.		<5		
	Sedge	1		
Vallisneria nana	Ribbonweed		5	8

Rocky Creek Dam spill rates at time of macroinvertebrate sampling

SAMPLING PERIOD	DATE	MLd^{-1}
Post-flush	17th October 2010	310
	18th October 2010	200
	19th October 2010	145
	20th October 2010	132
	21st October 2010	186
	22nd October 2010	120
Spring	21st November 2010	37
	22nd November 2010	22
	23rd November 2010	22
	24th November 2010	15
	25th November 2010	37
	26th November 2010	22
Autumn	26th March 2010	29
	27th March 2011	22
	28th March 2011	15
	29th March 2011	85
	30th March 2011	215
	31st March 2011	277
	1st April 2011	230

Appendix E: Fish results

Fish abundance

Total fish abundances for electrofishing and unbaited bait-trapping methods at two sites along Rocky Creek, Richmond River Catchment, Northern NSW (September 2010)

SPECIES	COMMON NAME	SITE 6			SITE 9		
		ELECTROFISHING	OBSERVED	TRAPS	ELECTROFISHING	OBSERVED	TRAPS
Anguilla reinhardtii	Longfin eel	2	7			3	
Hypseleotris compressa	Empire gudgeon	20	4	30			
Hypseleotris galii	Firetail gudgeon	2		1			3
Hypseleotris klunzingeri	Western carp gudgeon	4	1	1	2		
Gobiomorphus australis	Striped gudgeon	100	40	8	8	2	2
Gobiomorphus coxii	Cox's gudgeon	21	4				
Macquaria novemaculeata	Australian bass				3		
Mugil cephalus	Sea mullet				2		
Myxus petardi	Freshwater mullet				40	32	
Notesthes robusta	Bullrout	4					
Philypnodon grandiceps	Flathead gudgeon				2		
Retropinna semoni	Australian smelt	1					

SPECIES	COMMON NAME	SITE 6			SITE 9		
		ELECTROFISHING	OBSERVED	TRAPS	ELECTROFISHING	OBSERVED	TRAPS
Tandanus tandanus	Freshwater catfish				2		
Totals		**154**	**56**	**40**	**59**	**37**	**5**

Water Quality at time of fish sampling

Water quality results from measurements taken at two sites, at time of fish sampling, Rocky Creek, Richmond River Catchment, Northern NSW (September 2010)

DEPTH	0.2 M		1 M		2 M	
SITE	6	9	6	9	6	9
Temperature (ºC)	19.1	18.5	19	18.4	19	18.4
pH	7.32	7.32	7.21	7.31	7.19	7.22
DO (mg/L)	9.33	9.31	9.36	9.36	9.39	9.42
DO (%)	89.8	89.7	90.1	90.1	90.4	90.7
Conductivity (mS/cm)	.095	.090	.095	.090	.095	.090
Turbidity (NTU)	22	12	24	12	24	20
Secchi depth (m)	1.8	1.9				
Av. Pool depth (m)	1.9	2.8				

Appendix F: Bird results

Birds observed and recorded during the spring and autumn sampling periods at five sites along Rocky Creek and Terania Creek, Dunoon, NSW

SCIENTIFIC NAME	COMMON NAME	SITE 1		SITE 2		SITE 3		SITE 4	SITE 5	
		NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	NOV-10	MAR-11
Acanthiza pusilla+	Brown Thornbill		✓	✓			✓			✓
Alcedo azurea+	Azure Kingfisher	✓	✓						✓	
Ailuroedus crassirostris	Green Catbird						✓			
Anas superciliosa~	Pacific Black Duck				✓					
Ardea novaehollandiae~	White-faced Heron									✓
Cacatua galerita	Sulphur-crested Cockatoo		✓							
Cacatua roseicapillus	Galah									✓
Cacomantis flabelliformis	Fan-tailed Cuckoo		✓		✓		✓			
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		✓							
Chalcophaps indica+	Emerald Dove	✓							✓	
*Chrysococcyx lucidus^*	Shining Bronze-Cuckoo								✓	
Cisticola exilis~	Golden-headed Cisticola								✓	✓
Colluricincla harmonica	Grey Shrike-thrush		Possible							
Colluricincla megarhyncha~	Little Shrike-thrush		✓		✓		✓			
Columba leucomela	White-headed Pigeon					✓				
*Coracina tenuirostris^*	Cicadabird								✓	
Cormobates leucophaeus	White-throated Treecreeper		Possible		✓		✓			✓
Corvus orru	Torresian Crow		✓	✓	✓		✓	✓	✓	✓
Cracticus nigrogularis	Pied Butcherbird				✓			✓		✓
Dacelo novaeguineae	Laughing Kookaburra	✓			✓	✓				

SCIENTIFIC NAME	COMMON NAME	SITE 1		SITE 2		SITE 3		SITE 4	SITE 5	
		NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	NOV-10	MAR-11
Dicaeum hirundinaceum	Mistletoebird									✓
Dicrurus bracteatus^	Spangled Drongo					✓				
Eopsaltria australis	Eastern Yellow Robin			✓	✓		✓			✓
Eurystomus orientalis^	Dollarbird							✓	✓	
Geopelia humeralis~	Bar-shouldered Dove				✓			✓		
Gerygone mouki~	Brown Gerygone	✓	✓		✓		✓			
Grallina cyanoleuca	Magpie-lark									✓
Gymnorhina tibicen	Magpie			✓	✓					✓
Hirundo neoxena	Welcome Swallow				✓					
Ixobrychus flavicollis ~∞	Black Bittern								Possible	
Lichenostomus chrysops~	Yellow-faced Honeyeater									Possible
Lopholaimus antarcticus	Topknot Pigeon									✓
Macropygia amboinensis+	Brown Cuckoo-dove				✓		✓	✓		✓
Megalurus gramineus~	Little Grassbird									✓
Meliphaga lewinii	Lewin's Honeyeater		✓	✓	✓		✓	✓	✓	✓
Monarcha trivirgatus~+#^	Spectacled Monarch		✓			✓				
Myzomela sanguinolenta	Scarlet Honey Eater							✓		
Neochmia temporalis+	Red-browed Firetail									✓
Ninox novaeseelandiae^	Southern Boobook	✓								
Nycticorax caledonicus^	Nankeen Night Heron								Possible	
Orthonyx temminckii+	Logrunner		✓	✓	✓	✓	✓			
Pachycephala pectoralis	Golden Whistler	✓	Possible		✓		✓			✓
Phalacrocorax carbo ~	Great Cormorant			✓						
Phalacrocorax melanoleucos~	Little Pied Cormorant									✓
Psophodes olivaceus+	Eastern Whipbird	✓	✓	✓				✓		✓

SCIENTIFIC NAME	COMMON NAME	SITE 1		SITE 2		SITE 3		SITE 4	SITE 5	
		NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	MAR-11	NOV-10	NOV-10	MAR-11
Ptilinopus magnificus	Wompoo Fruit-dove	✓								
Rhipidura fuliginosa	Grey Fantail		Possible					✓		✓
Rhipidura leucophrys	Willie Wagtail									✓
Rhipidura rufifrons	Rufous Fantail		✓		Possible		✓			
Sericornis citreogularis	Yellow-throated Scrubwren	✓	✓				✓			
Sericornis frontalis	White-browed Scrubwren		✓							✓
Sericornis magnirostris	Large-billed Scrubwren						✓			
Sphecotheres viridis	Figbird				✓			✓		
Strepera graculina	Pied Currawong		✓		✓	✓	✓			✓
Todiramphus macleayii subsp. *incinctus*+ ~ ^	Forest Kingfisher				✓					
Todiramphus sanctus^+	Sacred Kingfisher					✓				
Tregellasia capito	Pale Yellow Robin						✓			
Trichoglossus haematodus	Rainbow Lorikeet							✓		✓
Vanellus miles	Masked Lapwing				✓	✓				
Zosterops lateralis	Silvereye			✓	Possible				✓	✓

^Denotes marine species; # denotes migratory species; + denotes riparian species; ~ denotes wetland species, ∞denotes vulnerable species

Appendix G: Threatened species assessments under Part 3A and EPBC Act Guidelines

The draft Guidelines for Threatened Species Assessment by the then Department of Environment and Conservation & Department of Primary Industries (2005) outline the assessment process for threatened species populations, or ecological communities or their habitats for development applications assessed under Part 3A of the Environment Planning and Assessment Act (1979).

Appendix 3 of the Guidelines details the questions to assess potential impacts of a proposal on threatened species, populations or ecological communities or their habitat (as listed under the TSC Act). The questions are included below and the tables below assess these criteria for each species identified within the study area, considered likely to occur or have the potential to occur.

The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) considered a number of species through the application of the Part 3A assessment of significance (SMEC 2011, Appendix 4). These Part 3A assessments of significance were undertaken for a number of threatened flora and fauna species and endangered ecological communities that occur within both the terrestrial and riparian/aquatic habitats within the study area. As such, the conclusions determined within the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) for species that have been recorded, likely to occur or have the potential to occur have been utilised within this aquatic ecology assessment, therefore these species have not been considered further within this aquatic ecology impact assessment.

Species	1 - Lifecycle Impacts	2 - EECs	3 - Habitat Impacts	4 - Distribution Limits	5 - Disturbance Regimes	6 - Critical Habitat	7 - Recovery plan/threat abatement plan	Conclusion
Maccullochella ikei Eastern Freshwater Cod	Breeding occurs in spring when water temperatures rise above 16º with hatching temperatures at 17-20º (NSW Fisheries 2004). Release of cold water into the system may result in temperatures not conducive to breeding.	Not an EEC therefore not applicable	This species does not undergo upstream or downstream migrations (NSW Fisheries 2004) therefore habitat disconnectivity is unlikely to be an impact. The species inhabits clear flowing rivers with rocky substrate. They are associated with deeper parts of rivers near cover and lay adhesive eggs to rocks and logs (NSW Fisheries 2004). The dam could potentially alter the substrate to be more silt-dominant, particularly within the inundation area and thereby reduce suitable habitat for this species.	The natural population of this species is considered extinct within the Richmond River system (NSW Fisheries 2004). Re-stocking with artificially bred juveniles was undertaken in the late 1980's and there is anecdotal information to suggest that stocked fish have survived in the Rocky Creek system (NSW Fisheries 2004)	n/a	No critical habitat has been declared for this species	Overall recovery objective of this species is to ensure the recovery and natural vaibility of Eastern Freshwater Cod populations within their former range. Recovery actions include habitat protection and restoration (NSW Fisheries 2004). This may be applicable to Rocky Creek in terms of identifying suitable sites to re-establish Eastern Freshwater Cod populations.	Although it is unlikely that a natural population of this species occurs in Rocky Creek it may be possible that re-stocked individuals still occur. Construction and subsequent operation of the dam would not likely have a significant impact on the habitat and potentially the breeding cycle of this species.
Morgunda adspersa Purple-spotted Gudgeon	Breeding occurs between December and February, when water temperatures are 20-34º and food is abundant. Hatching takes place at temperatures of 20-29º (McDowall 1996). Release of cold water into the system may result in temperatures not conducive to breeding.	Not an EEC therefore not applicable	Usually associated with benthic structures in water up to 2 m deep. May be associated with rocks, snags or aquatic vegetation (Wager & Jackson 1993). Adults feed on worms, mosquitofish, dragonfly larvae, chironomid and mosquito larvae (McDowall 1996). The dam could potentially alter the substrate to be more silt-dominant, particularly within the inundation area and thereby reduce suitable habitat for this species.	Is found locally in coastal streams from Northern NSW to Northern QLD.	n/a	No critical habitat has been declared for this species	A recovery plan for this species is currently being developed. Recovery strategies include surveying and mapping, monitoring, conservations stocking and recovery plan preparation (DPI 2012).	If this species occurs in Rocky Creek construction and subsequent operation of the dam would not likely have significant impact on the habitat and potentially the breeding cycle of this species.
Nannoperca oxleyana Oxleyan Pygmy Perch	Breeding usually occurs from early spring through to late autumn, although spawning is concentrated from October to December, when water temperatures exceed 20ºC. Release of cold water into the system may result in temperatures not conducive to breeding.	Not an EEC therefore not applicable	Oxleyan Pygmy Perch have a restricted and patchy distribution in coastal lowlands from north-eastern NSW to south-eastern Queensland including Fraser, Moreton and Stradbroke Islands. Populations are most common on the coastal floodplains of NSW where they disperse between water bodies during localised flood events. Oxleyan Pygmy Perch mostly occur in swamps, creeks and lakes of coastal 'wallum' (Banksia-dominated coastal heath). These waters are usually acidic, with low salinity and low conductivity, and are often darkly stained. They seem to prefer slow-moving or still waters with plenty of shelter in the form of dense aquatic vegetation (e.g. sedges) or undercut, root-filled banks fringed with submerged riparian (river bank) vegetation.	Oxleyan Pygmy Perch are a small freshwater fish, endemic to the coastal region of eastern Australia, from northern NSW to south-eastern Queensland.	n/a	No critical habitat has been declared for this species	Overall recovery objective of this species is to prevent the extinction and ensure the recovery and ongoing viability in nature of Oxleyan Pygmy Perch populations. Recovery actions include habitat protection and restoration (NSW Fisheries 2004). This may be applicable to Rocky Creek in terms of identifying suitable sites to re-establish Oxleyan Pygmy Perch populations.	If this species occurs in Rocky Creek construction and subsequent operation of the dam would not likely have significant impact on the habitat and potentially the breeding cycle of this species

Ephippiorhynchus asiaticus Black-necked Stork	Breeding activity for this species occurs year-round with most activity occurring between June and December. Storks usually nest in isolated paddock trees or shrubs within wetlands, usually in or near freshwater swamps. Eels have been the only food seen to be delivered to nestlings (BioNet 2012a). Construction of the dam requires clearing of trees which is a major threat to the Black-necked Stork. If nests are observed dam construction should be undertaken outside of the peak breeding season. As eels were recorded during the fish surveys, dam construction may impact this species which in turn could reduce food available for fledglings.	Not an EEC therefore not applicable	Black-necked Storks are found on a variety of wetland habitats and surrounding marginal vegetation. They mainly forage in shallow, still water, preferring open wetlands. They feed on a variety of prey including eels, fish, frogs, turtles, snakes and small invertebrates (BioNet 2012a). Dam construction will cause foraging disturbance but as this species is mobile and there are other permanent waterbodies nearby there will unlikely be a significant impact on food availability during this phase. Dam construction also requires the clearing of trees which is a major threat to this species. Upon completion of construction Dunoon Dam has the potential to provide additional habitat for this species.	Black-necked Storks are widespread in coastal and subcoastal northern and eastern Australia (BioNet 2012a). The proposed Dunoon Dam is not located within distribution limits for this species.	n/a	No critical habitat has been declared for this species, however; clearing of remnant vegetation patches and individual trees coupled with competition for nests with other species has resulted in a scarcity of appropriate nests sites (BioNet 2012a).	There is no recovery plan/threat abatement plan for this species.	Clearing of remnant vegetation and individual trees during the construction of the dam is likely to be the greatest threat to this species. Nests can be cryptic and may go unnoticed. Disturbance to foraging sites is likely to have a minor impact. Once construction is complete there is potential for the proposed dam to become additional habitat for this species. The proposed dam is not likely to have significant impact on this species.

Assessment of significance under the EPBC Act has been undertaken in accordance with the *Matters of National Environmental Significance (NES) Significant Impact Guidelines* (DEWHA 1999). The *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) considered a number of species through the application of the assessment of significance under the EPBC Act (SMEC 2011, Appendix 4). These assessments of significance were undertaken for a number of threatened flora and fauna species listed under the EPBC Act that occur within both the terrestrial and riparian/aquatic habitats within the study area. As such, the conclusions determined within the *Dunoon Terrestrial Ecology Impact Assessment* (SMEC 2011) for species that have been recorded, likely to occur or have the potential to occur have been utilised within this aquatic ecology assessment. Therefore these species have not been considered further within this aquatic ecology impact assessment. Two fish species, the Eastern Freshwater Cod and Oxleyan Pygmy Perch have been considered below through the EPBC Act assessment of significance.

Eastern Freshwater Cod and Oxleyan Pygmy Perch

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- *lead to a long-term decrease in the size of an important population of a species*

Within this assessment, an 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity and/or
- populations that are near the limit of the species range.

No populations for the vulnerable Eastern Freshwater Cod and Oxleyan Pygmy Perch have been recorded within the study area as important within recovery plans under the EPBC Act. The Eastern Freshwater Cod was recorded in two separate pools in the 1990s (Bishop 1998). It is unclear if these records relate to natural communities (distinct from stocked populations) as Whian Whian Falls at the downstream end of this reach provides a significant natural barrier to fish migration. It is unlikely that given the historical recording and no recordings of either species during the survey period, that the study area would constitute important populations of the species.

- *reduce the area of occupancy of an important population*

The proposed dam will not reduce the area of occupancy of any important population, given the absence of these species within the proposed inundation area.

- *fragment an existing important population into two or more populations*

No populations of these species were recorded within the proposed inundation area, therefore not fragmenting an existing population. However, potential habitat for these species will be fragmented by the construction of the proposed dam wall. Critical habitat has not been identified for these species within the study area. However, the works will remove the habitat

within the study area associated with their occurrence and therefore their survival within the study area may adversely be affected should.

- *disrupt the breeding cycle of an important population*

The proposed dam study area does not contain an important population of either the Eastern Freshwater Cod or the Oxleyan Pygmy Perch. The altered flow regimes and potential cold water release from the proposed dam may hinder the breeding cycle of these species, however, given that no populations have been recorded immediately downstream and cold water effects are only likely to impact as small area of the downstream habitat, it is anticipated that the proposed dam is unlikely to significantly disrupt the breeding cycle of these species.

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

The works will permanently remove a significant amount of habitat available for these species within the study area, however, given the habitat within the proposed dam impact area is not currently being utilised by these species, and natural barriers, including Whian Whian Falls immediately upstream of the proposed inundation area, it is anticipated that the proposed dam will not isolate or decrease the availability or quality of habitat to significantly impact the species so that the species is likely to decline.

- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*

The proposed dam will create a favourable habitat for a variety of native and alien species, including fish. Whilst the proposal itself does not advocate stocking with other fish species, experience elsewhere in Australia generally suggests that other species, including noxious species, are likely to become established. Species like common carp would change the environment to the detriment of Eastern Freshwater Cod and Oxleyan Pygmy Perch.

- *introduce disease that may cause the species to decline, or*

This is not anticipated to occur as a result of the proposed dam.

- *interfere substantially with the recovery of the species.*

Recovery plans exist for both the Eastern Freshwater Cod and Oxleyan Pygmy Perch. The recovery plans establish an objective to prevent extinction and maintain the viability of the species. Given that the study area does not provide critical habitat for these species and no viable populations have been recorded, it is considered that the proposed dam will not interfere substantially with the recovery plans for these species.

Conclusion: The proposed works are not likely to have a significant impact on the Eastern Freshwater Cod and Oxleyan Pygmy Perch. However, given that the potential impacts on other flora and fauna species within the proposed impact area, it is recommended that a referral including these species (from a precautionary principal) be undertaken accordance with the EPBC Act to the Minister for SEWPaC.

References used in assessment of significance

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Appendix H: Estimated cost of monitoring

ASPECT	RECOMMENDED MONITORING	ESTIMATED COST (BASED ON 2012 PRICES) *
Pre-construction Stage (until construction commences)		
Water quality	Thermister chains installed at deep pools upstream and downstream of the proposed dam (each with minimum of three water temperature data loggers)	$500 / thermister chain + installation ($1200) Regular downloading of data is required
	Water quality monitoring (suspended sediment, Total Kjehldahl Nitrogen and Nitrates) upstream and downstream of the existing Rocky Creek Dam	$275 / site (triplicate samples)
	Detailed soils assessment within the proposed full supply level and predicted top water levels	$13,000 Assumed approximately 1 bore hole / kilometre of perimeter and soil testing of two horizons
Aquatic ecology	AUSRIVAS-style macroinvertebrate monitoring (minimum of five sites)	Sample collection $6,250 / trip Bug identification $750 / trip Note that autumn and spring monitoring is recommended
	Monitoring of fish assemblages (upstream of, within and downstream of inundation area, including sites upstream and downstream of Terania Creek)	$3,600 / site
	Monitoring and mapping of platypus population	$6,000
Construction Stage (until dam is operational)		
Water Quality	Monitoring of water quality to determine if erosion and sedimentation control management plan is restricting the mobilisation of sediments in the habitat downstream	Weekly and after storm events $550 / sample round

ASPECT	RECOMMENDED MONITORING	ESTIMATED COST (BASED ON 2012 PRICES) *
	of the proposed water storage area.	
Operation Phase		
Water quality	Monitoring of water quality during the initial filling period to assist in controlled releases during filling (filling period only)	Weekly and after storm events $550 / sample round
	Within-dam water quality monitoring (temperature, dissolved oxygen and algal) to determine vertical variability to allow selection of suitable depth for intake of controlled releases (on-going during dam operation).	$2,000
	Dissolved oxygen probe maintained in large pool downstream of the dam wall	$5,000
	Monitoring of shoreline erosion to determine if (additional) mitigation measures are required (filling phase and at regular intervals during operation, as to be specified in the Foreshore Management Plan).	$3,300
Aquatic ecology	AUSRIVAS-style macroinvertebrate monitoring (minimum of five sites)	Sample collection $6,250/ trip Bug identification $750 / trip
	Monitoring of fish assemblages (upstream of, within and downstream of inundation area, including sites upstream and downstream of Terania Creek)	$3,600 / site
	Monitoring and mapping of platypus population Monitoring within the proposed inundation area should be undertaken to determine if habitat for platypus is achieved.	$6,000 Some 30 pools have been identified as potentially suitable for platypus. Dawn and dusk surveys at each site for minimum half hour period.
	Monitoring for exotic plants	$2,500

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