Volume 2
Appendix E and F

September 2012

Sydney WATER

Water and wastewater servicing of the West Dapto Urban Release Area and Adjacent Growth Areas

Environmental Assessment

Appendix E

Flora and fauna assessment

West Dapto Water & Wastewater Servicing - Flora, Fauna and Ecological Assessment Part 3A

Prepared for
Sydney Water

July 2012

DOCUMENT TRACKING

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Contents

List of Figures

List of Tables

Abbreviations

ABBREVIATION	DESCRIPTION
AGA	The Adjacent Growth Areas consists of the following Precincts: • Tallawarra • Huntley • Calderwood • Tullimbar Village • Yellow Rock Healthcare Facility
Benchmarks (vegetation benchmarks)	Quantitative measures of the range of variability in vegetation condition where there is relatively little evidence of modification by humans since European (post-1750) settlement. Benchmarks are defined for specified variables for vegetation communities. Vegetation with relatively little evidence of modification generally has minimal timber harvesting (few stumps, coppicing, cut logs), minimal firewood collection, minimal exotic weed cover, minimal grazing and trampling by introduced or overabundant native herbivores, minimal soil disturbance, minimal canopy dieback and no evidence of recent fire or flood. It is not subject to high-frequency burning and has evidence of recruitment of native species. Benchmarks are available by vegetation class (*sensu* Keith 2004) at http://www.environment.nsw.gov.au/projects/BioMetricTool.html and can also be obtained from reference sites or published sources
CA	Concept Plan Area: the entirety of the WDURA and the AGA
Cleared Land	Where the native over-storey has been cleared, there is no native mid-storey (or the native mid-storey has been cleared), and less than 50% of the ground cover vegetation is indigenous species or greater than 90% of the ground cover (dead or alive) is cleared.
CMA Area	The area of operation of a catchment management authority, as described in Schedule 2 of the *Catchment Management Authorities Act 2003*
CMA Sub-region	Sub-regions of catchment management authority areas as set out in the Environmental Outcomes Assessment Methodology, *Native Vegetation Regulation 2005*.
Derived Native Grassland	A vegetation type cleared of overstorey species that now maintains a grassland structure, ‗derived' from the former structural definition, e.g. woodland, forest etc.
DGRs	Director Generals Requirements
Endangered Ecological Community	As defined in s. 4(1) of the TSC Act and any additional endangered ecological communities listed under Part 13 of the EPBC Act.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

ABBREVIATION	DESCRIPTION
FFEA	Flora, fauna and ecological assessment
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component.
HBT	Hollow Bearing Tree
Local area	Defined as a 10 km radius from the PA and CA
Locality	See local area
Moderate to good condition vegetation	Native vegetation that is not in low condition.
Proposal	Proposal includes the Concpt Plan and the Project Application under Parts 3A of the EP&A Act
PA	Project Application Area: a subset of the CA on the north and eastern edge of the WDURA and the AGA
Rehabilitation	Land that is to be reconstructed from the ground up, i.e., revegetation of the final landform.
Revegetation	Cleared land (as per above definition) that is to be replanted with local provenance grasses/trees.
Study Area	Study Area means the development footprint and any additional areas that may be affected by the proposal, either directly or indirectly. For the purposes of this FFEA the Study Area is defined as a 50m corridor along the pipeline route, and around associated infrastructure installations.
The Proponent	Sydney Water Corporation
TEC	Threatened Ecological Community: collective term used to refer to critically endangered, endangered and vulnerable ecological communities, as defined under the EPBC and TSC Acts.
Threatened Species	Critically endangered, endangered or vulnerable threatened species and populations as defined in s. 4(1) of the TSC Act; or any additional threatened species listed under Part 13 of the EPBC Act as critically endangered, endangered or vulnerable.
TSC Act	NSW *Threatened Species Conservation Act 1995*
Vegetation Type	The finest level of classification of native vegetation used in the methodology. Vegetation types are assigned to vegetation classes, which in turn are assigned to vegetation formations. There are approximately 1,600 vegetation types within NSW.
WDURA	The West Dapto Urban Release Area (WDURA) consists of the following Precincts:

ABBREVIATION	DESCRIPTION
	• Kembla Grange • Sheaffes/Wongawilli • West Horsley • Dapto Sub-regional Centre • Horsley Industrial • Cleveland • Avondale • Yallah/Marshall Mount • East Horsley

1 Introduction

1.1 BACKGROUND

Sydney Water is responsible for planning for the provision of water and wastewater services in the West Dapto Urban Release Area (WDURA) and the Adjacent Growth Areas (AGA). Sydney Water is preparing an Environmental Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act), for construction and operation of the water and wastewater infrastructure required to service these areas (the Proposal). Sydney Water will seek Concept Approval (CA) and concurrent Project Approval (PA) from the NSW Department of Planning and Infrastructure (DP&I). The CA area includes the whole of the West Dapto Urban Release Area and Adjacent Growth Areas, whilst the PA only relates to pipelines in the northern area (refer to Figure 1).

The water and wastewater infrastructure components of the proposal include:

- Water pipelines (greater than 300mm diameter)
- Wastewater pipelines (greater than 300mm diameter)
- New water pumping stations and upgrades to existing water pumping stations
- New sewage pumping stations and upgrades to existing sewage pumping stations
- Transfer of wastewater flows from the new growth areas to Wollongong or Shellharbour Wastewater Treatment Plants
- Potential amplification and/or upgrade of Wollongong and Shellharbour Wastewater Treatment Plants
- Three new water reservoirs

The purpose of this flora, fauna and ecological assessment is to undertake and report on potential ecological impacts of construction of the pipelines and associated infrastructure. This assessment addresses the related flora, fauna and ecological aspects of the Director General's Requirements (DGRs), issued 18th November 2009 and re-issued on 4th July 2011.

This report includes consideration of direct and indirect impacts on any threatened species, populations, ecological communities and/or critical habitat and any relevant recovery plan in accordance with the *Guidelines for Threatened Species Assessment* (DEC & DPI, 2005). These impacts are also assessed for Matters of National Environmental Significance (MNES) (specifically threatened and migratory species), consistent with *MNES Significant Impact Guidelines 1.1* (DEWHA 2009). This assessment also takes into consideration the *Illawarra Escarpment and Coastal Plain - Bioregional Assessment* (DEC 2003), specifically the *Native Vegetation of the Illawarra Escarpment and Coastal Flood Plain* (NPWS 2003).

The riparian assessment includes an in situ evaluation of creeks, rivers and streams in the Proposal area for potential impacts to aquatic ecosystems, riparian zones, fish passage and the potential for weed infestation with consideration to the *Riparian Corridor Management Study* (DIPNR 2004).

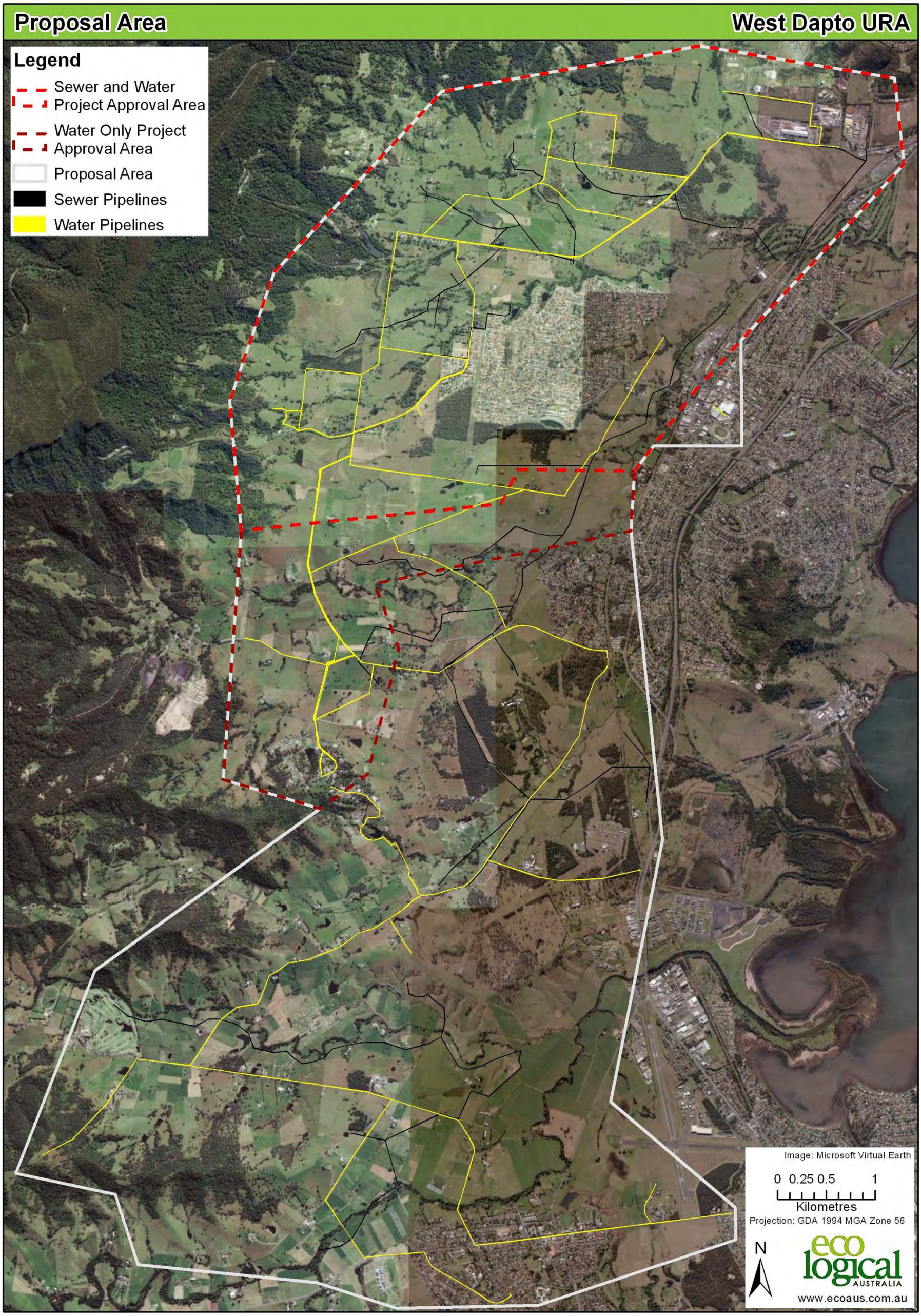

Figure 1: The Project Approval and Concept Approval Areas

1.2 COMPLIANCE WITH DIRECTOR-GENERAL'S REQUIREMENTS

The DGRs issued under s75F(2) of the EP&A Act identify the matters that must be covered by the Environmental Assessment for the Concept Approval and Project Approval applications. DGRs for the proposal were initially provided on the 18th November 2009 and were re-issued on the 4th July 2011. DGRs relating to flora, fauna and aquatic have habitat been identified in Table 1. This report also addresses other comments raised by agencies during preparation of the DGRs.

Table 1: Director Generals Requirements (DGRs) and relevant sections.

REQUIREMENT	RELEVANT REPORT SECTION
Impacts on any threatened species, populations, ecological communities and/or critical habitat and any recovery plan in accordance with the *Guidelines for Threatened Species Assessment (DEC&DPI, 2005)* and with consideration to the *Illawarra Escarpment and Coastal Plan – Bioregional Assessment (DEC July 2003)*.	**7.3**
This assessment shall include a description of the actions to avoid impact in the first instance and then mitigate impacts or compensate unavoidable impacts	**7.2**
The EA should address key threatening processes, justify the need for clearing and vegetation and/or habitat features and include an evaluation of potential impacts on waterways, aquatic ecosystems or riparian zones, including any instream stormwater basins, potential weed infestation and impacts to fish passage.	**7.2**
Offsets should be considered for clearing of native vegetation consistent with –improve or maintain principles". Sufficient details must be provided to demonstrate the availability of viable and achievable options to offset the impacts of the project	**7.2 and 8.5**
Where the proposal would be located adjacent to DECCW estate, the EA must identify management implications on DECCW estate from edge effects such as weed and pest management consistent with the *Guidelines for Development Adjoining DEC Land* and identify all reasonable and feasible measures to minimise impact.	**2.7**

1.3 REPORT OBJECTIVES

The objectives of this report are to:

- Assess the impacts to biodiversity values resulting from construction of the water and wastewater infrastructure required to service the West Dapto Urban Release Area and the Agreed Growth Areas (the Proposal)
- Undertake a flora, fauna and riparian assessment of the Proposal area i.e., the PA and CA areas, sufficient to address all aspects of construction of the Proposal in accordance with the Director Generals Requirements (DGRs) and State and Commonwealth Government agency comments on the DGRs
- Report on the known and potential occurrence of any relevant threatened species, populations, ecological communities and migratory species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) and/or the NSW *Threatened Species Conservation Act 1995* (TSC Act)
- Provide advice relevant to modifying the Proposal to avoid, mitigate or offset any potential impacts

2 Study Area

2.1 OVERVIEW

In this report, the term Proposal area refers to the West Dapto Urban Release Area and the Adjacent Growth Areas. Within the Proposal area, the study area is the 50m wide corridor in which the direct and indirect impacts may occur.

The WDURA and AGAs are situated partially in the Wollongong and Shellharbour Local Government Areas (LGAs), approximately 100 km south of the Sydney CBD. This area is located within the Central Coast botanical division of New South Wales (Anderson 1961), in the Sydney Basin Bioregion (Thackway and Creswell 1996).

The WDURA lies within the Illawarra Escarpment and Coastal Floodplain, an area characterised by the transition from the elevated ridgelines associated with the Illawarra Escarpment to the west, through the coastal floodplain to Lake Illawarra and the beaches of Wollongong and Shellharbour LGAs. It extends north as far as Kembla Grange, west to the Illawarra Escarpment, south to Calderwood Valley and east to Lake Illawarra.

The area consists predominantly of grassy woodlands, exotic grazing pastures, and urban to peri-urban development. Land use is generally small scale cattle farming and horse agistment with varying levels of pasture improvement. These land uses have been practised since the early 1800's (Fuller 1980), and have resulted in the native vegetation being either cleared, or extensively modified so that the remnant native vegetation is generally in a degraded and simplified condition state. These land uses are ongoing across the coastal floodplain, with agricultural land uses increasingly being replaced by urban development.

Given the history of agricultural land use, at the time of survey (May-June 2011), large areas of the vegetation are considered to be threatened ecological communities (TEC) under NSW legislation and remain disjunct as small remnants throughout the landscape.

2.2 SOIL LANDSCAPES

Soil Landscapes are areas of land that have recognisable and specifiable topographies and soils, that are capable of presentation on maps and can be described by concise statements (Northcote, 1978). *Landscapes* can be used to group Soil Landscapes, because of similar causal factors (McDonald et al 1998). There are five Landscapes recognised within the Proposal area, consisting of nine Soil Landscapes, as outlined in **Table 2** and presented in **Figure 2.**

Table 2: Soil landscapes present within the Field Assessment Area

SOIL LANDSCAPE GROUP	LOCATION WITHIN FIELD ASSESSMENT AREA	CHARACTERISTICS
RESIDUAL LANDSCAPE		
Gwynneville (gw)	Throughout the Mount Brown Reserve to the south of Kanahooka. Small outcrops along the highway north Dapto township and north of West Dapto Rd, Kembla Grange.	**Geology**: Illawarra Coal Measures – resistant interbedded quartz-lithic sandstone, grey siltstone and claystone, carbonaceous claystone clay and 5aminate; Dapto Latite Member – melanocratic coarse-grained to porphyritic latite **Landscape**: Undulating to steep hills on the Coastal Plain (local relief 10 – 70 m). **Vegetation**: In residual areas the original tall open-forest and open-forest have been extensively cleared. **Soils**: • Shallow (50 – 100 cm) • Brown Podzolic and Xanthozems on the upper slopes • Lithosols on simple slopes • Shallow Brown Earths on midslopes and lower slopes • Sandy clay loam, light to heavy clay.
COLLUVIAL		
Illawarra Escarpment (ie)	Small outcrop in the centre-west of the Field Assessment Area, Avondale.	**Geology**: Quaternary Talus – blocks of sandstone, deep colluvial detritus and soils materials. These materials overlie benches and smaller scarps cut from the Narrabeen Group, the Illawarra Coal Measures and the Shoalhaven Group. **Landscape**: Steep to very steep slopes on Quaternary talus (relief 100-500m). Gradients 20-50%. **Vegetation**: Mostly uncleared tall open-forest and closed forest. **Soils**: • Deep colluvial Red and Brown Podzolic Soils occur on slopes. • Lithosols occur where talus is recent.
EROSIONAL LANDSCAPES		
Albion Park (ap)	Throughout the Field Assessment Area.	**Geology:** Berry Formation – mid-grey to dark grey siltstone, mudstone, and fine sandstone with localised outcrops of Bundgong Sandstone on the mid to upper slopes. Localised outcrops of Bumbo Latite occasionally occur on crests. **Landscape:** Short steep upper slopes grading into long gently inclined footslopes (relief 60 - 100 m). **Vegetation:** Extensively cleared with remnant stands of tall open-forest. **Soils:** • Moderately deep (50 – 100 cm) • Brown Podzolic Soils on crests • Yellow Podzolic Soils on midslopes • Soloths on footslopes and drainage lines • sandy clay loam, light clay, heavy clay

SOIL LANDSCAPE GROUP	LOCATION WITHIN FIELD ASSESSMENT AREA	CHARACTERISTICS
Bombo (bo)	Marshall Mount Rd Yallah; South of the Illawarra Hwy, Albion Park.	**Geology:** Bumbo Latite Member – alphanitic to porphorytic latite **Landscape:** Rolling low hills, slope gradient 15-25% (relief 40-100m). Scattered benches and terracettes on upper slopes. Coastal headlands with cliffs and extensive rock platforms. **Vegetation:** Extensively cleared with remnant stands of closed-forest and tall open-forest. **Soils:** • Shallow (< 50cm) • Structured Loams occur on crests, moderately deep (50-100cm) • Kraznozems on upper slopes and benches • Brown and Red Podzolic soils occur on mid and lower slopes
Cambewarra (ca)	Upper reaches of the Cambewarra Range, Calderwood.	**Geology:** Cambewarra Latite Member – felsic latite with olivine basanite outcrops; Illawarra Coal Measures – interbedded quartz lithic sandstone, mudstone, carbonaceous claystones and coals. **Landscape:** Steep to very steep hills with broad colluvial benches on latite (relief 100-200m. Slope gradients >30% **Vegetation:** Uncleared to partially cleared closed-forest. **Soils:** • Deep Red Solonetzic Soils or Kraznozems occur on upper slopes and benches. • Lithosols occur on basanite outcrops.
Shellharbour (sh)	Rolling hills through the centre of the Field Assessment Area, west from Avondale through Dapto to the shores of Lake Illawarra. Large outcrop towards the south at Marshall Mount / Yallah.	**Geology:** Budgong Sandstone – red brown and grey volcanic sandstones on the Coastal Plain **Landscape:** Located on low rolling hills (20 – 50 m relief) with long sideslopes and broad drainage patterns. **Vegetation:** Extensively cleared with stands of tall open-forest and closed-forest in sheltered locations. **Soils:** • Deep (>150 cm) • Prairie soils on the crest and upper slopes • Brown Krasnozems on midslopes • Red Podzolic and Prairie Soils on lower slopes and drainage plains • Sandy loam, sandy clay to light clay

SOIL LANDSCAPE GROUP	LOCATION WITHIN FIELD ASSESSMENT AREA	CHARACTERISTICS
SWAMP		
Fairy Meadow (fa)	The vast majority of the Coastal Floodplain.	**Geology:** Quaternary Sediments – quartz, sand, lithic fluvial sand, silt and clay. **Landscape:** Alluvial plains, floodplains, valley flats and terraces below the Illawarra Escarpment (relief < 10 m). **Vegetation:** Almost completely cleared except for some isolated stands of low open forest and woodland. **Soils:** • Moderately deep (50– 100 cm) Alluvial loams and siliceous sands on terraces Prairie and Yellow Podzolic Soils on the drainage plains Light clay to sandy clay loam, heavy clay to medium clay
DEPOSITIONAL		
Wattamolla Rd (wt).	Hilly terrain to the south and west of the Field Assessment Area	**Geology:** Budgong Sandstone – red brown and grey volcanic lithic sandstones. **Landscape:** Long gently to moderately inclined sideslopes and undulating to rolling hills with broad benches on Budgong Sandstone (relief (<200m). Slopes 5-15% **Vegetation:** Extensively cleared with stands of tall open-forest. **Soils:** • Moderately deep (50-100cm) Red Podzolic Soils on upper slopes and benches. • Yellow Podzolic Soils on mid and lower slopes.
DISTURBED		
Disturbed Terrain (XX)		**Geology:** N/A. **Landscape:** Topography varies from level plains to undulating terrain. Has been disturbed by human activity to a depth of at least 100 cm. **Vegetation:** The original vegetation has been completely cleared. **Soils:** The original soils has been removed, greatly disturbed or buried.

Sources: Hazelton and Tille (1990) and Hazelton (2002)

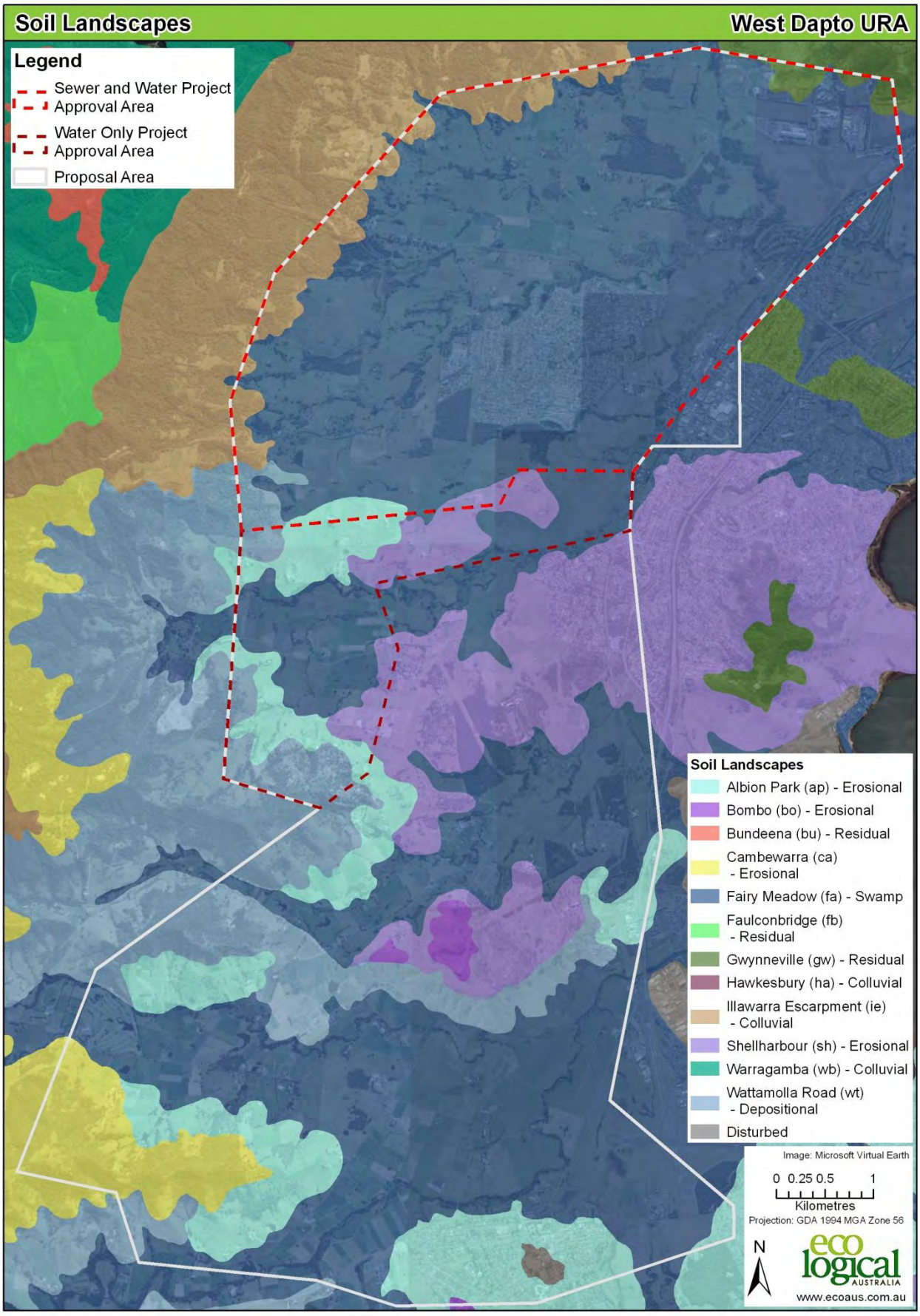

Figure 2: Soil landscapes of the Proposal Area [Hazelton and Tille (1990) and Hazelton (2002)].

2.3 VEGETATION COMMUNITIES

Native vegetation was present throughout much of the study area, with the majority subject to grazing of varying intensity and found to be in varied condition classes, from forest and woodland remnants to cleared exotic pastures. Roadside vegetation exists generally as cleared roadside verges, with some sites maintaining single remnant trees. Most remnants, regardless of size, were impacted upon to some degree by lantana incursions and cattle / horse grazing. Higher condition remnants were restricted to sites where no grazing had taken place (e.g. Yallah TAFE; TruEnergy substation, Yallah, Calderwood foothills) or sites that were only moderately grazed (property adjacent to Yallah TAFE).

The vegetation of the Illawarra Escarpment and Coastal Floodplain was mapped at 1:16,000 scale by the former National Parks and Wildlife Service (NPWS) in 2002. This regional scale vegetation map has been amalgamated into the South Coast and Illawarra Vegetation Integration (SCIVI) (Tozer et al. 2006), which provides a conglomeration of vegetation maps from the Hawkesbury River to the north of Sydney, south to the Victorian border, with the western boundary running from the Blue Mountains to Delegate. This SCIVI project undertook a revision of the classification of vegetation assemblages across this area, though the original aerial photo interpretation and consequent digitisation was not changed. NPWS (2002) remains the most up to date vegetation map for the study area.

The SCIVI project revised the vegetation classification for this area and subsequently these vegetation types were taken up by the BioMetric Vegetation Type (BVT) classification (DECCW 2008), which provides a vegetation classification system for the entire state of NSW. BVT's are the classification system employed in this report. The following BVTs have been mapped within the study area:

- Coachwood - Brown Possumwood warm temperate rainforest in sheltered gullies of the Illawarra Escarpment, southern Sydney Basin
- Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin
- Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner
- Coastal freshwater lagoons of the Sydney Basin and South East Corner
- Lilly Pilly - Sassafras - Stinging Tree subtropical/warm temperate rainforest on moist fertile lowlands, southern Sydney Basin
- Whalebone Tree - Native Quince dry subtropical rainforest on dry fertile slopes, southern Sydney Basin
- Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner
- Sydney Blue GumXBangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin
- Gully Gum - Sydney Peppermint - Yellow Stringybark moist open forest of coastal escarpments, southern Sydney Basin
- River Oak open forest of major streams, Sydney Basin and South East Corner

2.4 CREEKS, LAKES AND WATERCOURSES

Major creeklines that drain the area from north to south include: Sheaffes Creek, Dapto Creek, Robins Creek, Mullet Creek, Duck Creek, Marshall Mount Creek and Macquarie Rivulet. These creeks form the catchment of Lake Illawarra. The headwaters are steep rainforest creeks on the Illawarra Escarpment. They flow quickly onto the expansive alluvial plains where they slow into sinuous lowland creeks before entering the estuarine waters of Lake Illawarra.

In a study by DIPNR (2004), a considerable number of creeks and tributaries were mapped according to their riparian corridor value with an objective to establish protection buffers for different stream categories.

Studies of waterway health in the region have a strong focus on water quality in Lake Illawarra, especially heavy metals, seagrass, macroalgae, nitrogen cycling and fish biodiversity (Sherman et al. 2000). However, except for some water monitoring of larger creeks flowing into the lake, little research has focused on tributaries or smaller reaches in the catchment (O'Donnell et al. 2000). The *Illawarra Biodiversity Strategy* (Wollongong City Council 2010a and b) identifies numerous data gaps in the catchment, including a lack of regional aquatic, invertebrate and vegetation condition (riparian) data.

2.5 GROUNDWATER DEPENDANT ECOSYSTEMS

Groundwater Dependent Ecosystems (GDEs) are defined as ecosystems whose current composition, structure and function are reliant on a supply of groundwater (Eamus 2009), as opposed to surface watering from overland flows. This reliance may be expressed over a range of timescales from daily to inter-annually, however, it becomes clearly apparent when the supply of groundwater, and/or its quality, is altered for a sufficient length of time that changes in plant function result. It is noted that groundwater use does not necessarily equate to groundwater dependence (Dresel et al. 2010).

In Australia, the majority of ecosystems have little dependence on groundwater, although the understanding of the role of groundwater in maintaining ecosystems is generally poor. The exception to this is wetland communities, for which it is thought that most have some dependence on groundwater, ranging from a minor to essential interaction (Hatton and Evans 1998).

GDEs are generally classified into six categories (SCCG 2006, SKM 2001):

- *Terrestrial vegetation* – forests and woodland which develop a permanent or seasonal dependence on groundwater, often by extending roots into the water table
- *Base flow in streams* – aquatic and riparian ecosystem that exist in or adjacent to streams that are fed by groundwater base flow
- *Aquifer and cave systems* – aquatic ecosystems that occupy caves or aquifers. Generally karst or limestone caves found most commonly in NSW in the central-west
- *Wetlands* – aquatic communities and fringing vegetation that depend on groundwater-fed lakes and wetlands
- *Estuarine and near-shore marine ecosystems* – various ecosystems including mangroves, saltmarsh and seagrass, whose ecological function has some dependence on groundwater discharge
- *Terrestrial fauna* – fauna species assemblages reliant on groundwater for drinking water

GDEs have varying degrees of dependency on groundwater. These range from total to occasional dependency and include (SCCG 2006, SKM 2001):

- *Entirely dependent* – ecosystems for which only a slight change in the groundwater regime will have catastrophic consequences
- *Highly dependent* – ecosystems for which moderate changes in the groundwater regime will result in significant changes to ecosystem distribution, health and/or diversity. These ecosystems use both ground- and surface water
- *Proportionally dependent* – ecosystems for which changes in the groundwater regime result in a proportional response to the ecosystem characteristics

- *Opportunistically or minimally dependent* – ecosystems for which the reliance on groundwater is limited to seasonal or climatic variations e.g. end of dry season or drought. These ecosystems use surface water predominantly, however if access to groundwater is prolonged, declines in ecosystem distribution, health and/or diversity are likely

A final category is also recognised – *not apparently dependent*. This category acknowledges that some ecosystems, particularly wetland and riparian vegetation, might superficially appear to be groundwater dependent, but in actual fact are dependent entirely on surface flows and/or rainfall.

Various elements of the groundwater regime influence GDEs. These elements include (SKM 2001):

- Flow or flux – the rate and volume of groundwater supply
- Level – the depth below the water table surface
- Pressure (for confined aquifers) – exchange between the head of the aquifer and the groundwater discharge areas
- Quality – the chemical quality of groundwater including pH, salinity and other constituents such as nutrients and contaminants.

GDEs mapped in the Study area are confined to riparian vegetation that may utilise groundwater-fed base flows of creeks, and freshwater wetlands positioned on low-lying ground close to shallow aquifers (see figures in **Section 6.2**). Vegetation communities that may be recognised as potential GDEs in the Study area include:

- Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner (SR649)
- Coastal freshwater lagoons of the Sydney Basin and South East Corner (SR536)
- River Oak open forest of major streams, Sydney Basin and South East Corner (SR606)

Other vegetation identified by NPWS (2002), but not having a BioMetric Vegetation Type equivalent include:

- Artificial Wetlands
- Estuarine Alluvial Wetland
- Estuarine Lagoons and Channels
- Weeds and Exotics (in riparian zone)

The dependence on groundwater varies dramatically with each community and position in the landscape. There is little information on the dependency of these GDEs in the study area. However, as a safe-guard, estuarine GDEs (estuaries and saltmarsh) can be grouped as opportunistically or minimally dependent, due to their marine influence; and freshwater GDEs (streams, riparian zones and wetlands) can be grouped as highly dependent, especially during base flows.

2.6 SURROUNDING RESERVES

The Proposal area is located between the Illawarra Escarpment and Lake Illawarra. National Parks, reserves and conservation areas are shown in Figure 3. Most significant of these is the Metropolitan Special Area (MSA) immediately to the west and declared in the *Sydney Water Catchment Management Act 1998* for the protection of drinking water for Sydney, the Illawarra and the Blue Mountains. These Special Areas are jointly managed by the Sydney Catchment Authority (SCA) and the Office of Environment and Heritage (OEH).

Figure 3 shows the OEH, SCA, State Forest estate and Crown land parcels within 10km of the pipeline route. The current proposal will not impact on any of the above listed reserves.

Table 3: Surrounding Reserves

Name	Description	Total reserve area (ha)	Area within 10km of PA and CA
Berkley NR	Islands located within Lake Illawarra to the east of the PA	8.59ha	8.59ha
Buderoo NP	NP located to the south of the CA	7,214ha	2,319ha
Five Islands NR	Islands located off the coast of Port Kembla to the east of the PA	27.61ha	12.61ha
Illawarra Escarpment SCA	Located along the edge of the escarpment immediately to the east of the PA. Includes Kembla State Forest	2,511ha	1,501ha
Macquarie Pass NP	Located immediately adjacent to the south-west of the CA	1,062ha	1,062ha
Macquarie Pass SCA	Adjacent to the Macquarie Pass NP to the south-west of the CA	166ha	166ha
Robertson NR	Located to the west of the CA	5.35ha	5.35ha
Upper Nepean SCA	Located within the MSA to the immediate west of the CA and near the PA	25,134ha	1,268ha
Crown Reserves	Both land and road reserves located all around the PA and CA. These sites range from small plots in urban areas to significant parcels in bushland or foreshore areas. Some of these sites are included in the MSA and other listed reserves.	N/A	2,418ha

NP = National Park, NR = Nature Reserve, SCA = State Conservation Area, MSA = Metropolitan Special Area.

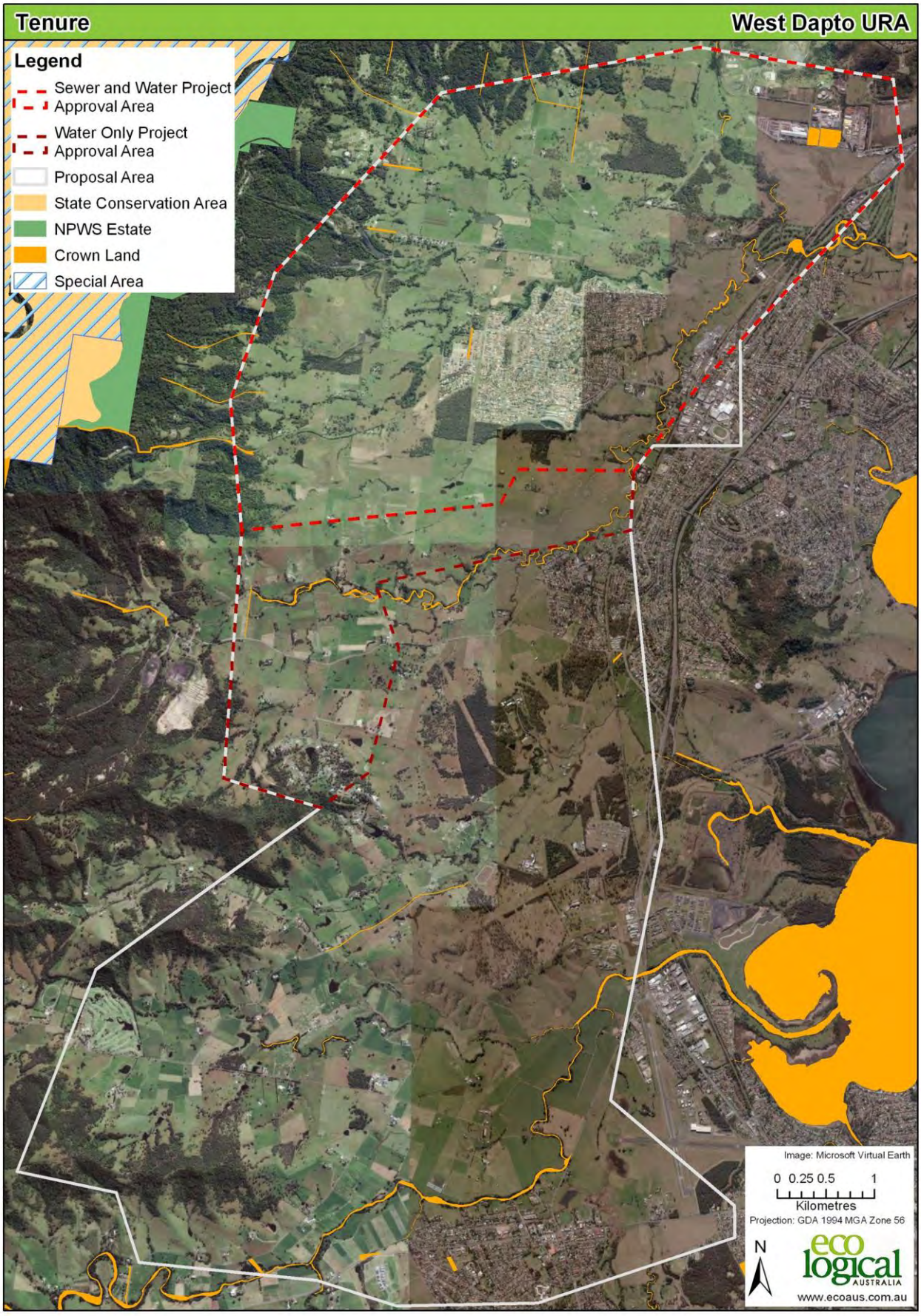

Figure 3: Reserve tenure and Crown Land surrounding the Proposal Area

2.7 CLIMATE

The climate of the Illawarra region is temperate and moderated by Lake Illawarra and the Pacific Ocean. Climatic data measured at the Port Kembla Signal Station (latitude -34.4772 S; longitude 150.9131 E; elevation 11 m) between 1950 and 2004 (BOM 2011) indicate the region experiences warm to hot summers (mean 24.4ºC in February) and cool to mild winters (mean 9.8ºC in July). The average annual daily maximum and minimum temperatures are 20.9ºC and 14.4ºC, respectively.

Mean rainfall is 1,277.4 mm pa with the wettest months being February, April and June, and the driest months being July and September (BOM 2011).

3 Description of Project

3.1 PROPOSED INFRASTRUCTURE

The water and wastewater infrastructure to be constructed as part of the proposal includes:

Table 4: Proposed infrastructure relevant to flora, fauna and ecology

Water services	Proposal components
Water	• 3 new reservoirs; Avondale, Calderwood and Marshall Mount • 14 km of new pipelines from Kembla Grange Water Filtration Plant (WFP) to the new reservoirs. • 59 km of new pipelines from the new reservoirs to the supply areas. • Upgrades to 3 km of existing pipelines from Dapto and Wongawilli Reservoirs • One new 127kW water pumping station in Calderwood • Two new Pressure Relief Valves (PRV)
Wastewater	• 37.9km of new gravity wastewater pipelines • 6.6km of new rising wastewater pipelines in Tallawarra, Yallah, Calderwood Valley and Calderwood • Five new wastewater pumping stations (WWPS) in Tallawarra, Yallah, Calderwood Valley and Calderwood • Upgrades to a number of existing WWPS • Upgrade to the existing Dapto Carrier

The following maximum disturbance footprints have been applied in this report. During construction, the disturbance footprint may be significantly less:

- Pipelines – 10m width disturbance for trenching
- Creek crossings: 10m width disturbance for trenching through dry creeks and/or intermittent creek crossings with flowing or standing water will potentially be bored having no impact on the creek itself
- Pumping Stations – 50m x 50m
- Reservoirs – the entire reservoir property (as determined by the boundary)

3.2 LOCATION OF WATER PIPELINES

The majority of the proposed water pipelines will be located in future road verges and pathways. The remainder will be laid in drainage reserve land or private property. Some of the road verges have already been cleared, whilst others will need to be cleared. Sydney Water will aim to construct water pipelines in the road verges at the time or soon after the NSW Roads & Traffic Authority (RTA) and/or Wollongong City Council undertake road construction.

3.3 LOCATION OF WASTEWATER PIPELINES

The proposed wastewater pipelines will generally be laid adjacent to drainage lines and creek lines to allow for gravity driven transport of wastewater. Rising wastewater pipelines will generally be laid within road reserves. Some of the creek lines that will be affected contain vegetation, whilst others have been previously cleared or disturbed.

Sydney Water will lay wastewater pipelines in the following locations as the preference.

- Within the street reserve in a location clear of carriageways
- Within public land with the permission of the controlling authority
- Within drainage reserves outside the 1 in 100 year flood area
- Within private property parallel to the front, rear, and/or side boundaries.
- Outside of the ~~"~~top of bank" of watercourses wherever possible.

The following locations are avoided for wastewater pipelines where possible:

- National parks, nature reserves, proclaimed reserves, state forests, stands of native vegetation
- Habitats of threatened species
- Steep slopes
- Waterways and floodways
- Wetlands, swamps, estuaries, sand dunes, foreshore areas
- Bushland and vegetation communities and/or fauna
- Heritage items and precincts
- Aboriginal relics and sacred sites
- Unstable areas subject to rock falls, slips and flows including areas steeper than 33% grade
- Aggressive ground conditions such as mining areas, acid sulphate soils and contaminated land, including suspected contaminated land
- Landfill sites and mine subsidence areas.

If these areas cannot be avoided Sydney Water will implement appropriate environmental management measures to manage these issues.

3.4 CONSTRUCTION

Construction of the water and wastewater infrastructure will be staged until 2048. Developers will generally construct the water and wastewater pipelines. Pipelines will be constructed in a sequential manner so that development can occur as Sydney Water's infrastructure is provided.

3.4.1 Pipeline construction methodology

The water and wastewater pipelines will be installed underground using a combination of open trenching and boring techniques, such as micro tunnelling and horizontal directional drilling (HDD). Trenching is the preferred method of pipe installation as it allows open access to the pipeline during construction. Trenching will be the primary pipeline construction method for the Proposal. Trenching will be used to cross dry creeklines and/or creeks with intermittent flow.

Boring will be undertaken when engineering or environmental constraints exclude or make open trenching impractical eg, major creek crossings, major road and rail crossings. Boring will be undertaken where ground conditions permit.

A creek crossing will be required at Mullet Creek for the gravity sewer constructed in Kembla Grange and part of Sheaffes/ Wongawilli to connect to the existing Berkeley Carrier. The crossing is likely to require an inverted syphon crossing due to relative levels in the creek and Berkeley Carrier. An inverted syphon is a closed pipeline with the end sections of the pipe at a higher elevation then the middle section. These crossing types ensure flow is maintained and also reduces wastewater retention time in the pipeline to reduce odour issues. The syphon crossing will be bored.

3.4.2 Open trench excavation and boring

The total construction footprint for the pipeline corridors is expected to be approximately 10 m wide. The trenches will generally be 1.3-1.7 m wide and range in depths from 1.5 m (water pipeline) to 3 to 5 m (wastewater pipeline), depending upon topography.

Construction activities associated with trenching typically include:

- Establish temporary site compounds at appropriate locations along the pipeline route
- Establish erosion and sediment control measures
- Implement traffic management measures
- Prepare site, including pavement, footpath and/or road surface removal or vegetation removal
- Provide temporary access to properties where trenches impact driveways
- Excavate trench, including stockpiling spoil material on the upslope side of trenches
- Shoring and dewatering trenches, depending upon trench depths and groundwater levels
- Spreading granular material such as sand or gravel along the bottom of the trench prior to pipe laying
- Installing and testing of the pipeline
- Constructing maintenance holes
- Backfilling the trenches with bedding material and excavated soil
- Compacting the fill material in the trenches
- Restoring areas disturbed by the construction works

Trenching methods can include both machine trenching and hand trenching. Trenching will generally be carried out using excavators and a small compactor. Rockbreakers may also be required where bedrock is encountered during excavation. Hand trenching may be carried out in environmentally sensitive areas, including areas where there is a need to avoid root damage to large trees and areas where heritage items are located in close proximity to the pipeline route.

In trafficable areas, full spoil removal may be required. In non-trafficable areas the majority of spoil excavated from the trenches will be used to backfill the pipeline route (per Water Services Association of Australia Water and Wastewater Codes).

Potential boring techniques for the Proposal include micro-tunnelling and HDD. Micro-tunnelling requires construction of a launch shaft (approximately 6 m long, 3 m wide and to pipeline depth) and an exit shaft of similar or smaller size. The final depth of the shafts is dependent upon the design level of the proposed pipeline. Additional space is required at the launch site to accommodate plant and equipment. Before micro-tunnelling can commence, the shafts need to be excavated.

Micro-tunnelling generally involves a hole being bored by the cutting heads with the boring equipment being thrust along a straight alignment from the launching shaft to the receiving shaft by means of rods or jacks. Guidance is by laser and survey equipment, which allows for the boring of very flat grades with great accuracy. A single bore hole is restricted to a maximum length of approximately 180 to 200 m.

With HDD, there is no need for a launch shaft to be excavated. Instead, the drilling rig sits on the ground surface and drills into the ground at an angle. The drill head is remote controlled from the surface and can be directed so that both vertical and horizontal curves can be drilled. A potential disadvantage of HDD is that the drill head can become misdirected when there is a change in strata. However, HDD is able to perform much longer bores compared to micro-tunnelling in a similar range of diameters. In a single HDD bore, a length of up to 2 km is achievable.

Activities associated with boring techniques include:

- Establishing sites for the launch and exit shafts, including,

  - Installation of erosion and sediment controls
  - Installation of measures for management of drilling fluids and cuttings
  - Installation of measures for management of groundwater
  - Removal of road/footpath surfaces and clearing of vegetation, as required
  - Installation of fencing and security measures
- Excavation of the launch and exit shafts
- Drilling of the borehole, including removal of spoil and cuttings
- Insertion of the pipe into the borehole
- Disposal at a licensed facility of excess spoil and cuttings that cannot be used in site restoration
- Commissioning of the pipeline
- Restoration of affected areas, including backfilling the bore shafts

3.4.3 Construction of water storage reservoirs and pumping stations

Construction of water storage reservoirs and pumping stations (water and sewage) will commence with basic site preparation works. Site preparation works will include:

- Establishment of site compounds and construction access
- Site levelling, removal of excess soil, vegetation and other earthworks
- Provision of services for construction

The specific activities involved for reservoir and pumping station construction are outlined in the following sections.

3.4.4 Water storage reservoirs

Construction of Water Storage Reservoirs will include:

- Excavation at the site
- Establishment of a concrete pads for the footings or foundations of the reservoirs
- Installation of the surface reservoir structures, including placement and welding of floor and wall sheets and installation of final supporting and connecting structures including roof support columns, roof beams, rafters, pipe fittings, stairs and access doors
- Installation of elevated reservoir structures (assembled and erected on-site and installed using a crane)
- Construction of auxiliary structures
- Installation of underground connecting inflow/outflow pipelines using open trenching techniques
- Electrical and mechanical fitout
- Commissioning

3.4.5 Water pumping stations

Construction of WPS will include:

- Excavation
- Establishment of a concrete pad
- Construction of pumping station building
- Installation of the pumps
- Installation of connecting inflow/outflow pipelines using open trenching techniques
- Electrical and mechanical fitout
- Commissioning

3.4.6 Wastewater pumping stations

Construction of the new SPS will include:

- Excavation and concrete work for construction of wet well and emergency storage
- Installation of the pumps
- Installation of connecting inflow/outflow pipelines using open trenching techniques
- Installation of access covers
- Installation of an electrical control housing structure
- Electrical and mechanical fitout
- Commissioning

Connection to existing network and upgrade of the wastewater pumping station

Water and wastewater pipelines will generally be connected to the existing network by pipe welding and joining, then restoration of roads and affected areas. Upgrading the WWPS will include constructing additional emergency storage and connecting inflow/outflow pipelines using open trenching techniques.

3.4.7 Construction equipment

The machinery/equipment likely to be used during construction includes:

- Excavator
- Small compactor
- Saw cutters
- Welding equipment
- Delivery and concrete trucks
- Powered hand tools
- Small compressor
- Small generator
- Trucks and pumps (if dewatering required)
- Micro-tunnelling or directional drilling rigs
- Crane for wastewater pumping station upgrade.

4 Legislative Context

4.1 COMMONWEALTH LEGISLATION

Environment Protection and Biodiversity Conservation Act 1999

The primary objective of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is to, ‗provide for the protection of the environment, especially those aspects of the environment that are Matters of National Environmental Significance.'

Environmental approvals under the EPBC Act are required for an ‗action' that is likely to have a significant impact on the following.

- Matters of National Environmental Significance (MNES) including:
  - World Heritage Areas
  - National Heritage Places
  - Ramsar wetlands of international importance;
  - Nationally listed threatened species and ecological communities
  - Listed migratory species
  - Nuclear actions
  - Commonwealth marine areas
  - Commonwealth heritage places
- Actions taken on Commonwealth land that are likely to have a significant impact on the environment
- Actions that are likely to have a significant impact on the environment of Commonwealth land, even if the action is taken outside Commonwealth land
- Any action taken by a Commonwealth agency that is likely to have a significant impact on the environment

An ‗action' is considered to include a project, development, undertaking, activity or series of activities.

Actions that may have a significant impact on one or more matters of NES should be referred under the EPBC Act. Of potential relevance to the PA and CA are MNES which include nationally listed threatened species and ecological communities and listed migratory species.

The Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) is responsible for administering the EPBC Act. The Australian Government Environment Minister or DSEWPC (as delegate) then has 20 business days to determine if the action will require further assessment and approval. The only way to get legal certainty as to whether or not the loss constitutes a significant impact is through the Referral process.

The EPBC Act Referrals process can produce one of four outcomes:

I. *Non-controlled action (NCA)*: Assessment and approval under the EPBC Act is not required. This indicates that the project is designed or located in a way that it will not have a significant impact on any matters of NES. The project may proceed without further approval under the EPBC Act.

II. *Non-controlled action – particular manner (NCA-PM)*: Assessment and approval under the EPBC Act is not required provided the action is undertaken in a specific way (similar to conditions). This decision dictates that provided the project is undertaken in a way that avoids significant impacts on matters of NES it may proceed without further assessment or approval.

III. *Controlled Action (CA)*: The project will, or is likely, to have a significant impact on one or more matters of NES. The project will require assessment and approval before it can proceed.

IV. *Refused – unacceptable levels of impact*: At the referral stage the Minister may determine that the referred project will have unacceptable levels of impact on matters of NES and can determine that the project should not proceed.

A Referral under this Act was not considered necessary, as there were no impacts to Matters of NES. The requirements of the EPBC Act are addressed in **Sections 6**, **7** and **Appendix 7** of this report.

4.2 INTERNATIONAL AGREEMENTS

International Migratory Bird Agreements

- Japan - Australia Migratory Bird Agreement (JAMBA)
- China - Australia Migratory Bird Agreement (CAMBA)

The JAMBA and CAMBA agreements list terrestrial, water and shorebird species which migrate between Australia and the respective countries. In both cases, the majority of listed species are shorebirds.

Both agreements require the parties to protect migratory birds by:

- Limiting the circumstances under which migratory birds are taken or traded;
- Protecting and conserving important habitats;
- Exchanging information; and
- Building cooperative relationships.

The JAMBA agreement also includes provisions for cooperation on the conservation of threatened birds.

Australian government and non-government representatives meet every two years with Japanese and Chinese counterparts to review progress in implementing the agreements and to explore new initiatives to conserve migratory birds (DEWHA 2010a).

- Republic of Korea – Australia Migratory Bird Agreement (ROKAMBA)

In April 2002, Australia and the Republic of Korea agreed to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA.

The ROKAMBA formalises Australia's relationship with the Republic of Korea in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (DEWHA 2010a).

Any actions that have the potential to impact upon these agreements are formally addressed under the EPBC Act.

4.3 NEW SOUTH WALES LEGISLATION

Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal planning legislation for NSW. It provides a framework for land use control and assessment, determination and management of development. The PA and CP for this project were submitted under Part 3A of the EP&A Act. Director-Generals Requirements (DGRs) have been issued for the Concept and Project Applications. See **Table 1** for more detail on where the DGR's have been addressed in this report.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. The Act is integrated with the NSW EP&A Act and requires consideration of whether a major infrastructure or other project (formerly Part 3A of the EP&A Act), a development (Part 4 of the EP&A Act) or an activity (Part 5 of the *EP&A Act*) is likely to significantly affect threatened species, populations and ecological communities or their habitat.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) aims to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. The FM Act defines ‗fish' as any marine, estuarine or freshwater fish or other aquatic animal life at any stage of their life history, exclude whales, mammals, reptiles, birds, amphibians or species specifically excluded. No threatened fish species, or endangered populations are known to occur within the Field Assessment Area.

In accordance with section 75U of the EP&A Act, applications for separate permits under section 201, 205 or 219 of the FM Act are not required as these matters are addressed and approved as part of the EP&A Part 3A process.

Noxious Weeds Act 1993

The Noxious Weeds Act 1993 (NW Act) defines the roles of government, councils, private landholders and public authorities in the management of noxious weeds. The Act sets up categorisation and control actions for the various noxious weeds, according to their potential to cause harm to our local environment.

The objectives of the NW Act include:

- To identify noxious weeds in respect of which particular control measures need to be taken;
- To specify those control measures;
- To specify the duties of public and private landholders as to the control of those noxious weeds; and
- To provide a framework for the State-wide control of those noxious weeds by the Minister and local control authorities.

Under this Act, noxious weeds have been identified for Local Government Areas and assigned Control Categories (e.g. 1, 2, 3, 4 and 5). Part 3 of the NW Act provides that occupiers of land (this includes owners of land) have responsibility for controlling noxious weeds on the land they occupy.

State Environmental Planning Policy 44 (Koala Habitat)

State Environmental Planning Policy 44 (Koala Habitat) (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline.

SEPP 44 applies to the Wollongong LGA, however SEPP 44 does not apply to Part 3A Projects. An assessment under SEPP 44 is therefore not required.

5 Methodology for flora and fauna assessment

5.1 DATA AUDIT AND LITERATURE REVIEW

A review of relevant data and background literature was undertaken for the Proposal area prior to field surveys. Relevant datasets and information included:

- Existing vegetation, soil and landscape mapping, as well as other available GIS data
- Atlas of NSW Wildlife (OEH 2011)
- EPBC Protected Matters Search Tool (DSEWPAC 2011)
- Illawarra Biodiversity Study (WCC 2010a and b)
- Previous flora and fauna survey reports including:
    - Eco Logical Australia (2004, 2006a, b, c, d, 2007, 2009a, b, 2010a, b, and 2011a, b, c)
    - Niche Environment and Heritage (2010). Native Vegetation and Threatened Flora Assessment. Report prepared for NRE Wongawilli Colliery Lease Area by NEH
    - Brandis (2010) Birds of the Tallawarra Site. Illawarra Bird Observers Club Inc. (unpublished report)
- DEC 2003. Illawarra Escarpment and Coastal Plain - Bioregional Assessment. NSW Department of Environment and Conservation.
    - Burcher (1997) Assessment of Fauna and Flora – Lands Associated with the Tallawarra Power Station. Prepared for Pacific Power
    - Chafer (1997) Biodiversity of Wetlands in the Illawarra Catchments: an inventory. Illawarra Catchment Management Committee, Wollongong
    - MWH+PB (2010). West Dapto Detailed Planning Water and Wastewater Options Study Ecological Constraints. Report prepared for Sydney Water Corporation by MWH and Parsons Brinckerhoff Australia P/L
    - SWC (2009) Water and wastewater servicing of the WDURA and Adjacent Growth Areas – Preliminary Environmental Assessment. Publication no. SW75 09/09. Sydney Water Corporation.
- Groundwater Dependant Ecosystem literature
    - DLWC (2002) The NSW State Groundwater Dependant Ecosystems Policy. NSW Land and Water Conservation, Sydney.
    - DIPNR (2004) Riparian Corridor Management Study. Covering all of the Wollongong Local Government Area and Calderwood Valley in the Shellharbour Local Government Area. Department of Infrastructure, Planning and Natural Resources.
    - Dresel et al (2010) Mapping Terrestrial Groundwater Dependent Ecosystems: Method Development and Example Output. Victoria Department of Primary Industries, Melbourne VIC. 66 pp.
    - Eamus (2009) Identifying Groundwater Dependent Ecosystems – A Guide for Land and Water Managers. Land & Water Australia, Canberra.
    - Fairfull and Witherbridge (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla.
    - Hatton et al. (1998) Dependence of Groundwater and its Significance to Australia. LWRRDC Occasional Papers No 12/98, Land and Water Resources Research and Development Corporation, Canberra.

- Naimen et al. (2005) Riparian: Ecology, Conservation, and Management of Streamside Communities. Elsevier.
- O'Donnell et al. (2000) Water Quality in the Lake Illawarra Catchment. In Wetlands (Australia), 21(2).
- Sherman et al. (2000) Lake Illawarra Data Compilation and Assessment. CSIRO Land & Water Consultancy Report #99-75 prepared for the Lake Illawarra Authority.
- SKM (2001) Environmental Water Requirements of Groundwater Dependent Ecosystems. Environmental Flows Initiative Technical Report Number 2, Commonwealth of Australia, Canberra.

An assessment of the ‗likelihood of occurrence' was made for threatened ecological communities, populations and species, and migratory species identified from a search of a 10 km radius from the extent of proposed works (an area approximately 35km by 27km covering 78,868ha the centre of which is at co-ordinates S 34˚32'26, E 150˚46'13). This assessment included database and other records (as outlined above).

A full summary of the results of this data audit along with a ‗likelihood of occurrence' ranking using the following terminology can be found at **Appendix 2**.

- ―Known" = the species was or has been observed within the study area
- ―Likely" = a medium to high probability that a species uses the study area
- ―Potential" = suitable habitat for a species occurs within the study area, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur
- ―Unlikely" = a very low to low probability that a species uses the study area
- ―No" = habitat within the Study areaand in the vicinity is unsuitable for the species.

The results of this search identified five threatened ecological communities, 27 threatened flora species, 83 threatened fauna and 40 migratory species. Of these it was determined that four (4) threatened ecological communities (TEC), four (4) threatened flora, eight (8) threatened fauna and one (1) migratory species were ‗known' to occur within the study area, two (2) migratory species were ‗likely' to occur, and one TEC, five (5) threatened species and three (3) migratory species had the ‗potential" to occur within the study area (

Table 5).

Assessment of significance have been undertaken for species ‗known', ‗likely' or with the ‗potential' to occur in the Field Assessment Area post field assessment, cif they will be impacted upon by the proposal (**Appendix 7**).

Table 5: Threatened and migratory species, known,r likely or with the potential to occur within the PA & CA

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS		LIKELIHOOD OF OCCURRENCE
		TSC ACT	EPBC ACT	
ECOLOGICAL COMMUNITIES				
Illawarra Sub-tropical Rainforest		E	-	Known
Illawarra Lowland Grassy Woodlands		E	-	Known
Swamp Oak Floodplain Forest		E	-	Known
Coastal Saltmarsh		E	-	Known
River-flat Eucalypt Forest on Coastal Floodplains		E	-	Potential
FLORA				
Chorizema parviflorum	*Chorizema parviflorum* population in the Wollongong LGA	EP	-	Known
Cynanchum elegans	White-flowered Wax Plant	E	E	Known
Daphnandra sp. C Illawarra EPBC Act as *Daphnandra johnsonii*	Illawarra Socketwood	E	E	Potential
Irenepharsus trypherus	Illawarra Irene	E	E	Potential
Lespedeza juncea subsp. *sericea*	*Lespedeza juncea* subsp. *sericea* population in Wollongong LGA	EP	-	Known
Pterostylis gibbosa	Illawarra Greenhood Orchid	E	E	Known
Solanum celatum	Nightshade	E	-	Potential
Zieria granulata	Hill Zieria	E	E	Potential
AVES				
Ardea alba	Great Egret, White Egret	-	M	Likely
Ardea ibis	Cattle Egret	-	M	Known
Merops ornatus	Rainbow Bee-eater		M	Likely
Lathamus discolor	Swift Parrot	E	E and M	Potential
Monarcha melanopsis	Black-faced Monarch	V	-	Potential
Ninox connivens	Barking Owl	V	-	Potential
Ninox strenua	Powerful Owl	V	-	Potential
Rhipidura rufifrons	Rufous Fantail	-	M	Potential

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS		LIKELIHOOD OF OCCURRENCE
		TSC ACT	EPBC ACT	
Hirundapus caudacutus	White-throated Needletail	-	M	Potential
MAMMALIA				
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Potential
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	Known
Miniopterus australis	Little Bent-wing Bat	V	-	Known
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	V	-	Known
Mormopterus norfolkensis	Eastern Free-tail Bat	V	-	Known
Myotis macropus	Large-footed Myotis	V	-	Known
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Known
Saccolaimus flaviventris	Yellow-bellied Sheath-tail Bat	V	-	Known
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Known

5.2 FIELD ASSESSMENT OVERVIEW

The following sections outline the survey and assessment methodologies undertaken for this report, which were designed to meet the requirements of the NSW ‗Draft Threatened Biodiversity Survey and Assessment Guidelines' (DEC 2004) (as required by the ‗Draft Guidelines for Threatened Species Assessment (DEC and DPI, July 2005) and the DGRs (DoP 2009). Reference was also made to the Commonwealth ‗Survey Guidelines for Threatened Species' (DEWHA 2010a and b), for birds and microchiropteran bats (microbats) where applicable.

A preliminary site assessment was conducted by two Eco Logical Australia ecologists, Lucas McKinnon and Michael Ward on the 23rd of May 2011, to identify access constraints, on ground location of the proposed infrastructure and habitat features to inform the placement of Anabat recording devices for targeted microbat survey.

The study area was then assessed over 10 days in two field trips, from 23rd to 27th May 2011 and again from 6th to 10th June 2011. The field team consisted of ELA Terrestrial Ecologists Lucas McKinnon, Michael Ward, Anna Foley, Andrew Whitford, and Aquatic Ecologist Ian Dixon. Curriculum vitae for all project staff are located in **Appendix 1**.

Four follow up field assessments were undertaken in the Field Assessment Area. On the 21st of June, Lucas McKinnon and Liz Norris (Senior Botanist, ELA), attended reference sites for Illawarra Greenhood Orchid, to determine if rosettes had presented above ground (expected June-July). On the 4th of July, Lucas McKinnon, Ian Dixon, and a Senior Environmental Scientist and Construction Engineer from Sydney Water attended various sites to discuss potential impact avoidance and mitigation strategies. Following on from these discussions, the Proposal was modified and revised infrastructure layout maps were provided for

progression of the impact assessment. A further field survey was then undertaken by Lucas McKinnon and Rodney Armistead (Terrestrial Ecologist), on the 18th of August, to identify significant habitat features, mark hollow bearing trees and record any threatened flora that may have potentially occurred in the final proposed impact areas.

Field survey was designed to target threatened flora and fauna regarded as having the potential to occur in the Field Assessment Area. Targeted threatened flora and fauna survey followed the NSW Department of Environment and Conservation (now the OEH) guidelines for surveying threatened species (DEC 2004). Information on the methods and effort employed for surveying vegetation communities, flora, fauna and groundwater dependant ecosystems are outlined in detail in **Sections 5.3**, **5.4, 5.5** and **5.6**, but generally, the following methods were implemented:

- Flora: quadrat surveys, transects, traverses, and opportunistic observations
- Diurnal birds: habitat assessments and opportunistic observations
- Nocturnal birds: habitat assessments and spotlighting
- Mammals (not including microbats): spotlighting and habitat assessments
- Microbat species: Anabat detection and habitat assessments
- Reptiles: opportunistic observations

Field surveys were conducted within the study area, although observations on habitat were also made for areas directly adjacent to the Study area in order to determine the fauna and flora potentially occurring nearby. A summary of field survey effort is shown in **Figure 4** and **Figure 5**.

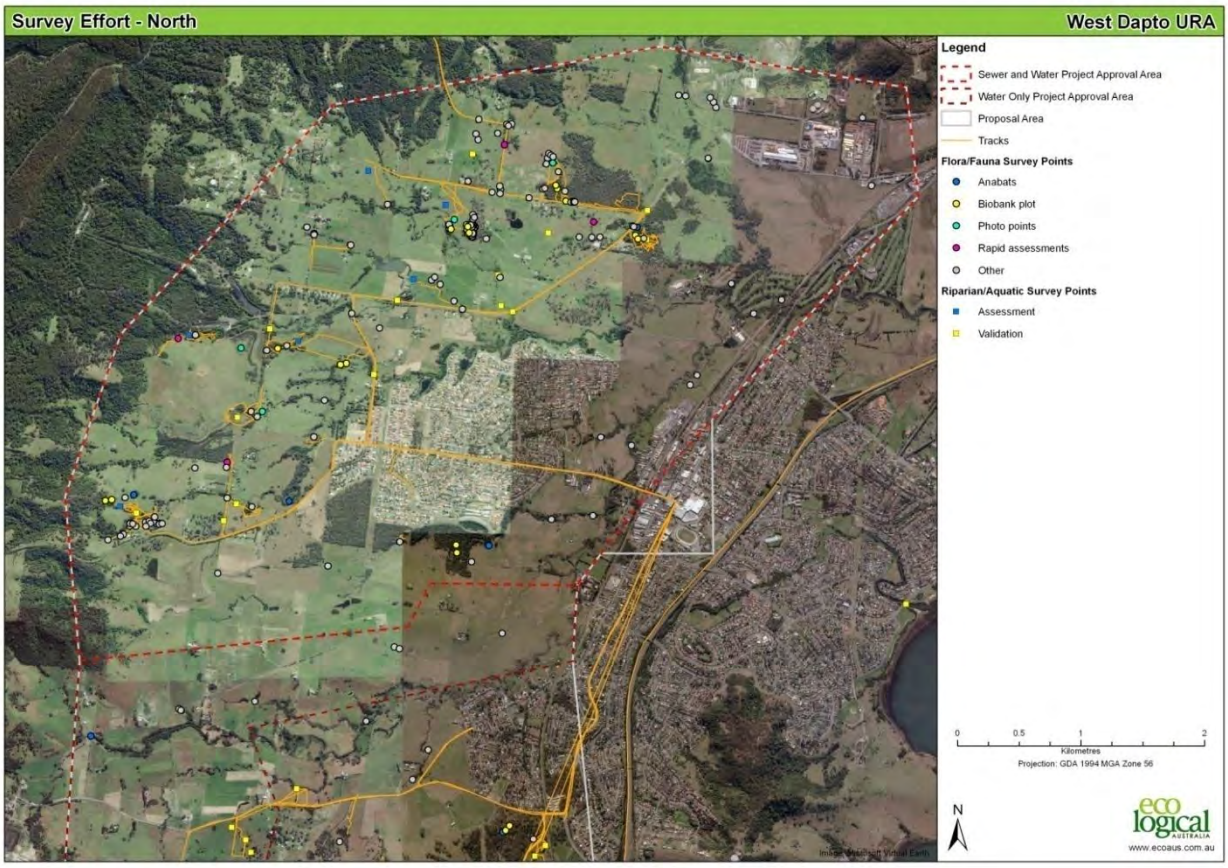

Figure 4: Survey effort in the Proposal Area (north)

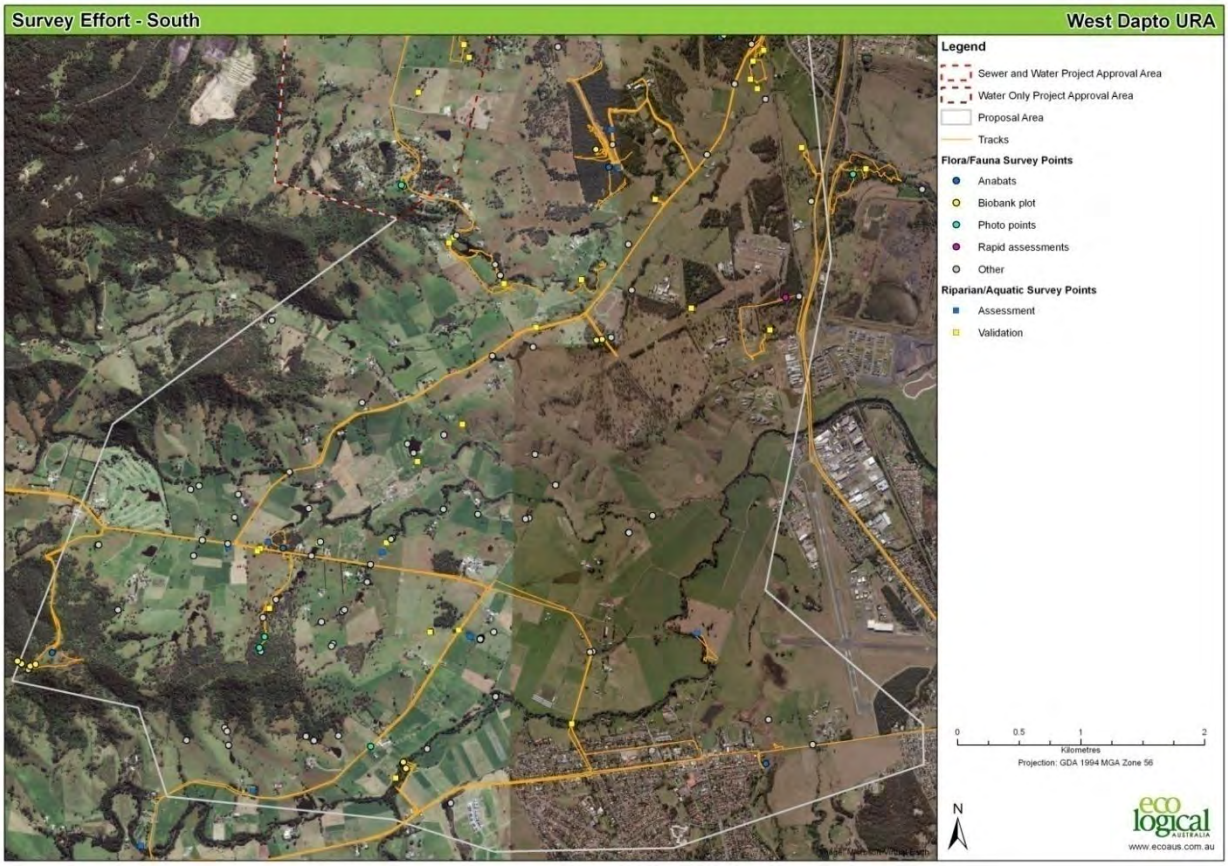

Figure 5: Survey effort in the Proposal Area (south)

5.2.1 Weather

Weather conditions during the survey were considered to be good (**Table 6**). Bureau of Meteorology data from the nearest weather station at Wollongong (~17km north east) showed daytime temperatures ranged from 12.7°C to 22.5°C for the week in May and 9.5°C and 15.8°C for the week in June. Rainfall of 8mm was recorded during the first survey week and 1.4mm during the second survey week. Cloud cover was largely minimal with a few days of heavy cover.

Table 6: Weather conditions during field survey recorded at Wollongong, NSW (~17km northeast of PA and CA)

Date	Temps		Rain	9:00 AM					3:00 PM				
	Min	Max		Temp	RH	Cld	Dir	Spd	Temp	RH	Cld	Dir	Spd
	°C	°C	mm	°C	%	8th		km/h	°C	%	8th		km/h
23-May	15.3	23.1	0	16.3	75	-	WNW	13	22.5	37	1	WNW	19
24-May	13.2	17.9	0	16.5	54	-	WSW	22	16	69	8	SSE	15
25-May	11.4	14.5	6.8	12.7	69	6	S	52	13.5	74	8	S	44
26-May	10.8	17.3	1.2	14.2	58	4	S	26	16.5	66	-	SSE	31
27-May	10.1	16.8	0	15	59	-	WSW	11	16.1	61	-	SSE	24
6-Jun	11.2	17.1	0	15.1	50	4	WSW	20	13.5	63	7	SSE	22
7-Jun	6.6	14.9	0	9.8	58	-	WNW	20	13.1	41	-	SW	22
8-Jun	7.5	12.8	1.4	9.5	42	-	SW	30	11.5	41	-	W	35
9-Jun	8.3	16.3	0	11.3	53	-	WSW	22	15.8	43	-	W	22
10-Jun	10.6	16.1	0	14	54	-	SSW	22	13.5	66	7	SSW	24

Blue text indicates monthly low in that category. Red text indicates monthly high in that category.

May Data: http://reg.bom.gov.au/climate/dwo/201105/html/IDCJDW2146.201105.shtml

June Data: http://reg.bom.gov.au/climate/dwo/201106/html/IDCJDW2146.201106.shtml

5.3 VEGETATION COMMUNITIES

The vegetation classification system employed in this report follows the BioMetric Vegetation Type Database (DECCW 2009). Listed threatened ecological communities (TECs) may consist of a single BioMetric vegetation type or be made up of various BioMetric vegetation types.

5.4 FLORA

Field survey targeted locations in which the proposed pipelines run through mapped vegetation communities, or in close proximity to threatened flora records. Quadrats were surveyed following the DECCW Interim Vegetation Standard (Sivertsen 2009). Quadrat surveys were 0.04ha (20m x 20m) and recorded presence of all vascular flora species, along with cover and abundance for each species using a modified Braun-Blanquet scale (i.e. measures of cover and abundance to determine species dominating each stratum). Habitat features were determined over 0.1 ha survey (50m x 20m quadrat); measures including number of hollow bearing trees and length of fallen dead timber greater than 10 cm diameter. Within the 0.1 ha quadrats, projected foliage cover of each strata level and exotic flora was assessed along a 50m transect.

The dimensions of the 0.04ha and 0.1ha area were altered in narrow, linear remnants/communities (such as riparian zones) to 10x40m and 10x100m, respectively.

Transect habitat assessments were also undertaken following the NSW Biobanking Methodology (DECC 2008) in order to provide sufficient information to undertake the ~~-im~~prove or maintain" test as required in the DGRs.

Quadrats and transects were conducted in the following previously mapped vegetation units (NPWS 2002):

- Coachwood Warm Temperate Rainforest (MU 1)
- Coastal Grassy Red Gum Forest (MU 23)
- Coastal Swamp Oak Forest (MU 36)
- Floodplain Wetland (MU 54)
- Lowland Dry-Subtropical Rainforest (MU 4)
- Lowland Woollybutt-Melaleuca Forest (MU 24)
- Moist Box-Red Gum Foothills Forest (MU 13)
- Moist Gully Gum Forest (MU 10)
- Riparian River Oak Forest (MU 37)
- Exotic Grasslands/Pastures

Random meander traverses focussed on ‗pastureland' communities to identify any derived native grasslands that may conform with the NSW TSC Act endangered ecological community listings.

Random meanders for threatened flora species were undertaken in areas where the pipeline work affected suitable habitat, in accordance with DECCW guidelines (DEC 2004). The location of random meanders were determined in the field based on suitable habitat. Existing records indicated previous recordings and therefore offered some guidance to potential threatened species locations.

Potential species were identified through the Biobanking Tool, Atlas of NSW Wildlife and expert local knowledge. The survey was timed to ensure that species were targeted before the end of May and after August. Threatened flora targeted are presented in **Table 7**.

Table 7: Threatened flora species targeted during survey

Scientific Name	Common Name	TSC Act Status	EPBC Act Status	Survey / Flowering Period
Chorizema parviflorum	*Chorizema parviflorum* population in the Wollongong LGA	EP		September to January (seeds maturing from November)
Cynanchum elegans	White-flowered Wax Plant	E	E	August to May, with a peak in November
Daphnandra sp. C Illawarra	Illawarra Socketwood	E	E	All year - Flowers in September and early October with fruits taking 10 to 12 months to mature
Haloragis exalata subsp. exalata var. *laevis*	Square Raspwort	V	V	All year. Flowers November to January
Irenepharsus trypherus	Illawarra Irene	E		February to June
Lespedeza juncea subsp. *juncea*	*Lespedeza juncea* subsp. *sericea* population in	EP		December to May (flowering February to March)

Scientific Name	Common Name	TSC Act Status	EPBC Act Status	Survey / Flowering Period
	Wollongong LGA			
Melaleuca biconvexa	Biconvex Paperbark	V	V	All year - flowering occurs over 4 weeks in September and October
Pimelea spicata	Spiked Rice-flower	E	E	All year
Pterostylis gibbosa	Illawarra Greenhood	E	E	Only visible above the ground between late summer and spring. Flower stem in winter. Spring flowering
Senna acclinis	Rainforest Cassia	E		All year
Solanum celatum		E		Flowers August to October Produces fruit December to January
Wilsonia backhousei	Narrow-leafed Wilsonia	V		All year
Zieria granulata	Illawarra Zieria	E	E	All year

Whilst targeted threatened flora survey was undertaken outside of the *Chorizema parviflorum* optimal survey period, this species is not known from any records within the 10m impact footprint. Where records occurred adjacent to the impact footprint, in each case the required infrastructure was water pipelines and they were to be placed in cleared or highly disturbed road verge vegetation. The locations of all flora survey undertaken are shown in **Figure 4** and **Figure 5**.

Utilising an impact area of 10m across the centreline of the proposed pipeline route (i.e. 5m either side), the Total Potential Impact Areas were calculated and compared for consistency with the survey requirements of the Threatened Biodiversity Survey and Assessment (TBSA) Guidelines (DEC 2004) and the Biobanking Assessment Methodology (BBAM) (DECC 2008).

The TBSA Guidelines and BBAM require vegetation to be stratified using remnant size (hectares) and condition class, and for this reason survey effort can only be estimated prior to field validation. ELA's analysis estimated a maximum of four condition classes for each BioMetric vegetation type (BVT) depending on the size of the potential impact area. For example, the BVT, ‗Forest Red Gum – Thin-leaved Stringybark grassy woodland', may be present in the Study area in the following condition classes:

- Dense Lantana understorey
- Grazed – with Lantana understorey
- Grazed – no understorey
- No overstorey – native understorey (i.e. Derived Native Grassland)

From this analysis it was determined the Total Potential Impact Areas would require potentially 29 vegetation plots to meet the TBSA Guidelines, and from 29 – 40 vegetation plots to meet the BBAM, dependant on the size (ha) and condition class of each remnant. These results are a maximum survey effort and are presented in **Table 8**.

Table 8: Summary of flora survey effort and compliance with TSBA Guidelines (DEC 2004) and BBAM (DECC 2008) within the Study area (figures calculated prior to reductions in the footprint from pipeline route reconfiguration)

Native Veg of the Illawarra (NPWS 2002)	SCIVI Map Units (Tozer et al 2006)	BioMetric Vegetation Types (DECCW 2008)	EEC	Moderate to Good	Scattered Trees	Unassessed	Other	Total Potential Impact Area	Biobanking		TSBA Guidelines
									Plots required (lower)	Plots required (upper)	Plots / Transects required
Artificial Wetlands (MU 57a)	N/A	N/A				1.07		1.07	N/A	N/A	N/A
Coachwood Warm Temperate Rainforest (MU 2)	Budderoo Temperate Rainforest (RF314)	Coachwood - Brown Possumwood warm temperate rainforest in sheltered gullies of the Illawarra Escarpment, southern Sydney Basin (SR528)		0.12				0.12	1	1	1
Coastal Grassy Red Gum Forest (MU 23)	South Coast Grassy Woodland (GW p34)	Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin (SR545)	Yes – Illawarra Lowland Grassy Woodlands (ILGW)	4.29	3.97			8.26	9	12	8
Coastal Swamp Oak Forest (MU 36)	Floodplain Swamp Forest (FoW p105)	Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner (SR649)	Yes – Swamp Oak Floodplain Forest	0.14				0.14	1	1	1
Floodplain Wetland (MU 54)	Coastal Freshwater Lagoon (part) (FrW p313)	Coastal freshwater lagoons of the Sydney Basin and South East Corner (SR536)	Yes – Freshwater Wetlands on Coastal Floodplains			0.59		0.59	1	1	1
Lowland Dry-Subtropical Rainforest (MU 4)	Sub-tropical Dry Rainforest	Lilly Pilly - Sassafras - Stinging Tree subtropical/warm temperate rainforest on moist fertile lowlands, southern Sydney Basin (SR568)	Yes – Illawarra Sub-tropical Rainforest	0.95				0.95	1	1	1
	Sub-tropical Complex Rainforest	Whalebone Tree - Native Quince dry subtropical rainforest on dry fertile slopes, southern Sydney Basin (SR662)									
Lowland Woollybutt-Melaleuca Forest (MU 24)	Illawarra Lowland Woodland (GW p3)	Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner (SR662)	Yes – ILGW	3.62	2.97			6.59	9	12	8
Moist Box-Red Gum Foothills Forest (MU 13)	Warm Temperate Layered Forest	Sydney Blue GumXBangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin (SR652)	No	1.87				1.87	1	1	1
Moist Gully Gum Forest (MU 10)	Escarpment Foothills Wet Forest (WSF p100)	Gully Gum - Sydney Peppermint - Yellow Stringybark moist open forest of coastal escarpments, southern Sydney Basin (SR553)	No	0.51				0.51	1	1	1
Riparian River Oak Forest (MU 37)	Riverbank Forest (FoW p32)	River Oak open forest of major streams, Sydney Basin and South East Corner (SR606)	No	0.62	0.06			0.68	1	1	1
Saltmarsh (MU 52)	Estuarine Saltmarsh (SL p509)	Saltmarsh in estuaries of the Sydney Basin and South East Corner (SR614)	Yes – Coastal Saltmarsh			0.01		0.01	1	1	1
Weeds and Exotics (MU 56a)	N/A	N/A	No				5.41	5.41	0	3	2
Paddocks/cleared/DNG	N/A	N/A	Potentially ILGW				153.2	153.2	3	9	3
Total				**12.12**	**7**	**1.67**	**159.41**	**180.2**	**29**	**44**	**29**

5.5 FAUNA

The locations of fauna survey undertaken within the Study area are shown in **Figure 4** and **Figure 5**. Survey effort was tailored to target threatened fauna considered to potentially occur in the Study area (as provided in

Table 5). These survey requirements were met for all threatened fauna expected to occur in the Study areaand compliance with the TBSA Guidelines (DEC 2004) are summarised in **Table 9**.

5.5.1 Avifauna

Diurnal Birds

Survey for diurnal birds was opportunistic with observers moving through vegetation communities supporting potential habitat for diurnal birds over the entire survey period (23rd to 27th May and 6th to 10th June). Additional observations were undertaken during follow up survey dates, June 21st, July 4th and August 18th.

Nocturnal Birds

Nocturnal bird survey focused on identifying potential roosting / nesting trees during the survey period, through the incidence of large hollow bearing trees, owl wash and faecal pellets.

Where suitable nesting or roosting habitat was found, spotlighting was undertaken to determine species present. No stag watching was conducted as no owl wash was observed at the base of any large trees supporting tree hollows.

Spotlighting was conducted by two people from a vehicle travelling at approximately 5km/h along existing vehicle access tracks, vegetation remnants maintaining hollow bearing trees and in transit to call playback sites. Spotlighting was undertaken between the hours of 1800 and 2200 hours using a high powered (12V; 100W) hand held spotlight and vehicle high beam head lights. The total effort spent on spotlighting was approximately 9 person hours, over 7 days.

Table 9: Summary of field survey effort and compliance with NSW Threatened Biodiversity Survey and Assessment guidelines (DEC 2004)

GROUP	TARGET SPECIES OR TYPE	DECC (2004) THREATENED BIODIVERSITY SURVEY AND ASSESSMENT GUIDELINES (APPROPRIATE SURVEY OPTIONS)	SURVEY EFFORT (ELA 2010D)	SAMPLING SATISFIES DEC (2004) GUIDELINES
Avifauna - Diurnal	All species	Opportunistic sightings - time unspecified	Opportunistic sightings	Yes
Avifauna - Nocturnal	All nocturnal birds	Day habitat search - search habitat for pellets and likely hollows.	Opportunistic sightings	N/A
		Spotlighting - 10 minutes before and after call playback	9 person hours, over 7 nights. No call playback deemed necessary.	Yes
Mammals (excluding microbats)	All mammals	Spotlighting - 1 hour walking at approximately 1km per hour on 2 separate nights per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares.	9 person hours, over 7 nights. Study area~ 800ha.	Yes
	All mammals	Search for scats and signs – 30 minutes searching each relevant habitat, including trees for scratch marks per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares.	Approximately 240 person hours	Yes
Mammals (microbats)	All species	Anabats - Two Anabats utilised for the entire night (a minimum of four hours), starting at dusk for two nights per 100 hectares of stratification unit in October to March.	15 sites, 2 nights/site (total 30 nights), 12hrs+/night.	Yes
Reptiles	All species	Habitat Search – 30-minute search on two separate days targeting specific habitat per stratification unit up to 200 hectares	Rock-rolling, tree bark removal, displacement of fallen timber and opportunistic sightings, for a total of 260 person hours over 12 days, over 800 ha	Yes
Amphibians	No threatened amphibians likely to occur in impact areas	Combination of tadpole surveys, call surveys and day/night active searching.	Opportunistic sightings	N/A

5.5.2 Mammals

Ground dwelling and arboreal mammals

Faunal habitat assessments were initially undertaken remotely using aerial photography, with waterbodies, woodland remnants, grasslands, rocky outcrops and manmade structures delineated in order to target survey accordingly. Additional habitat assessments and opportunistic surveys were undertaken continuously during daytime hours over the 10 day survey period (23rd to 27th May and 6th to 10th June), whilst traversing suitable habitat within the study area. Additional observations were undertaken during follow up survey dates, June 21st, July 4th and August 18th.

Any indirect evidence of fauna present was recorded including, fur, tracks, dens, scratches, and chew marks. Where suitable nesting or roosting habitat was found for arboreal mammals, spotlighting was undertaken to determine species present.

Ground dwelling and arboreal mammals were surveyed using hair tubes, spotlighting, habitat assessments and opportunistic sightings throughout the 10 day survey period.

Microchiropteran bat species

Survey for Microchiropteran (microbats) bat species included the use of ultrasonic Anabat detectors equipped with ZCAIM recording devices in 15 locations across the Study areafor two nights at each site in accordance with DECCW guidelines (DEC 2004) (**Figure 4** and **Figure 5**). Survey locations focused on larger remnants of native vegetation, major watercourses and large hollow bearing trees. On each night of survey the Anabats were turned on between 1630 hours and 1800 hours and then turned off the following morning between 0730 hours and 0900 hours. Anabat calls were downloaded in the office and analysed by Alicia Lyon (Ecologist, Eco Logical Australia, Coffs Harbour).This survey was supplemented by numerous recent harp trap and Anabat surveys undertaken within the immediate Study areaby Eco Logical Australia (ELA 2009a; 2010 c, d; 2011b).

Bat calls were analysed using the program AnalookW (Version 3.3q 03 October 2006, written by Chris Corben, www.hoarybat.com). Call identifications were made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay *et al*. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from north-eastern NSW (http://www.forest.nsw.gov.au/research/bats/default.asp).

Bat calls are analysed using species-specific parameters of the call profile such as call shape, characteristic frequency, initial slope and time between calls (Reinhold *et al*. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd *et. al*. 2006) were followed:

- Recordings containing less than three pulses were not analysed (Law et al. 1999).
- Only search phase calls were analysed (McKenzie et al. 2002).
- Four categories of confidence in species identification were used (Mills et al. 1996):
    - Definite – identity not in doubt;
    - Probable – low probability of confusion with species of similar calls;
    - Possible – medium to high probability of confusion with species with similar calls; and
    - Unidentifiable – calls made by bats which cannot be identified to even a species group.
- *Nyctophilus* spp. are difficult to identify confidently from their calls and no attempt was made to identify this genus to species level (Pennay et al. 2004).

5.5.3 Reptiles and Amphibians

Opportunistic observations and habitat assessment for reptiles and amphibians were undertaken throughout the survey period. The Atlas of NSW Wildlife provided no threatened reptile or amphibian records within the study area, as such no targeted searches were undertaken.

5.6 RIPARIAN ASSESSMENT

Riparian zones are defined as the land alongside creeks and rivers that are either influenced by stream water (e.g. creek banks prone to regular flooding, sediment deposition, debris accumulation and scouring) or that influence creek habitats (e.g. shading, organic input, physical habitat, bank stabilisation, decreased water velocity, sediment trapping and nutrient uptake) (Naimen et al. 2005). Riparian health or condition can be evaluated by looking at key vegetation indicators that represent the functioning of the zone. Key indicators as defined by DEWHA (2009b) can be broadly grouped as:

- *Spatial Integrity* – canopy width and longitudinal connectivity.
- *Nativeness* – proportion of weeds versus native flora.
- *Structural Integrity* – number of strata present (canopy, midstorey, understorey, ground cover).
- *Age Structure* – variety of age classes and recruitment success.
- *Debris* – cover of logs and leaf litter.

In addition, the extent of bank erosion can be assessed to determine impacts from flooding, cattle access, feral animals, in-stream structures and loss of deep rooted trees (see Aquatic Assessment, **Section 5.7**).

Assessment of riparian condition in the field was targeted at representative reaches that intersected with the proposed pipe route. Streams were grouped into three categories as defined by the Riparian Corridor Management Study (RCMS) (DIPNR 2004):

- *Category 1 - Environmental Corridor*. Provides biodiversity linkages ideally between one key destination to another (e.g. between the coast and the escarpment, or large nodes of vegetation).
- *Category 2 - Terrestrial & Aquatic Habitat*. Provides basic habitat and preserves the natural features of a watercourse (not necessarily linking key destinations).
- *Category 3 - Bank Stability and Water Quality.* Has limited (if any) habitat value but contributes to the overall basic health of a catchment.

Within each group a further division was made into ‗cleared' and ‗uncleared' zones, based on land clearing immediately adjacent to the riparian zone, resulting in a total of six representative types. In this instance ‗cleared' is defined as ―land immediately adjacent to the riparian zone of both banks are substantially cleared of terrestrial canopy"; and ‗uncleared' is defined as ―land immediately adjacent to the riparian zone of at least one bank has some terrestrial canopy, although clearing may still be present and dominant".

A rapid assessment of riparian condition was applied to at least one of these six types using a multi-metric scoring proforma (**Appendix 6**). However, no representative ‗uncleared' site for RCMS Category 3 was surveyed due to the low number of intersect sites and highly disturbed nature of the region. A total of 21 sites were assessed using this method. Preference of site selection was given to sites that were in or adjacent to Endangered Ecological Communities (EECs) and Groundwater Dependant Ecosystems (GDEs). At each site the riparian assessment was applied to a 50 m reach, centred by the proposed pipe route.

An additional 77 riparian sites along the proposed route were visited to verify the representative nature of the assessed sites. Photographs and notes were taken to record the similarity of riparian condition. Following field validation, the remainder of the Study areawas assessed using aerial photographs to determine the likely condition and impact at each riparian intersect.

The geomorphic ‗top of bank' (ToB) was mapped where pipeline routes crossed, or ran parallel to watercourses in the Project Approval area. This was undertaken using Lidar data and ground truthed using a highly accurate differential GPS unit (accuracy <1m). The ToB identifies the geomorphologic extent of each watercourse (transition of bank to floodplain), and forms the point at which the Core Riparian Zone (CRZ) and associated Vegetated Buffer (VB) required for the watercourse are measured.

5.7 AQUATIC HABITAT ASSESSMENT

Aquatic habitats are the in-stream features that form pools, runs and riffles of flowing creeks and rivers; and still-water bodies such as dams and lakes. These habitats may range from permanent water with large catchments on low-lying land, to ephemeral creeks near the escarpment that only flow after local rainfall. In-stream habitat values can be assessed by describing and rating several common physical and biotic features, including:

- Hydrology – stream type and modifications to channel.
- Physical form – bank slope and erosion.
- Water quality and habitat – connectivity, habitat variety, turbidity, wetted width, depth, substrate variety, velocity, aquatic flora richness and abundance, and in-stream woody debris.
- Fish – potential habitat (Fairfull & Witheridge 2003; **Appendix 6**).
- Other fauna – opportunistic sightings of significant waterbird and frog habitats.

Using a scoring proforma developed by Eco Logical Australia (2010, **Appendix 6**), assessment of aquatic habitats was conducted at the riparian-pipe intersect sites described above in **Section 5.6**, including representative sites, validation sites and desktop sites.

5.8 GROUNDWATER DEPENDANT ECOSYSTEMS

Groundwater Dependent Ecosystem (GDEs) within or near the path of the proposed pipe route were primarily riparian corridors along creeks, or lowland freshwater wetlands (swamps and dams). In the case of riparian GDEs, surveys were absorbed by the riparian assessment described above in **Section 5.6**. In the case of freshwater wetlands, they were also included as part of any riparian/aquatic assessment, but were generally classed as ‗no-go zones' for the proposed pipeline routes.

6 Survey Results

6.1 LITERATURE AND DATABASE REVIEW

Vegetation across the Study area has been classified by various authors (NPWS 2002; Tozer et al 2006). The relationship between the vegetation mapping units classified by these authors is included in **Table 10**.

Table 10: Relationships between vegetation classifications in the Field Assessment Area

Native Veg of the Illawarra (NPWS 2002)	SCIVI Map Units (Tozer et al 2006)	BioMetric Vegetation Types (DECCW 2009)	EEC
Coachwood Warm Temperate Rainforest (MU 2)	Budderoo Temperate Rainforest (RF314)	Coachwood - Brown Possumwood warm temperate rainforest in sheltered gullies of the Illawarra Escarpment, southern Sydney Basin (SR528)	No
Coastal Grassy Red Gum Forest (MU 23)	South Coast Grassy Woodland (GW p34)	Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin (SR545)	Yes – Illawarra Lowland Grassy Woodlands (ILGW)
Coastal Swamp Oak Forest (MU 36)	Floodplain Swamp Forest (FoW p105)	Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner (SR649)	Yes – Swamp Oak Floodplain Forest
Floodplain Wetland (MU 54)	Coastal Freshwater Lagoon (part) (FrW p313)	Coastal freshwater lagoons of the Sydney Basin and South East Corner (SR536)	Yes – Freshwater Wetlands on Coastal Floodplains
Lowland Dry-Subtropical Rainforest (MU 4)	Sub-tropical Dry Rainforest	Lilly Pilly - Sassafras - Stinging Tree subtropical/warm temperate rainforest on moist fertile lowlands, southern Sydney Basin (SR568)	Yes – Illawarra Sub-tropical Rainforest
Lowland Woollybutt-Melaleuca Forest (MU 24)	Illawarra Lowland Woodland (GW p3)	Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner (SR662)	Yes – ILGW
Moist Box-Red Gum Foothills Forest (MU 13)	Warm Temperate Layered Forest	Sydney Blue GumXBangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin (SR652)	No
Riparian River Oak Forest (MU 37)	Riverbank Forest (FoW p32)	River Oak open forest of major streams, Sydney Basin and South East Corner (SR606)	No

A number of threatened flora and fauna species have previously been recorded within the locality (i.e. 10 km radius).

Table 5 (**Section 5**) lists those species previously recorded within the locality (OEH 2011) or that are considered to have the potential to occur (DSEWPC 2011). The likelihood of these species occurring on site has been addressed in more detail in **Appendix 2**.

6.2 VEGETATION COMMUNITIES

Eight BioMetric Vegetation Types (BVTs) were recognised across the Proposal area (DECCW 2010b). Corresponding vegetation maps are provided in **Figure 6** and **Figure 7.**

Four BVTs will be impacted upon by the Proposal and are described further below with reference to DECCW 2010b, Tozer et al 2006 and NPWS 2002. Particular reference is provided to Tozer et al 2006, as the BioMetric Vegetation Types have generally been derived with this as a primary resource.

Three other non-BioMetric vegetation types will be impacted upon by the proposal, these are also described below.

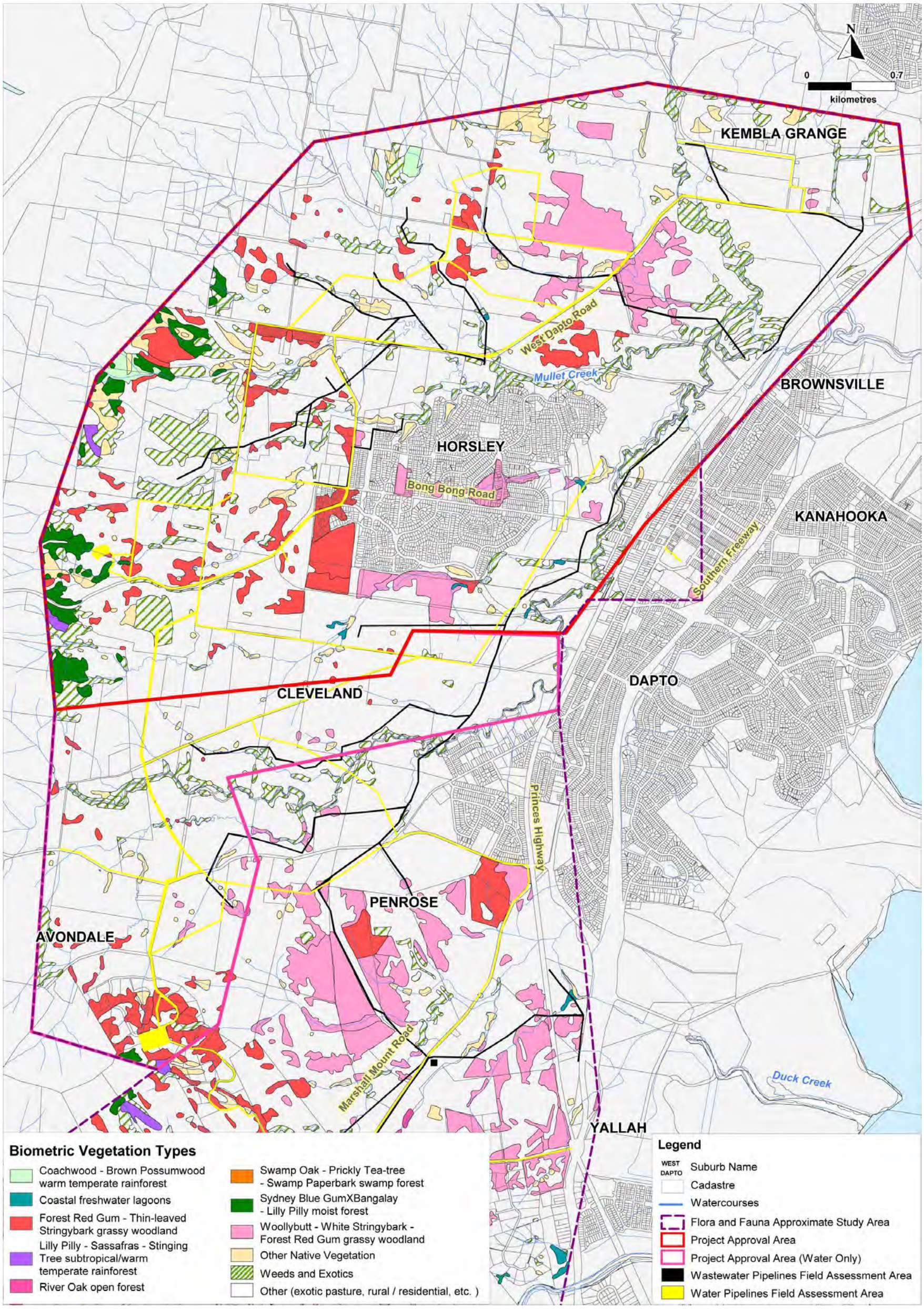

Figure 6: BioMetric Vegetation Types of the Proosal Area (northern) (NPWS 2003)

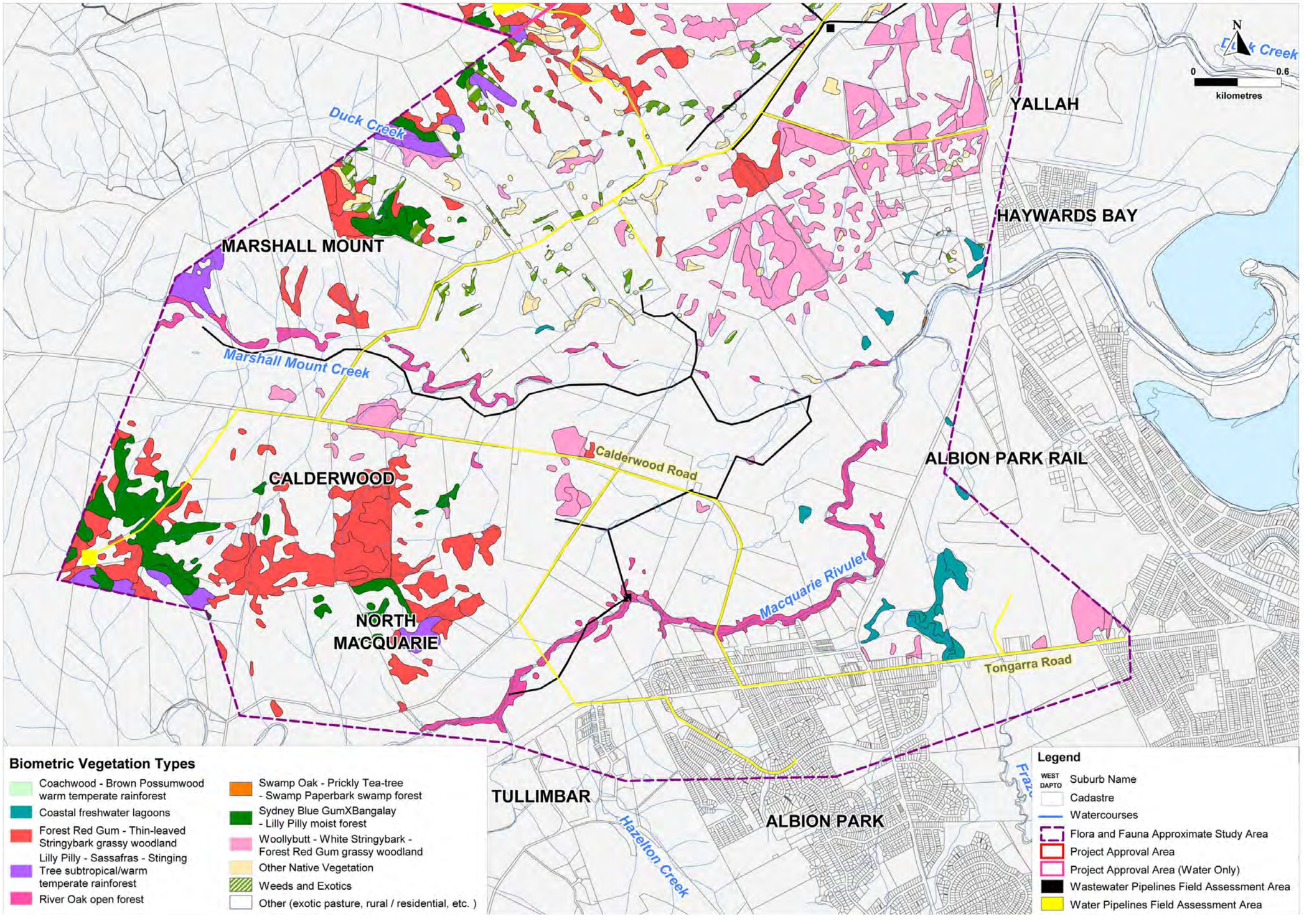

Figure 7: BioMetric Vegetation Types of the Area (southern) (NPWS 2003)

6.2.1 Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin (SR545)

Vegetation Formation	Grassy Woodlands
Vegetation Class	Coastal Valley Grassy Woodlands
Conservation Status	Listed as an endangered ecological community under the NSW TSC Act. Extant Vegetation • Cleared estimate: 85% (DECCW 2010b): • 3100 ha of extant vegetation (180ha in reserve) (Tozer et al. 2006)

‗Forest Red Gum – Thin-leaved Stringy bark grassy woodland on coastal lowlands, southern Sydney Basin', is a eucalypt woodland with an open shrub layer and a continuous grassy groundcover, found on lower slopes in coastal rainshadow valleys, below 350m ASL, from Wollongong to Milton and west to Yalwal. These areas receive mean annual rainfall of 850-1500mm, and have loamy soils derived from a variety of substrates.

This vegetation is a component of the EEC, ‗Illawarra Lowlands Grassy Woodland' EEC as listed on Schedule 1 of the NSW *Threatened Species Conservation Act* (1995). It has been depleted throughout its range by land clearing. Remnants are generally small, located on freehold lands, and exposed to continuing attrition by overgrazing, frequent fire and small-scale clearing.

Floristic Summary:

Trees: *Eucalyptus tereticornis, E. eugenioides, E. amplifolia, E. viminalis*

Shrubs: *Lantana camara*, Ligustrum sinense*, Lomatia ilicifolia X silaifolia, Pomaderris ligustrina subsp. ligustrina*

Climbers: *Pandorea pandorana*

Groundcover: *Sporobolus fertilis, Pennisetum clandestinum*, Axonopus fissifolius*, Carex appressa, Microlaena stipoides, Dichondra repens, Oplismenus aemulus, , Commelina cyanea*

6.2.2 Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner (SR662)

Vegetation Formation	Grassy Woodland
Vegetation Class	Coastal Valley Grassy Woodlands
Conservation Status	Listed as an endangered ecological community under the NSW TSC Act Extant Vegetation • Cleared estimate: 95% (DECCW 2010b): • 1100 ha of extant vegetation (90 ha in reserve) (Tozer et al. 2006)

Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner' is a grassy eucalypt woodland found in coastal valleys and floodplains, most extensively around Lake Illawarra and in the Moruya - Congo area, but with sporadic occurrences between including small areas near Worrigee, Kioloa and Nelligen. Its distribution is restricted to flats below 100m ASL with sandy loam soils and partially impeded drainage, receiving over 1000mm of annual rainfall.

This vegetation is a component of the Illawarra Lowland Grassy Woodland in the Sydney Basin Bioregion' EEC, as listed on Schedule 1 of the NSW *Threatened Species Conservation Act* (1995). The naturally small distribution of this community has been severely depleted by land clearing and is threatened by continuing fragmentation, weed invasion and high frequency fire.

Floristic Summary:

Trees: *Eucalyptus longifolia, Eucalyptus pilularis, Eucalyptus oblonga, Glochidion ferdinandi*

Shrubs: *Lantana camara*, Leucopogon juniperinus, Breynia oblongifolia*

Groundcover: *Imperata cylindrica, Carex appressa, Dichondra repens, Digitaria parviflora, Pratia purpurascens, Geitonoplesium cymosum, Cynodon dactylon, Oplismenus aemulus.*

6.2.3 Sydney Blue GumXBangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin (SR652)

Vegetation Formation	Wet Sclerophyll Forests (Shrubby subformation)
Vegetation Class	North Coast Wet Sclerophyll Forests
Conservation Status	Not listed as threatened Extant Vegetation • Cleared estimate: 45% (DECCW 2010b): • 21500 ha of extant vegetation (4500ha in reserve) (Tozer et al. 2006)

Sydney Blue GumXBangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin' is a tall eucalypt forest characterised by an open eucalypt canopy, a dense small tree subcanopy and a moist shrubby understorey. Warm Temperate Layered Forest occurs predominantly south from the Hacking River along the Illawarra escarpment, to Nowra and throughout the Kangaroo Valley. Localised occurrences are also recorded as far south as Durras Mountain and as far north as Ku-ring-gai Chase National Park. Within this area it is found below 400m on sheltered slopes in gullies and on escarpments with loamy soils where mean annual rainfall exceeds 1000mm.

Floristic Summary:

Trees: *Eucalyptus tereticornis*

Shrubs: *Acacia maidenii, Cassine australis, Lomatia ilicifolia X silaifolia, Bertya pomaderroides, Pomaderris ligustrina subsp. ligustrina, Lantana camara**

Climbers: *Coprosma perpusilla, Pandorea pandorana*

Groundcover: *Oplismenus aemulus, Dichondra repens, Pterostylis hispidula*

6.2.4 River Oak open forest of major streams, Sydney Basin and South East Corner (SR606)

Vegetation Formation	Forested Wetlands
Vegetation Class	Eastern Riverine Forests
Conservation Status	Not listed as threatened Extant Vegetation • Cleared estimate: 40% (DECCW 2010b): • 9400 ha of extant vegetation (3900ha in reserve) (Tozer et al. 2006)

River Oak open forest of major streams, Sydney Basin and South East Corner' is a distinctive tall River Oak forest with an open shrub layer and a dense or patchy groundcover of grasses and forbs. It is found on sand/gravel alluvium strewn with cobbles along swift-flowing reaches of streams, at elevations from 20-800m above sea level. The community occurs widely across southeast NSW, along major streams including the Coxs, Abercrombie, Wollondilly, Shoalhaven, Deua and Brogo River systems, and Araluen and Wandella Creeks.

Floristic Summary:

Trees: *Casuarina cunninghamiana*

Shrubs: *Ricinus communis*, Sida rhombifolia**

Climbers: *Acetosa sagittata*, Delairea odorata, Anredera cordifolia*

Groundcover: *Pennisetum clandestinum*, Urtica incisa, Tradescantia fluminensis*, Geranium homeanum, Rumex brownii*

6.2.5 Weeds and Exotics

Infestation by weeds and other exotic species is common on the Illawarra Escarpment and Coastal Plain. Lantana (*Lantana camara**) is the most conspicuous of these species, often forming scrambling impenetrable scrubs. These areas are prominent on former grazing and mining sites on escarpment benches and gullies. Weeds and exotics have been mapped as a feature where they dominate and as a disturbance descriptor where they occur in combination with native vegetation communities. Remnant vegetation along riparian strips are often a combination of Willow Trees (*Salix* spp.*), Coral Trees (*Erythrina X sykesii**) and isolated native species.

Impacts to this vegetation are considered to be positive and are not quantified in this report.

6.2.6 Other Native Vegetation

This classification has been applied where native vegetation exists as single standing trees over managed parkland or in exotic pastures.

6.2.7 Cropped/cultivated paddocks (Cleared Land)

A large proportion of the Study areahas previously been cleared for grazing, cultivation and cropping, and as such no longer maintains native vegetation communities. These areas have been modified from the natural state to the extent that native species are now uncommon. Most of these cultivated areas are dominated by pasture improving exotic species such as Kikuyu (*Pennisetum clandestinum**) and Paspalum (*Paspalum dilatum**).

Although these paddocks are now either cleared or under cultivation, in the majority of cases they would have previously been covered by variants of the ‗Illawarra Lowland Grassy Woodlands' EEC. Where native species resilience is found in these communities, they would potentially meet the definition of a ‗derived native grassland (DNG)', that is a degraded state of the woodland EEC with the canopy no longer intact. The large majority of these paddocks were traversed within the impact zone of the proposed pipelines, and none were found to be dominated by native grasses.

6.2.8 Threatened Ecological Communities

Four threatened ecological communities (TECs) were identified within the Study arealisted on Schedule 1 of the NSW *Threatened Species Conservation Act 1995* (TSC Act) as ‗Endangered'. These communities are:

- Illawarra Lowland Grassy Woodland
- Swamp Oak Floodplain Forest
- Freshwater Wetlands on Coastal Floodplains
- Illawarra Sub-tropical Rainforest

Impacts to these EECs from the Proposal will be limited to the, Illawarra Lowland Grassy Woodlands, endangered ecological community (EEC).

No threatened ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* were present within the study area.

6.3 FLORA

Native vegetation was present throughout much of the study area, with the majority subject to grazing of varying intensity and found to be in varied condition classes. However, the condition of vegetation across the landscape is dynamic, with the 2011 assessment only providing a snap shot in time and not necessarily reflecting the year round condition.

A total of 234 flora species were recorded during surveys undertaken in 2011, of these, 155 were native, 79 were exotic species with five of these considered noxious under the *Noxious Weeds Act 1993* (NW Act).

6.3.1 Noxious Weeds

Five noxious weeds were recorded within the study area during the 2011 survey. A list of the noxious weeds recorded in the Study area is included at **Table 11**, with a full inventory of native and exotic flora recorded at **Appendix 3**.

Table 11: Noxious weeds recorded at the Project Site

SCIENTIFIC NAME	COMMON NAME	CATEGORY OF WEED	ACTION REQUIRED
Lantana sp.	Lantana	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Lycium ferocissimum	African boxthorn		
Opuntia sp.	Prickly Pear		
Eragrostis curvula	African Lovegrass		
Asparagus asparagoides	Bridal Creeper		

6.3.2 Threatened Flora

A number of threatened species are known to occur within the Wollongong and Shellharbour LGA's and are either ‗known', ‗likely' or considered to have the ‗potential' to occur within the Study area (OEH 2011; DSEWPC 2011, ELA internal records) (**Table 7**). An assessment of the likelihood of each species being present within the Study area has been included in **Appendix 2**, together with their conservation status under both state and Commonwealth legislation, habitat requirements and any vegetation communities across the Study area that would provide potential habitat for these species.

The only threatened flora species recorded within the Study area during the 2011 surveys, was an endangered population of, *Lespedeza juncea* subsp. *sericea*, along Marshall Mount Rd. Other species known to occur in the immediate area include, *Chorizema parviflorum, Cynanchum elegans* and *Pterostylis gibbosa,* though none were recorded in the study area.

6.4 FAUNA

6.4.1 Fauna Habitat

Seventy two species of fauna were recorded across the Study area between 2006 and 2011 (**Appendix 4**). Based on the overcleared state of much of the native vegetation present within the study area, habitat for species such as ground-dwelling mammals and some arboreal mammals is limited. However, the landscape supports habitat features such as grasslands, hollow bearing trees, coarse woody debris (fallen dead timber), rocky areas, disused and in use anthropogenic structures (i.e. fences, houses, sheds, dams etc). Key habitat features are outlined in **Table 12** and discussed in more detail below.

Table 12: Key fauna habitat features present across the Field Assessment Area

Habitat feature	Habitat type	Species
Hollow-bearing trees / stags	Woodlands Grasslands	Arboreal mammals, microchiropteran bats, hollow-dependent birds including owls, reptiles
Dead Tree Stags	Woodlands	Birds, particularly birds of prey
Rocky outcrops	Foothills of the Illawarra Escarpment	Reptiles
Dams	Grasslands	Amphibians, birds, reptiles, microchiropteran bats
Autumn / winter-flowering eucalypts	Woodlands	Foraging resources for birds, bats and mammals
Flowering myrtaceous trees and shrubs	Woodlands	Foraging resources for birds, bats and mammals
Coarse woody debris	Woodlands	Small mammals and reptiles
Leaf litter	Woodlands	Amphibians, reptiles, ground-dwelling mammals
Defoliating bark	Woodlands	Microchiropteran bats, reptiles
Primary and Secondary Koala feed trees	Woodlands Cabbage Gum (*Eucalyptus amplifolia*) Forest Red Gum (*E. tereticornis*), Woollybutt (*E. longifolia*) Coastal Grey Box (*E. bosistoana*)]	Koala
Anthropogenic structures	Across the Project Site	Vantage points and shelter for birds, bats, mammals and reptiles
Pastures	Grasslands	Foraging resources for birds, bats, reptiles, ground-dwelling mammals

Hollows Bearing Trees

Hollows bearing trees (HBTs) are an important habitat feature for more than 75% of Australian fauna (Gibbons and Lindenmayer 2002), and are present across much of the grassy woodland vegetation of the study area. Where HBT's were identified within the 10m impact corridor they were tagged using a handheld GPS unit (Garmin *GPSMap76*). HBTs were recorded for the Project Approval area only.

Of the species identified during survey, >50% utilise tree hollows for at least a portion of their life cycle (i.e. roosting, feeding or breeding).

Corridor Values / Movement Pathways

As discussed in the Illawarra Biodiversity Strategy (WCC 2010a&b), regional corridors for the Wollongong LGA have been largely defined through existing studies (Mills and Associates 2000, NPWS 2002b, NPWS 2003a, Eco Logical 2004, WCC 2005, Mills and Associates 2006b, WCC 2007, DECC 2007d, and DoP 2006). The West Dapto Ecological Assessment (ELA 2004), identifies three corridors running from the escarpment through the floodplain to the coast, with the Yallah Corridor identified as an indicative regional corridor in DoP 2006. **Table 13** is taken directly from ELA 2004.

Table 13: Ecological corridors of the West Dapto Urban Release Area (ELA 2004)

Kembla Corridor	2 reasonably large, good condition patches of Lowland Woollybutt-Melaleuca Forest Endangered population of *Chorizema parviflorum* Provides opportunity to connect with Lake Illawarra and the Escarpment.
Horsley Region	Largest patch of high quality Coastal Grassy Red Gum Forest Large patch of Lowland Woollybutt-Melaleuca Forest along riparian zone
Yallah-Corridor Region	North of Marshall Mount Rd, large areas of good condition Lowland Woollybutt-Melaleuca Forest South of Mt Marshall Rd, smaller patches of reasonable condition Many records of endangered species and populations Linkage value across to the Escarpment, and to the southern end of Lake Illawarra

The Study area is located across these three east-west corridors, though currently the linkage between these corridors is hindered by limited connectivity between woodland remnants. This is due to current agricultural land uses, that preferentially maintain grassland vegetation for grazing rather than woodland vegetation, along with the urban interface at Dapto and the Princes Highway. The currently treeless paddocks create a lack of movement pathways for arboreal and ground dwelling fauna, with limited islands in the landscape for fauna to take refuge.

6.4.2 Avifauna

Diurnal birds

The Study area supports potential foraging, nesting and roosting habitat for a large variety of bird species. A total of 64 bird species from 28 Families have been recorded over the period of 2009 to 2011 within the study area. The species recorded are mostly considered common, with the exception of Pacific Baza, which is usually a summer migrant to the Illawarra but was sighted at the Yallah Powerstation on June 21st, 2011. Further detail is provided below, with a full inventory found at **Appendix 4**.

Species commonly recorded at the Project Site included the Australian Magpie (*Gymnorhina tibicen*), Noisy Miner (*Manorina melanocephala*), Australian Raven (*Corvus coronoides*), Crimson Rosella (*Platycercus elegans*), Red Wattlebird (*Anthochaera carunculata*), Eastern Rosella (*Platycercus adscitus eximius*), Striated Pardalote (*Pardalotus striatus*), and Magpie-lark (*Grallina cyanoleuca*).

Birds of prey were common throughout the study area. Five species were recorded over the period 2006 to 2010, including two from the ‗Eagle' family, Wedge-tailed Eagle (*Aquila audax*) and Pacific Baza (*Aviceda subcristata*), and two from the ‗Falcon' family, Nankeen Kestrel (*Falco cenchroides*) and Brown Falcon (*Falco berigora*). Other birds of prey known from the Study areainclude, Peregrine Falcon (*Falco peregrinus*), Australian Hobby (*Falco longipennis*), White-bellied Sea Eagle, Osprey and Black-shouldered Kite.

Habitat for waterbirds was present in a number of farm dams across the study area, with four species of duck recorded, including, Australian Wood Duck (*Chenonetta jubata*), Pacific Black Duck (*Anas superciliosa*), and Plumed Whistling Duck (*Dendrocygna eytoni*). Other waterbirds included White-faced Heron (*Egretta novaehollandiae*) and the Australasian Grebe (*Tachybaptus novaehollandiae*).

Nocturnal birds

No nocturnal bird species were recorded during survey, though two are known from previous studies of the area (**Appendix 4**) including the Barn Owl (*Tyto alba*) and Tawny Frogmouth (*Podargus strigoides*).

Threatened Species

Given the large proportion of tree hollows found in the woodland areas of the study area, there is potential for threatened hollow dependant species to occur within the study area. Whilst none were recorded during the period of survey between 2006 and 2011, three were identified as potentially occurring within the Field Assessment Area, Swift Parrot (*Lathamus discolor*), Barking Owl (*Ninox connivens*) and Powerful Owl (*Ninox strenua*). Swift Parrot is listed as an ‗endangered' species under the TSC and EPBC Acts, and both Owls are listed as ‗vulnerable' species under the TSC Act, but not listed under the EPBC Act.

6.4.3 Mammals

Ground dwelling and arboreal mammals

Habitat across most of the Study area for ground-dwelling mammals persists in larger bush remnants that are not managed for grazing. Migration between remnants is limited due to limited vegetation connectivity and fallen timber to provide refuge and shelter sites. However, in those areas where woodland patches are present and grazing is less intense, coarse woody debris such as fallen timber and logs provide nesting and shelter resources for ground-dwelling mammals. Lantana infestations are common in unmanaged remnants, which provides a sheltering resource for ground mammals.

The high quantity of tree hollows present within the study area would also provide good nesting habitat for arboreal mammals. Scats from Sugar-gliders were identified in a remnant of woodland in the Project Application area, in an area with a high incidence of hollow bearing trees.

Only one native mammal was recorded (i.e. Sugar-glider), but other common native species ‗likely' to occur in the Study areainclude, Eastern Grey Kangaroo (*Macropus giganteus*), Short-beaked Echidna (*Tachyglossus aculeatus*), Common Wombat (*Vombatus ursinus*), Swamp Wallaby (*Wallabia bicolor*) and Common Brushtail Possum (*Trichosurus vulpecula*).

The Koala (*Phascolarctos cinereus*) is considered ‗unlikely' to utilise the study area, although a number of Koala feed trees from SEPP 44 and the Koala Recovery Plan (are present across the Field Assessment Area, including, Cabbage Gum (*Eucalyptus amplifolia*), Forest Red Gum (*E. tereticornis*), Woollybutt (*E. longifolia*) and Coastal Grey Box (*E. bosistoana*). The Koala has previously been recorded to the west of the study area, but never below the Illawarra Escarpment on the Coastal Floodplain.

Seven introduced mammals were also recorded within the Study area including the European Red Fox (*Vulpes vulpes*), European Rabbit (*Oryctolagus cuniculus*), Rusa Deer (*Cervus timoriensis*), and the domesticated species Domestic Cow (*Bos taurus*), Domestic Dog (*Canis lupus familiaris*), Sheep (*Ovis aries*), Llama (*Lama glama*) and other exotic species ‗likely' to occur include, Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*) and House Cat (*Felis catus*).

Microchiropteran Bats (microbats)

The calls of fifteen species, including seven threatened species, were identified in the West Dapto recordings (**Table 14**). Of these, 13 species utilise hollow bearing trees as roost sites.

A total of 8228 Anabat sequences were submitted for analysis from recordings made during May and June 2011 throughout West Dapto, NSW. There were 6456 sequences (78%) that did not contain any microbat calls. One thousand and sixty (13%) were unable to be positively identified to species or genus level due to the low quality or short length of the sequences. Many of these low quality and short sequences contained ―cruise" phase calls potentially emitted by any of the identified species which are difficult to separate with poor quality calls. Cruise phase calls indicate that microbats were commuting between foraging areas on and around the site.

Seven hundred and nine (9%) of the sequences could be identified confidently to species or genus level. Call sequences indicative of foraging activity (feeding buzzes) were often recorded. Example call profiles for these species are shown in **Appendix 5**. The remaining three sequences (<1%) could not be identified to genus level and included sequences containing social calls.

Calls were often recorded during dusk, pre-dawn; and on the 23rd May at the West Dapto Agricultural School Huntley Rd site, up until 1.5h after sunrise, which suggests that microbats were roosting nearby.

Relative microbat activity levels, as estimated by the number of positively identified microbat call sequences recorded per site per night, were generally low to moderate with an average of 23 calls per night over 30 nights of Anabat recording. However, the notable exception was on 23rd May 2011 at West Dapto Agricultural School, where microbat activity levels were high (477 calls per night) and the greatest species diversity was also recorded (11/15 species).

The calls of Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) often display very similar characteristics to other species such as Eastern Broad-nosed Bat (*Scotorepens orion*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*). Calls of Eastern False Pipistrelle were distinguished by the characteristic frequency, frequency of the knee, lack of an up-sweeping tail and length of pre-characteristic section. Greater Broad-nosed Bat calls were positively identified when the frequency of the knee was greater than 37kHz and the drop in frequency of the pre-characteristic section was greater than 3kHz, provided the call fell within the frequency range of this species.

The calls of Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) can often display very similar characteristics to other species such as Large Forest Bat (*Vespadelus darlingtoni*) and Southern Forest Bat (*Vespadelus regulus*). Calls of *Eastern Bent-wing Bat* were distinguished by the irregular pulse shape and time between calls, lack of an up-sweeping tail and drop in frequency of the pre-characteristic section of more than 2kHz.

The calls of Large-footed Myotis (*Myotis macropus*) are very similar to several *Nyctophilus* species and it is often difficult to separate these species on Anabat sequences. Calls were identified as Large-footed Myotis when the time between calls (TBC) was less than 75ms and the initial slope of the call was greater than 400OPS. Calls of *Nyctophilus* sp. were identified when the TBC was greater than 95ms and when the initial slope was less than 300OPS.

Megachiropteran bats

The Grey-headed Flying Fox (*Pteropus poliocephalus*) is considered likely to utilise the Proposal area for foraging, with the closest camp located to the west of Farmborough Heights (<1km north of the Proposal area), though none were recorded during survey.

Threatened Bats

Of the 15 microbat species recorded within the study area, seven are considered vulnerable species under the TSC Act. A full inventory of the bats present across the Study area and a chronology of their identification date are included in **Appendix 4**.

Table 14: Results of Anabat recordings across the Study areaduring May 2011

			Dates	23rd and 24th May 2011				25th and 26th May 2011				6-7th June 2011				8-9th June 2011		
			Location	Darkes Rd, Kembla Grange	West Dapto Ag School, Huntley Rd, Dapto	Fairwater Drive, Horsley	Avondale Reservoir, Bong Bong Rd, Avondale	Illawarra Hwy, Albion Park	Calderwood Rd and Marshall Mount Rd, Calderwood	Calderwood Rd (West), Calderwood	Tongarra Rd, Albion Park	Sheafes Rd , Kembla Grange	Gujarat NRE Coal Mine	Cleveland Rd, Huntley	Bong Bong Rd, Horsley	Marshall Mount Rd, Yallah	Marshall Mount Rd, Yallah	Calderwood Reservoir, Calderwood
Scientific name	**Common Name**	**Roost site**		**PA**	**CA**	**PA**	**PA**	**CA**	**CA**	**CA**	**CA**	**PA**	**PA**	**PA**	**PA**	**CA**	**CA**	**CA**
Chalinolobus gouldii	Gould's Wattled Bat	Hollows, foliage, structures		po	X					X		X				X		
Chalinolobus morio	Chocolate Wattled Bat	Hollows, bark, nests, structures			X	po			X			X				X	X	X
Falsistrellus tasmaniensis	**Eastern False Pipistrelle**	**Hollows, bark, structures, caves**			**X**													
Miniopterus australis	**Little Bent-wing Bat**	**Caves, hollows, structures**		**po**	**X**				**po**						**X**			
Miniopterus schreibersii oceanensis	**Eastern Bent-wing Bat**	**Caves, structures**			**X**				**X**	**X**	**po**	**X**		**po**				**X**
Mormopterus norfolkensis	**Eastern Free-tail Bat**	**Hollows, bark, nests, structures**		**po**	**X**		**X**											
Mormopterus species 2		Hollows							po									
Myotis macropus		**Caves, hollows, structures, foliage**		**X**					**X**	**X**		**po**				**po**		
Nyctophilus sp.		Hollows, bark			X				X			X				X		
Rhinolophus megaphyllus	Eastern Horseshoe Bat	Caves, structures								X								
Saccolaimus flaviventris	**Yellow-bellied Sheath-tail Bat**	**Hollows, bark, nests, structures**			**po**													
Scoteanax rueppellii	**Greater Broad-nosed Bat**	**Hollows, bark, structures**							**po**									
Austronomus australis	White-striped Free-tail Bat	Hollows			X	X			X									
Vespadelus darlingtoni	Large Forest Bat	Hollows, structures			X	po						X		po		X		
Vespadelus vulturnus	Little Forest Bat	Hollows, structures			X			X	X			X				X		

Species in **Bold** signify threatened species listed under the NSW *Threatened Species Conservation Act 1995; PA = Project Application Area; CA = Concept Application Area; X = positive identification; po = Possible identification*

6.4.4 Reptiles

Much of the study area provides suitable habitat for a variety of reptile species. In addition, the fallen debris in woodland areas and tree bark throughout the woodlands provides further habitat for reptiles.

Ten species from five Families were recorded across the Project Site during all survey periods. A full inventory of reptiles is included at **Appendix D**.

Threatened reptiles

No endangered reptiles are known from the general region and none have been recorded from the immediate area.

6.4.5 Amphibians

Habitat for amphibians was present within the Study areain the form of farm dams, trees and leaf litter in close proximity of these water sources.

Specific survey was not conducted for amphibians during the 2011 survey, as no threatened species were considered likely to occur within the study area. An opportunistic identification was made, however, of the Common Eastern Froglet (*Crinia signifera*).

Threatened Amphibians

Five threatened amphibians have been recorded within 10kms of the Proposal Site, these species are, Stuttering Frog (*Mixophyes balbus*), Giant Burrowing Frog (*Heleioporus australiacus*), Green and Golden Bell Frog (*Litoria aurea*), Littlejohn's Tree Frog (*Litoria littlejohni*) and Red-crowned Toadlet (*Pseudophryne australis*).

Green and Golden Bell Frog is the only species that has been recorded below the Illawarra Escarpment, with the nearest records to any impact sites found to the east of Lake Illawarra. This species is not considered likely to occur within the study area.

6.4.6 Migratory Fauna

One migratory species listed under the EPBC Act was recorded within the Study area during survey, the Cattle Egret (*Ardea ibis*). Two were considered ‗likely' to occur, Great Egret (*Ardea alba*) and Rainbow Bee-eater (*Merops ornatus*). Two were considered to have the ‗potential' to occur, Rufous Fantail (*Rhipidura rufifrons*) and Swift Parrot (also listed as endangered, see **Section 6.4.2**).