APPENDIX 13

Ecological Assessment

J.J.Richards & Sons Pty Ltd

Total Waste Management

Ecological Assessment for the

Northern Channel adjacent to Rayben and Owen Streets, Glendenning

April 2015

DUGGAN & HEDE Pty Ltd
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TABLE OF CONTENTS

FIGURES

APPENDICES

1 Introduction

1.1 Background

JJ Richards & Sons Pty Ltd intends to establish a Waste Management Facility as an adjunct to its existing depot at 14 Rayben Street Glendenning, which is described as Lot 123 DP 870988 (formerly Lots 1-3 DP802117) Parish of Rooty Hill County of Cumberland (Figure 2.3) and has an area of 7,214 m^2.

This site was developed in the 1990s and has been used as a transport depot, including workshop and ancillary offices.

This assessment has been prepared as part of an EIS to support the development of this Waste Management Facility. It has been undertaken to document the Northern Drainage Channel's ecology and habitat importance for native species. It was also completed to confirm whether any endangered, threatened or significantly listed species were present.

1.2 Adjoining Land Uses

Figure 1.2 is an aerial photo of the site and adjoining properties.

There is a drainage channel (the northern drainage channel) to the immediate north of the site.

Land to the north of this northern drainage channel is industrial and warehousing.

The lot to the immediate west of the site is transport and warehousing complex, whilst the lot to the south-west of the site across the Rayben Street cul-de-sac is used for the storage of scaffolding.

J.J. Richards & Sons Pty Ltd also own and operate a maintenance workshop, truck holding yard and ancillary offices opposite this site at 7-11 Rayben Street.

Transpacific Industries operate a waste management facility to the immediate east of the site whilst Earthworks Australia (a demolition contractor) occupy the lot further to the east.

Warehousing and industrial activities are undertaken to the southeast on the opposite side of Rayben Street.

1.3 Northern Drainage Channel Details

The Northern Drainage Channel (hereafter referred to as NDC) is a linear corridor which runs behind industrial properties fronting Glendenning Road, Owen Street Lamb Street and Rayben Street. The NDC to Owen Street is 1200m long and approximately 30m wide. After Owen Street, it then flows into Eastern Creek which

is located within Nurragingy reserve. The NDC receives localised stormwater and run-off inflows from the neighbouring industrial properties.

The study site is a subsection of the NDC centred around the JJ Richards site and is shown in Figure 2.1. Figure 2.2 shows a cross section representation of the NDC at the study site.

The northern riparian zone is an exposed 7-10m wide revegetated batter. It has no canopy creating trees and a high biomass of exotic ground covering grasses and shrubs dominate.

The southern riparian zone is 8-12m wide and consists of a 6-10m high, canopied forest of young native Eucalyptus, Casuarina and Paperbark trees.

The stream channel is approximately 5-8m wide. It has a pool-riffle sequence with pool depths to 1.5m. The stream bottom in the pools was typically composed of detritus, silt and mud. The riffle sequences were typically large artificially placed granite rocks. A concrete weir is present at Owen Street.

1.4 Qualifications of Field Ecologist

The field ecology investigation was undertaken by Daniel Hede whose resume is provided in Appendix 1.

1.5 Date of Field Investigation

Work in the field was undertaken between the hours of 8am and 6pm on Friday 24 April 2015. Weather conditions on the day were mostly fine with cloud cover at times and no rainfall. The temperature was estimated to reach a maximum of ~24 degrees and winds were light to moderate.

2 Flora Assessment

2.1 Desktop Review

Prior to work in the field, a desktop review was undertaken to determine which flora species had the potential to occur within the NDC.

This included reviewing the list of endangered, vulnerable or near threatened flora under the *Threatened Species Conservation Act 1995* (TSCA).

A spatial search was conducted in New South Wales Flora online to determine which TSCA listed species, Rare or Threatened Australian Plants (ROTAP) listed species, gazetted weed and introduced species had the potential to occur within a 25km radius of the NDC. This list is shown in Appendix 2. This was done to optimise the survey efforts around confirming their presence.

The Native Vegetation Map for the Blacktown region, Cumberland Plain, Western Sydney was reviewed to assist with the plant ecosystem classification (refer to Figure 2.3).

Reference material on the target species (species profiles, etc.) was also used to confirm their habitat requirements and distinguishing features to assist in field identification.

2.2 Field Survey Methods

Different sub habitats (The Northern and Southern Riparian zones) were first identified based on their vegetation structure. A detailed plot assessment was then undertaken in each sub habitat. A 60 x 10m dimensioned plot was centred within the most representative riparian vegetation patch to best characterise the habitat. The projected foliage and canopy covers of native and introduced species was quantified along a 60m transect which ran within the 60x10m plot at 20cm intervals using a point-intercept method (Eyre et al. 2011).

Following the plot assessment, a broader meander traverse of the NDC was undertaken to obtain a more comprehensive understanding of floristic composition at the site as well as search for significant flora species.

2.3 Field Survey Results

The NDC is categorised as degraded shale plains woodland with canopy cover of less than 10% on the Native Vegetation Map for the *Blacktown region, Cumberland Plain, Western Sydney 2012 (refer to Figure 2.4).*

Figures 2.4-2.8 show photos of the Northern and Eastern riparian zones and stream channel at equal intervals along the NDC starting at Owen Street. A total of 34 flora species were identified along the entire NDC survey site and of these 15 were introduced species (*refer to Table 1*). **No TSCA or ROTAP species were identified**.

The Northern and Southern Riparian zone dominant flora species projected foliage and canopy cover results are shown in *Table 2* and *Table 3*. The Southern Riparian zone was estimated to have an average canopy height of 6-10m and average canopy cover of between 40-70%.

Table 1. List of the flora identified in the Northern Drainage Channel survey site along with their listed conservation status.

Flora species	Flora Type	Flora species	Flora Type
Canopy		***cont. Groundcover***	
Allocasuarina littoralis	Tree	*Dianella sp^*	Tuffed plant
Casuarina glauca	Tree	*Juncus usitatus*	Tufted perennial
*Eucalyptus sp. (smooth bark)^*	Tree	*Lomandra longifolia*	Tufted perennial grass
Eucalyptus tereticornis	Tree	*Microlaena stipoides var. stipoides*	Annual grass
Melaleuca linariifolia	Tree	*Onopordum acanthium**	Biennial Herb
Melaleuca sieberi	Tree	*Panicum repens**	Perennial grass
		*Persicaria sp^*	Decumbent plant
Midstorey		*Pennisetum alopecuroides*	Tufted perennial grass
*Araujia sericifera**	Spikey Shrub	*Phragmites australis*	Reed
Bursaria spinosa	Shrub	*Ranunculus sessiliflorus*	Annual herb
Glochidion ferdinandi	Tree	*Sida rhombifolia**	Small Shrub
*Olea europaea subsp. cuspidata**	Shrub	*Solanum linnaeanum**	Shrub
*Pyracantha spp**	Spikey Shrub	*Sonchus oleraceus**	Annual herb
*Ricinus communis**	Shrub	*Sporobolus natalensis**	Tufted perennial grass
		Themeda triandra	Perennial grass
Groundcover		*Verbena incompta**	Annual Herb
*Araujia sericifera**	Vine		
*Bidens pilosa**	Herb	***Aquatic Plants***	
*Cirsium arvense**	Biennial Herb	*Typha orintalis*	Aquatic perennial reed
Cyperus difformis	Tufted annual	*Typha domingensis*	Aquatic perennial reed

Key: * denotes an introduced species
+ denotes a species listed on the schedules of the Threatened Species Conservation Act (TSCA)
◊ denotes a ROTAP listed species
‡ denotes a gazetted weed.
^ species identification not found due to the absence of distinguishing floristic elements.

Table 2. The dominant Northern Riparian zone Flora species recorded and their corresponding projected foliage cover results from the plot-based assessment.

Flora species	Flora type	Projected cover (%)
Lomandra longifolia	Tufted perennial grass	32.5
*Sporobolus natalensis**	Tufted perennial grass	20.2
*Panicum repens**	Perennial grass	11.5
Typha domingensis	Aquatic perennial reed	10.2
*Persicaria sp^*	Decumbent plant	10.0
*Verbena incompta**	Annual Herb	2.8
*Bidens pilosa**	Herb	2.4
Pennisetum alopecuroides	Tufted perennial grass	2.0
*Sida rhombifolia**	Small Shrub	2.0
Bare Ground or leaf litter		6.4

Table 3. The dominant Southern Riparian zone Flora species recorded and their corresponding projected canopy cover results from the plot-based assessment.

Flora species	Flora type	Projected foliage canopy cover (%)
Casuarina glauca	Tree	34.1
Melaleuca linariifolia	Tree	18.3
Melaleuca sieberi	Tree	18
Eucalyptus tereticornis	Tree	15.4
Eucalyptus sp. (smooth bark)	Tree	13.8

3 Fauna Assessment

3.1 Desktop Review

An initial desktop review of available information was undertaken to determine which fauna had the potential to occur within the NDC.

This included reviewing the listed endangered, vulnerable or near threatened fauna and fish species and their habitats under the TSCA and the *Fisheries Management Act 1994* . This was done in order to tailor the survey efforts around confirming their presence.

A spatial search was also conducted on with the Atlas of Living Australia to determine which TSCA listed species, had the potential to occur within a 25km radius of the NDC. This list is shown in Appendix 3.

Reference material on the target species (species profiles, etc.) was also used to confirm their habitat requirements and distinguishing features to assist in field identification.

3.2 Field Survey Methods

As well as making incidental species recordings throughout the course of the flora survey, a general mammal and reptile fauna search was conducted by looking for burrows and scats around hollows, logs and in and amongst ground layer grasses and shrubs. Tree hollows and fallen branches which are critical habitats for many native mammals were noted.

To maximise the likelihood of identifying birds a sit and wait method was employed for 1 hour around dusk (which is the most active time for many species). Low altitude flying birds which either flew over or were actively moving about the NDC were documented.

To identify fish within the stream, scoop net sampling was employed amongst an array of different stream habitat (such as over rocks, amongst *Typha sp.* etc.). A variety of scoop techniques were employed (such as surface scoops and bottom scoops) to best sample the entire water column. Scooping occurred at random intervals along the stream. Incidental fish species recordings were also made throughout the course of the flora survey.

To identify amphibians, a 3 minute sound recording was recorded around dusk in order to pick up their calls. The recorder was set up close to the stream amongst favourable frog habitat (such as shallow pools with a high amount of within-stream and riparian vegetation cover).

3.3 Field Survey Results

No significant fauna or their habitats listed under the *TSCA* were found to occur in the NDC.

Table 4 shows birds observed within the vicinity of the NDC.

Table 4. Bird species observed in the Northern drainage channel.

Bird Species
Australian Wood Duck *(Chenonetta jubata)* (*refer to Figure 3.1 i*))
Dusky Moorhen *(Gallinula tenebrosa)*
Australian White Ibis *(Threskiornis moluccus)*
Red-rumped Parrot *(Psephotus haematonotus)*
Rainbow Lorikeet *(Trichoglossus moluccanus)*
Crested Pigeon *(Ocyphaps lophotes)*
Willie Wagtail *(Rhipidura leucophrys)*
Noisy Miner *(Manorina melanocephala)*
Australian Magpie *(Cracticus tibicen)*

Only exotic *Gambusia* fish were collected and observed in the survey (*refer to Figure 3.1 ii*)). **No significant fish or their habitats listed under the *Fisheries Management Act 1994* were found to occur in the NDC.**

A total of 3 different frog and toad calls were identified on the recording. One call was that of the *Bufo marinus*. The other 2 recorded calls are believed to be from native frogs but were not able to be further identified.

No small mammals or any scats or marking were physically observed in the NDC. The Southern riparian zone was found to contain a small amount suitable tree hollows fallen logs and other critical small mammal and reptile habitat.

4 Macro-invertebrate water quality assessment

4.1 Desktop Review

The Blacktown City Council Waterway Health Report Card 2013-2014 was reviewed to gain an appreciation for the wider catchment streams water quality ratings. This report is shown in Appendix 4.

4.2 Field Survey Methods

A macro-invertebrate sweep was undertaken. Macro invertebrate sub habitats (for example pools, riffles, amongst water plants) were identified. Then using a specialised scoop net, scoop sampling occurred in all sections of the water column and under rocks for each of the sub habitats.

Different macro-invertebrates have different sensitivity levels to water pollutants. The survey followed the methodology outlined in Water Watch Field Manuals Guide to Macro-invertebrate Surveys (Appendix 5). Basically, macro-invertebrates harvested in the reserve were assigned a sensitivity rating from 1-10 and their abundances recorded and weighted. From this the stream pollution index was calculated.

Bottle traps using bread and banana as bait were used to survey the benthic zones of pools deeper than ~1.2m. The design of these bottle traps is shown in Figure 4.1 i).

4.3 Field Survey Results

Only two types of macro-invertebrates were caught; freshwater water snails dragonfly nymph (refer to Figure 4.1 ii)). Both these macro-invertebrates are considered tolerant to high levels of water pollution. After an intensive 1 hour long survey effort, less than 50 macro-invertebrates were captured and thus, a stream pollution index (SPI) could not be calculated. The fact that only a low number of highly pollution tolerant macro-invertebrates were captured suggests that water quality in the drainage channel is low.

The polluted nature of the stream is further highlighted in Figure 4.2 i) where a stream surface scum layer can be visibly seen. Numerous plastic rubbish was observed along the entire length of the NDC refer to Figure 4.2 ii).

5 Conclusions

5.1 Flora Issues

The NDC contains little remnant vegetation which is confined to a thin riparian strip. The NDC contains numerous exotic plant species. The surrounding landscape has been heavily urbanised and the remnant vegetation severely fragmented.

5.2 Fauna Issues

Despite the small amount of suitable tree hollows fallen logs and other critical small mammal and reptile habitat present in the Southern riparian zone, the NDC has limited ecological significance for small native mammals and reptiles. This is due to the NDC small overall area, lack of connectivity to surrounding remnant vegetation and thin nature of the riparian zones.

Due to the small overall area and thin nature of the riparian zones, the NDC channel has limited ecological significance for Native birds. However, the Southern riparian zone contains numerous mid storey shrubs which is good habitat too for a small number of wrens, robins and swallows. The stream pools are good foraging grounds for aquatic birds such as Dusky Moorhens, Pacific Black Ducks and Australian Wood Ducks.

The NDC has limited ecological significance for native fish. This is mainly due to the poor water quality and the presence of an artificial weir near Owen Street which creates a barrier for fish migration into the NDC.

The heavily vegetated riparian zones of the NDC are likely to act as a local reservoir for resilient species of native frogs. However, it is unlikely that less resilient endangered or vulnerable frogs such as the Green and Golden Bell Frog reside in the NDC due to the heavily disturbed and urbanised nature of the surrounding area.

5.3 Water Quality Issues

The water quality in the drainage reserve is low and it is likely to be highly polluted.

This assessment concurs with the Blacktown City Council Waterway Health Report Card 2013-2014 (refer Appendix 5) which observes poor macro-invertebrates diversity is present in all waterways upstream and downstream of site.

6 Reference Material

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The Royal Botanic Gardens and Domain Trust (04/05/15). PlantNET - The Plant Information Network System of The Royal Botanic Gardens and Domain Trust, Sydney, Australia. http://plantnet.rbgsyd.nsw.gov.au

Leiper, G, Glazebrook, J, Cox, D, Rathie, K, (2008). Mangroves to Mountains: a field guide to the native plants of south-east Queensland, Revised Edition, Society for Growing Australian Plants (Queensland Region) Inc, Browns Plains, QLD.

ALA (2015). Atlas of Living Australia online database. Available from: http://www.ala.org.au/ (accessed 04/05/2015)

FIGURES

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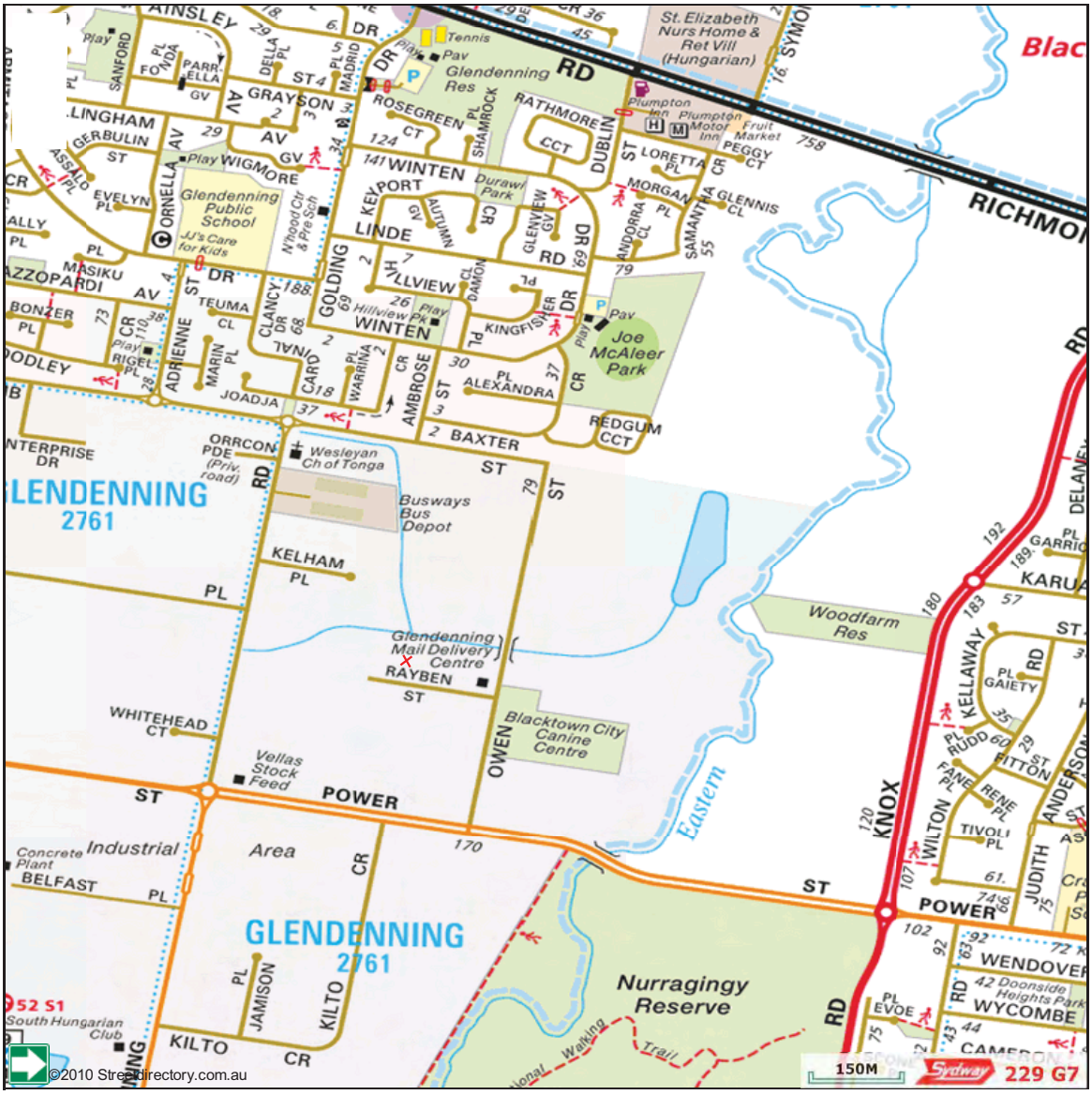

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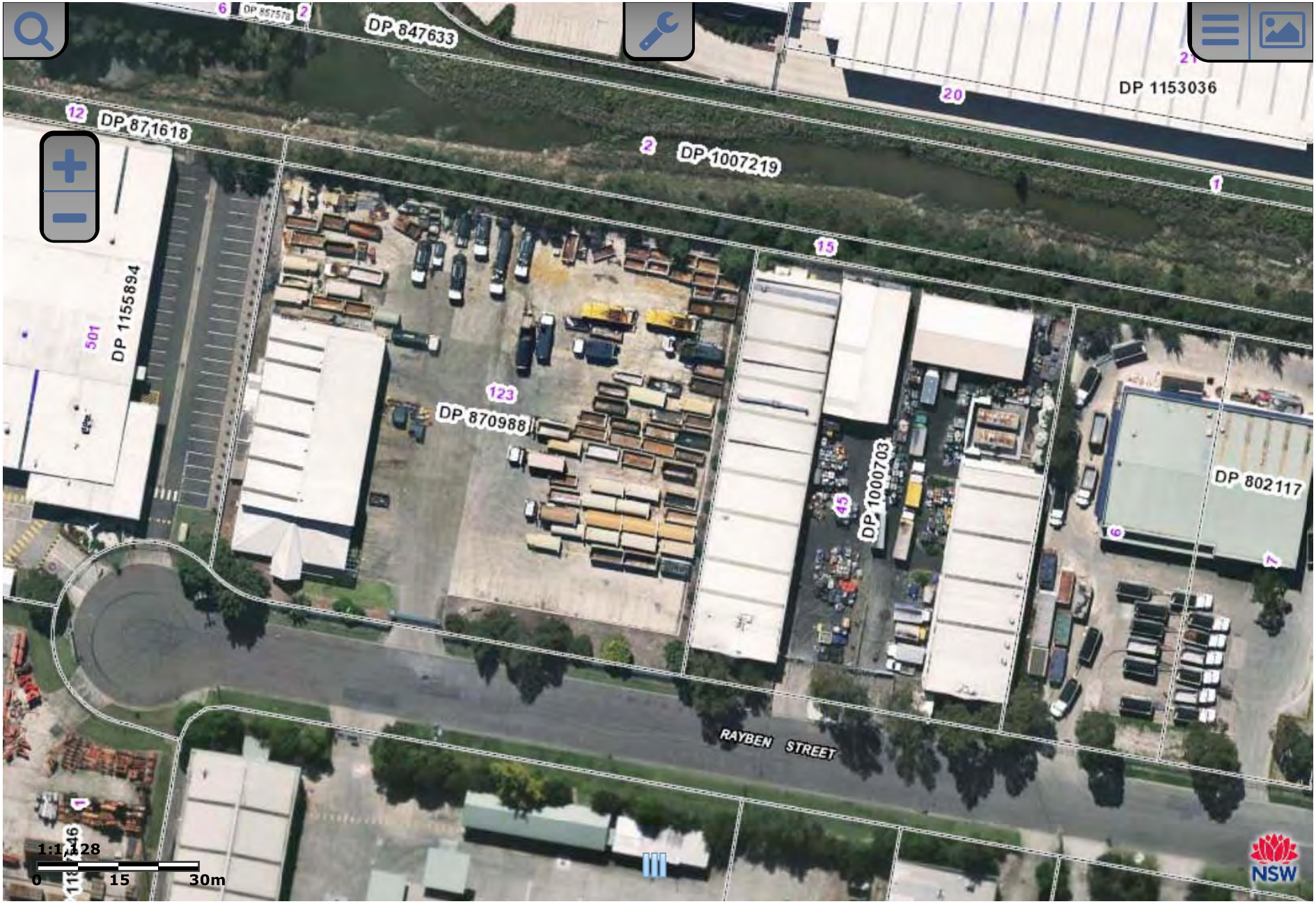
JJ RICHARDS & SONS PTY LTD	SCALE
WMF & DEPOT AT 14 RAYBEN ST, GLENDENNING SITE LOCATION	SHEET
	FIGURE 1.1



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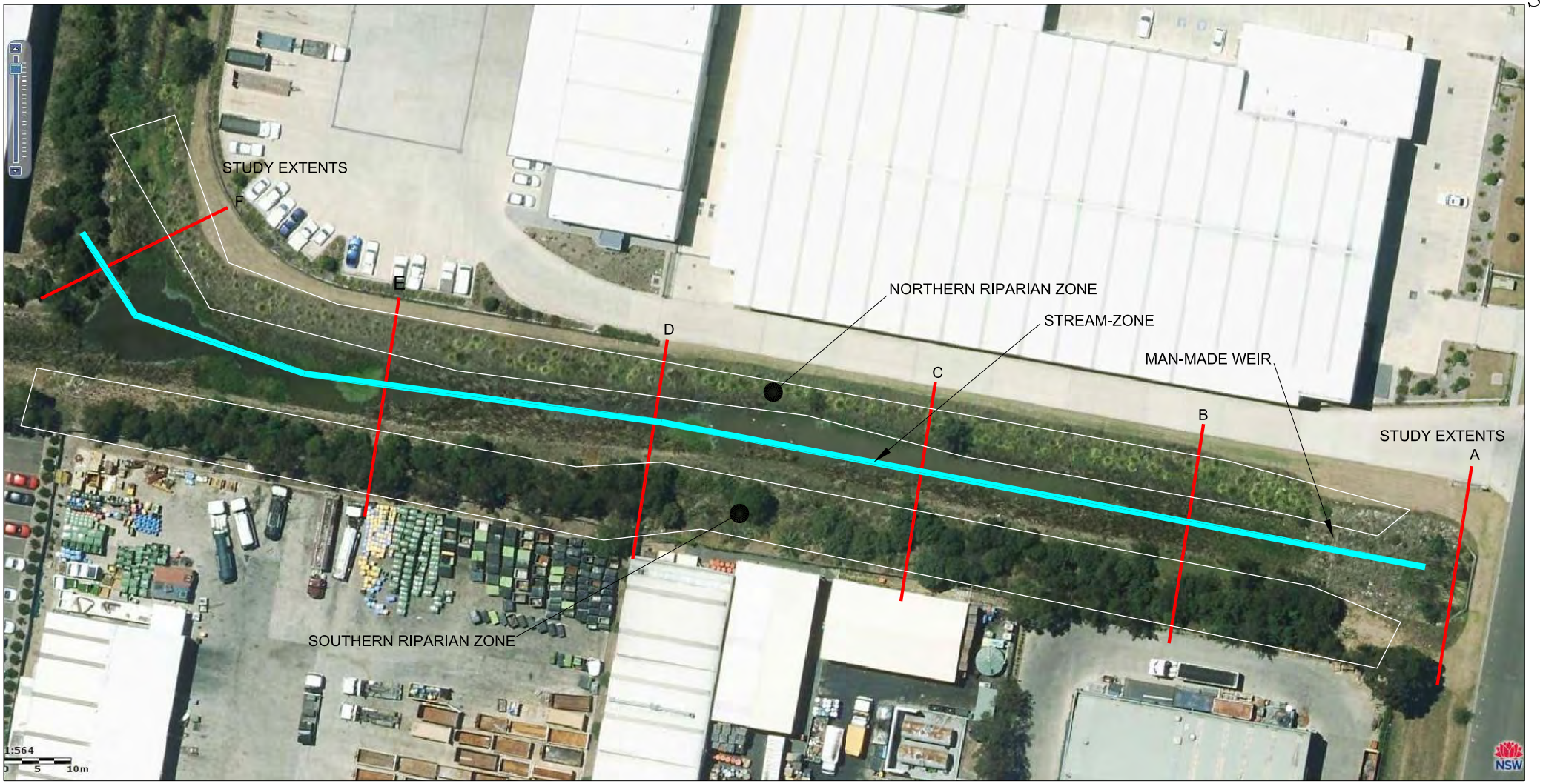
WMF & DEPOT AT 14 RAYBEN ST, GLENDENNING AERIAL PHOTOGRAPH		REF.	
		FIGURE	1.2



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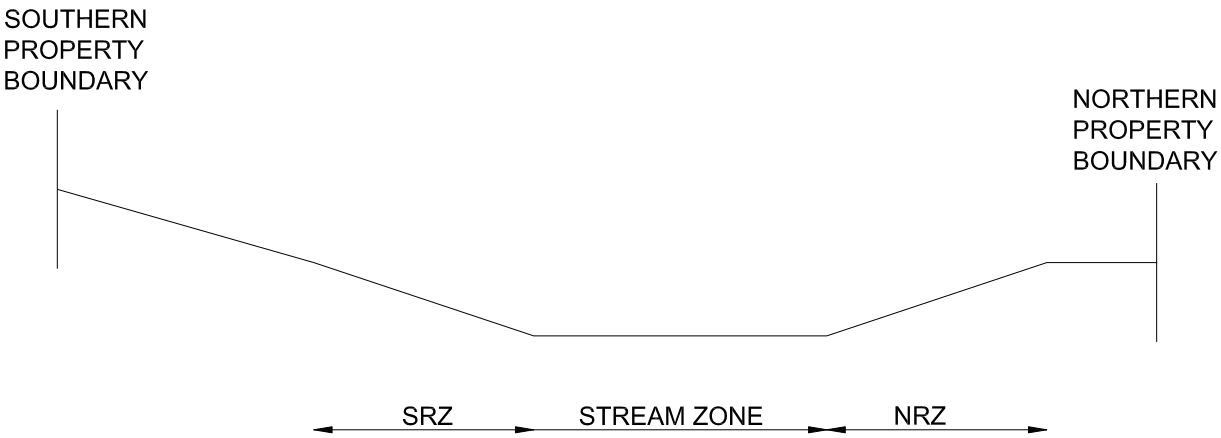
WMF & DEPOT AT 14 RAYBEN ST, GLENDENNING ECOLOGICAL PLAN	REF.	
	FIGURE	2.1



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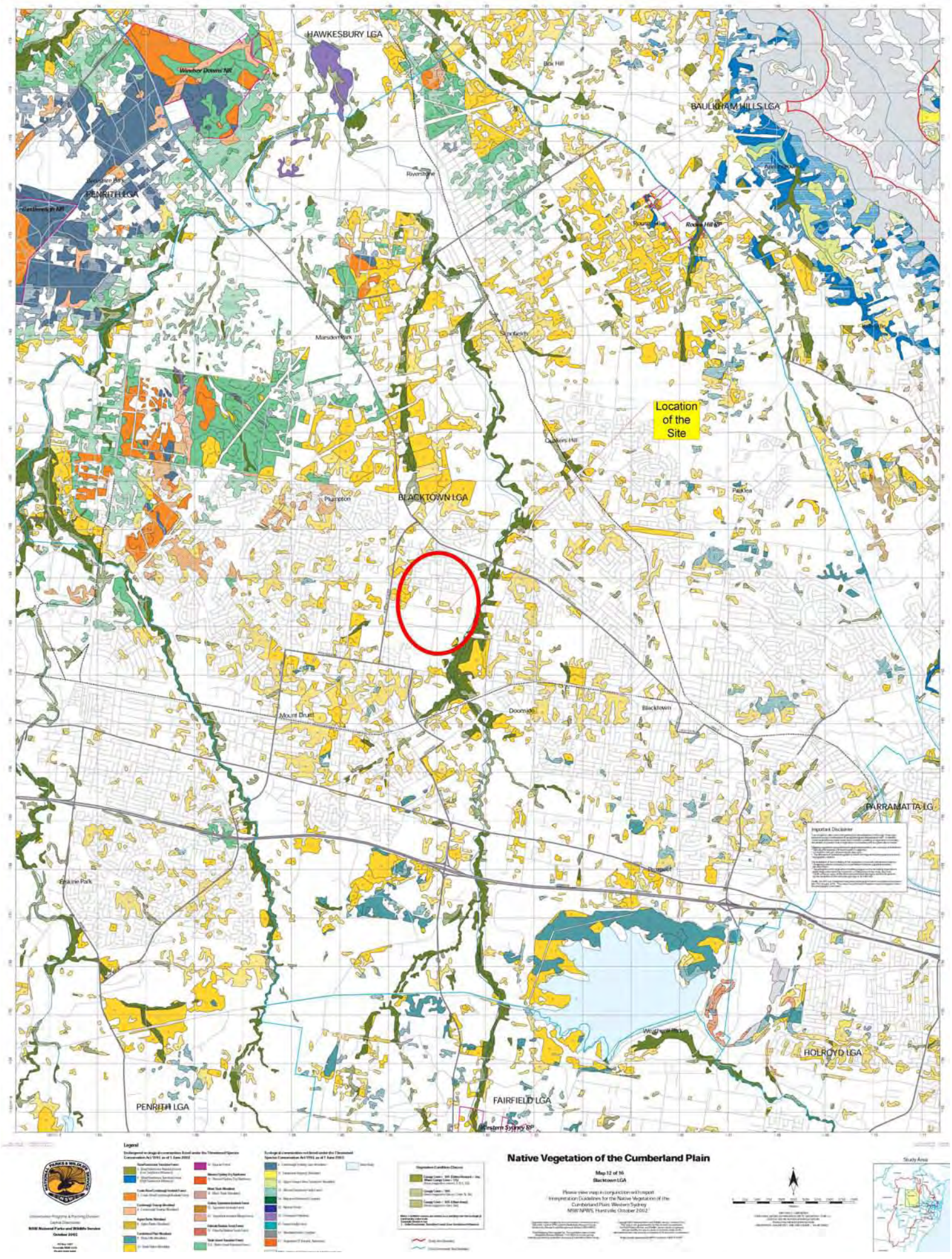
JJ RICHARDS & SONS PTY LTD	SCALE	AS SHOWN
WMF & DEPOT AT 14 RAYBEN ST, GLENDENNING TYPICAL DRAINAGE CHANNEL DETAILS	REF.	
	FIGURE	2.2



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	WMF & DEPOT 14 RAYBEN ST, GLENDENNING NSW PARKS AND WILDLIFE VEGETATION CLASSIFICATION	SHEET	
		FIGURE	2.3

From east

From west

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WMF & DEPOT AT
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FLORA SURVEY PHOTOS - SECTION A

SCALE	NOT TO SCALE
SHEET	
FIGURE	2.4

From northern riparian

From southern riparian

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FLORA SURVEY PHOTOS - SECTION B

SCALE	NOT TO SCALE
SHEET	
FIGURE	2.5

From northern riparian

From southern riparian

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FLORA SURVEY PHOTOS - SECTION C

SCALE	NOT TO SCALE
SHEET	
FIGURE	2.6

From northern riparian

From southern riparian

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FLORA SURVEY PHOTOS - SECTION D

SCALE	NOT TO SCALE
SHEET	
FIGURE	2.7

From northern riparian zone

From northern zone

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FLORA SURVEY PHOTOS - SECTION E

SCALE	NOT TO SCALE
SHEET	
FIGURE	2.8

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FLORA SURVEY PHOTOS - SECTION F

SCALE	NOT TO SCALE
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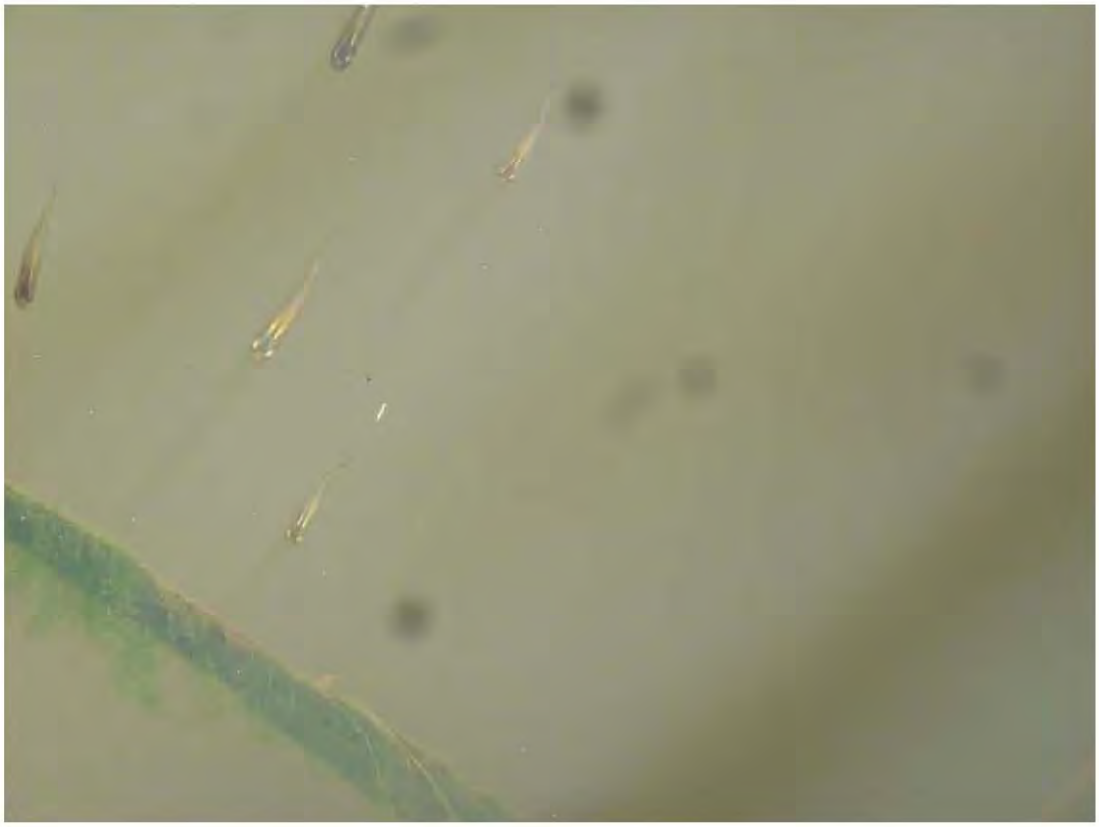
FIGURE	2.9



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FAUNA SURVEY PHOTOS

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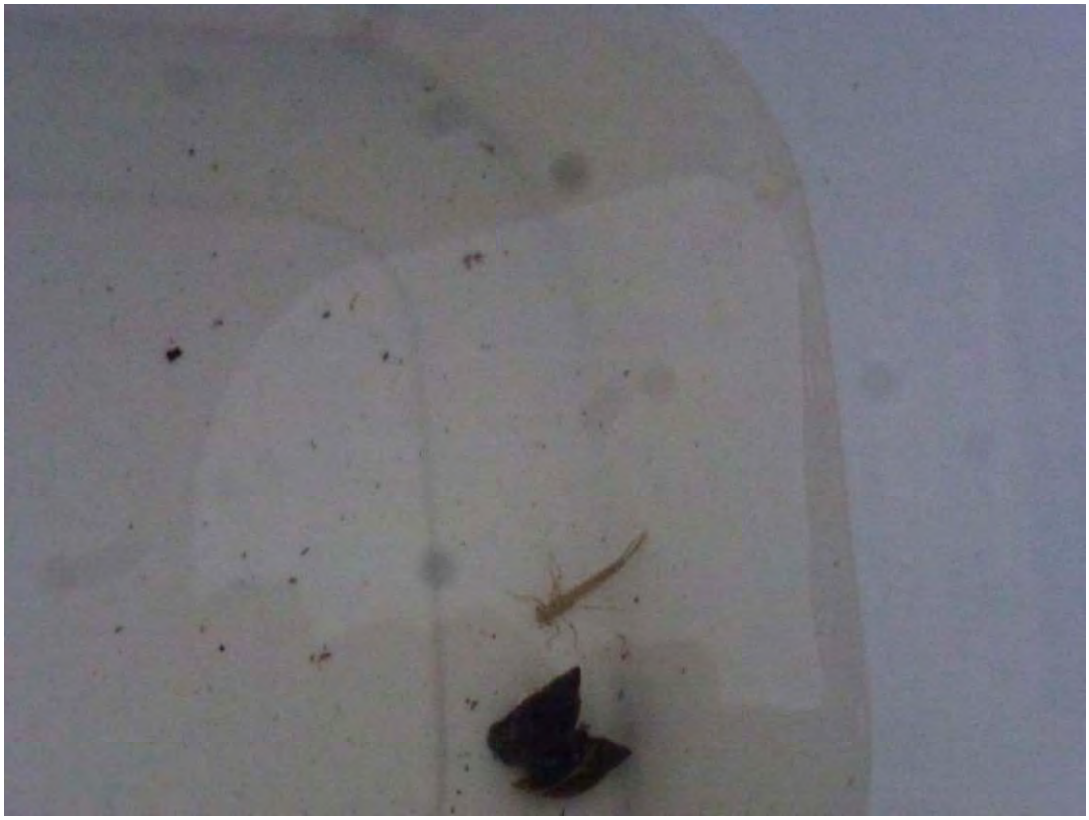
FIGURE	3.1



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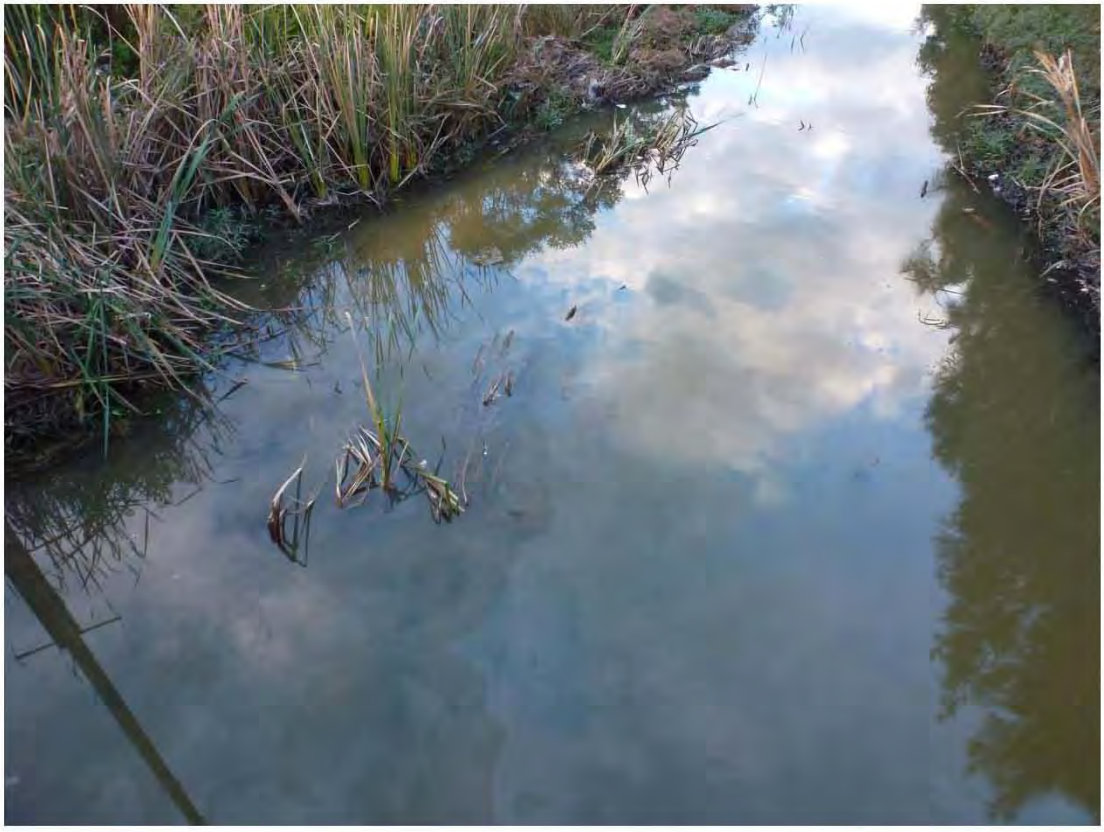
MACRO-INVERTEBRATE SURVEY PHOTOS

SCALE	NOT TO SCALE
SHEET	
FIGURE	4.1



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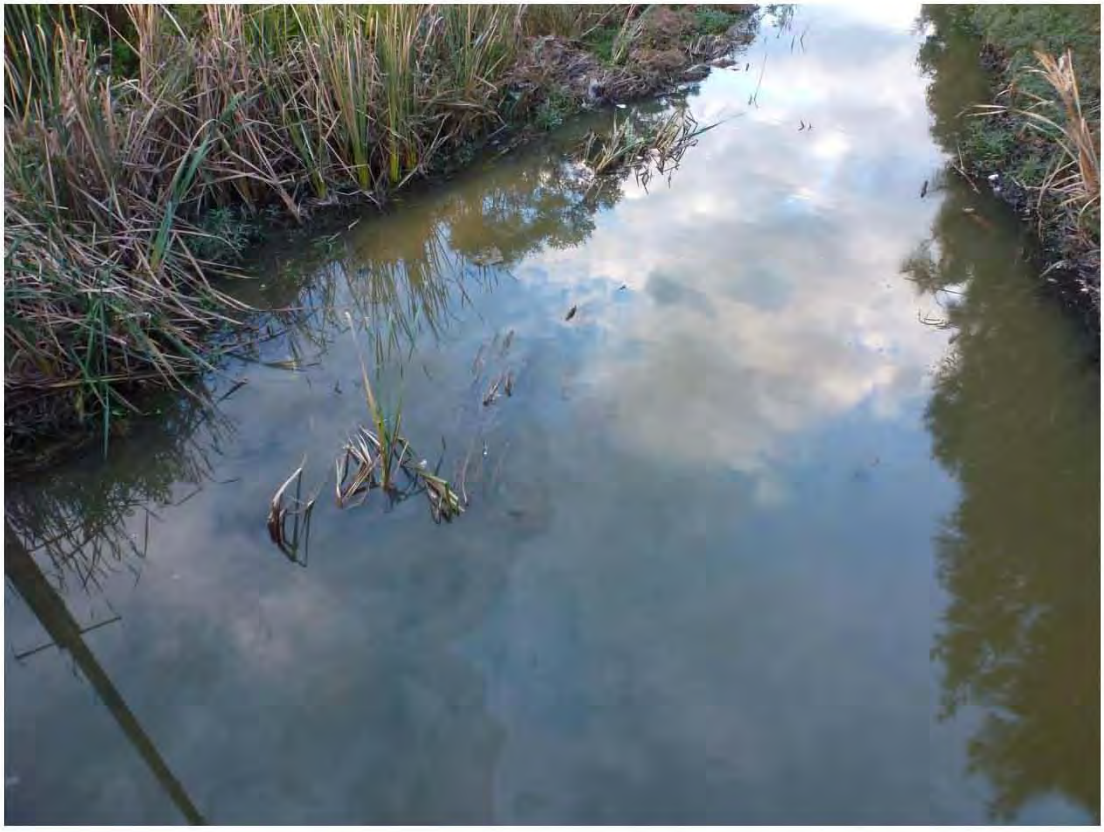
PHOTOS - STREAM DETAILS

SCALE	NOT TO SCALE
SHEET	
FIGURE	4.2



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PHOTOS - STREAM DETAILS

SCALE	NOT TO SCALE
SHEET	
FIGURE	4.2

APPENDIX 1

Resume of Daniel Hede

Resume of Daniel Hede

1. Personal Information

Date of Birth:	24 August 1990
Address:	14 Dove Court Albany Creek, Queensland, Australia 4035
Telephone:	Mobile: +61 450 585 635
Email:	danhede22@gmail.com

2. Education

a) Completed a Level 3 Spanish course at the Central University of Languages in Buenos Aires, Argentina a in December 2014.
b) Completed a Bachelor of Science majoring in Ecology at The University of Queensland in 2012 with a G.P.A of 5.75.
c) Awarded an academic Merit scholarship from UQ for 2010.
d) Awarded a Dean's Commendation for High Achievement from the Faculty of Science for semester 2 2010 and semester 1 2011.
e) 2008 Hillbrook Anglican High School QLD graduate with an OP 2.

Training Achievements

2011 - Accredited level 1 sports trainer through Sports Medicine Australia.
2011- Accredited sports first aider through Sports Medicine Australia.
2011- Completed a Leader Development workshop through The University of Queensland.
2011- Completed a Responsible Service of Alcohol.
2007 - Completed a PADI Open Water dive course to become a certified SCUBA diver.

3. Science and Environmental Consultancy Work Experience

June 2012 to November 2013

Environmental consultancy contract work for Spectrapave Pty Ltd.
I was in charge of regenerating a 1.34HA patch of degraded sclerophyll forest for a construction development in Oxenford QLD. I led a 3 man team on monthly weed sweeps, conducted a flora and fauna survey and wrote an environmental site report which was submitted and approved by council.

Work Experience February to June 2013

Environmental Consultancy with Geolyse Pty Ltd.
Worked 2 days a week with ecologists conducting flora and fauna surveys and environmental impact statements for development projects in Orange NSW.

Work Experience November 2012

Vegetation Survey and Assessment with 3D Environmental Pty Ltd.
Assisted in conducting a vegetation survey and learnt the underlying techniques and methodology involved in vegetation surveying with landscape ecologist David Stanton in Warwick QLD.

November 2011 to June 2012

Bush Regeneration with Environmental Management International Pty Ltd.
Tasks included planting native trees and identifying and removing exotic species from numerous ecosystems around South East Queensland.

March 2011 to October 2012

Tuition with The University of Queensland
Twice a week I led biology and statistics classes at university. This involves preparing worksheets based on the course material. Typically there were 15-25 students in each class.

Work Experience September 2007

Zoology Research assistant with The University of Queensland
Spent 1 week helping tag Moreton bay dugongs and cataloguing their samples with zoologist Dr Janet Lanyon.

4. Community Service

April 2007 to August 2008 — **Hand**
Attending excursions and assisting with the care of mentally disabled people.

5. Interests

a) **Travel**
- I have spent the last 10 months travelling and living in South America. Amongst numerous other things, I actively visited national park and wilderness areas in Uruguay, Argentina, Bolivia, Peru and Ecuador and gained an appreciation for how eco-tourism and national park systems operate in different countries.

- From the end of 2013 I spent 2 months in Sri Lanka and 1 month in India and visited 15 national parks. Whilst in Sri Lanka I befriended and stayed 3 weeks with local families in small, rural rice farming areas amongst the rainforest and learnt about some of their cultural customs and knowledge of rainforest medicines and foods.

b) **Music**
- Have played the drums for 10 years and currently learning the guitar
- Played and gigged in numerous bands around Brisbane, including recording an album with an 8-piece funk and soul band called The Greenwich Means.

c) **Personal Enjoyment**
- Botany, Hiking and fishing
- Surfing, AFL and sport

6. Referees

a) Maree Barton
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Department of Education and Training
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b) Ray Duggan
Engineer
Spectrapave
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APPENDIX 2

Endangered Flora Species List

Click on a name to see the page for that taxon.

* denotes an introduced species

\+ denotes a species listed on the schedules of the Threatened Species Conservation Act (TSCA)

◊ denotes a ROTAP listed species

‡ denotes a gazetted weed.

Both TSCA and ROTAP listed species collected in a 25 km radius around Blacktown (150.9,-33.76666)

PLANT FAMILY	PLANT GENUS	PLANT STATUS	PLANT SPECIES
Apiaceae	Platysace	◊	clelandii
Apocynaceae	Cynanchum	◊+	elegans
Asteraceae	Ozothamnus	◊	adnatus
	Senecio	◊	macranthus
Cabombaceae	Brasenia	◊	schreberi
Casuarinaceae	Allocasuarina	◊+	glareicola
Convolvulaceae	Convolvulus	◊	erubescens
	Wilsonia	+	backhousei
		+	rotundifolia
Dilleniaceae	Hibbertia	◊	nitida
		+	sp. Menai (A.T. Fairley 15 Dec 2004)
		+	sp. Turramurra (A.F. Robinson s.n. NSW981514)
		+	stricta subsp. furcatula
		+	superans
Elaeocarpaceae	Tetratheca	◊+	glandulosa
		◊+	juncea
		◊	neglecta
Ericaceae - Styphelioideae	Epacris	+	purpurascens var. purpurascens
	Leucopogon	◊+	exolasius
		◊+	fletcheri subsp. fletcheri
	Lissanthe	◊	sapida
	Monotoca	◊	ledifolia
	Rupicola	◊	sprengelioides
Euphorbiaceae	Amperea	◊	xiphoclada var. papillata
	Bertya	◊	brownii

Fabaceae - Faboideae	Dillwynia	◊+	tenuifolia
	Pultenaea	+	humilis
		◊+	parviflora
		+	pedunculata
Fabaceae - Mimosoideae	Acacia	◊+	bynoeana
		◊+	gordonii
		◊+	pubescens
		◊+	terminalis subsp. terminalis
Gyrostemonaceae	Gyrostemon	◊+	thesioides
Haloragaceae	Gonocarpus	◊	longifolius
		◊	salsoloides
	Haloragodendron	+	lucasii
Juncaginaceae	Maundia	+	triglochinoides
Lamiaceae	Prostanthera	◊+	marifolia
Lindsaeaceae	Lindsaea	◊	trichomanoides
Lobeliaceae	Isotoma	◊+	sessiliflora
Lomandraceae	Lomandra	◊	brevis
		◊	fluviatilis
Malvaceae	Lasiopetalum	◊+	joyceae
Marsileaceae	Pilularia	◊+	novae-hollandiae
Monimiaceae	Daphnandra	+	johnsonii
Myrtaceae	Angophora	◊	crassifolia
	Callistemon	◊+	linearifolius
		◊	shiressii
	Darwinia	◊+	biflora
		◊+	peduncularis
		◊	procera
	Eucalyptus	◊+	benthamii
		◊+	camfieldii
		◊	luehmanniana
		+	sp. Cattai (Gregson s.n., 28 Aug 1954)
	Leptospermum	◊+	deanei
	Melaleuca	+	biconvexa
		◊+	deanei
	Micromyrtus	◊+	blakelyi
		◊+	minutiflora
	Syzygium	◊+	paniculatum
	Triplarina	◊+	imbricata
Orchidaceae	Caladenia	◊	curtisepala
		◊+	tessellata
	Genoplesium	◊+	baueri
		◊+	plumosum
	Pterostylis	◊+	saxicola
Poaceae	Ancistrachne	◊+	maidenii
	Deyeuxia	◊+	appressa
Proteaceae	Grevillea	◊+	caleyi

		+	juniperina subsp. juniperina
		◊	longifolia
		+	parviflora subsp. parviflora
		+	parviflora subsp. supplicans
	Persoonia	◊+	hirsuta
		◊+	hirsuta subsp. hirsuta
		◊+	mollis subsp. maxima
		◊+	nutans
Rubiaceae	Galium	+	australe
Rutaceae	Boronia	◊	fraseri
		◊	serrulata
	Zieria	◊+	involucrata
Scrophulariaceae	Myoporum	◊	floribundum
Solanaceae	Cyphanthera	◊	scabrella
Thymelaeaceae	Pimelea	+	curviflora var. curviflora
		◊+	spicata
Zannichelliaceae	Zannichellia	◊+	palustris

APPENDIX 3

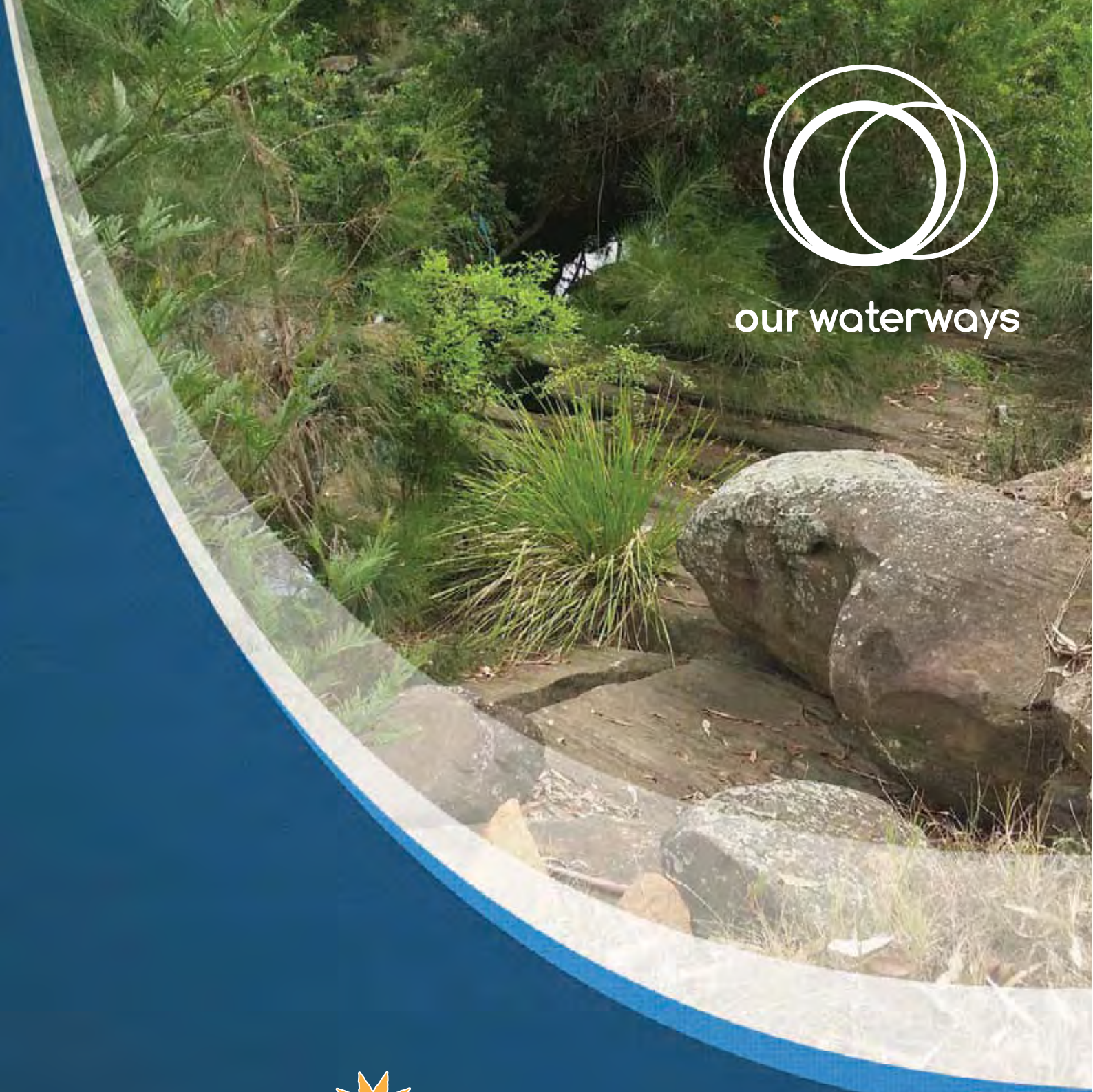
Endangered Fauna Species List

	Common name	Scientific name	NSW status	Comm. status	No. of records	
Animalia **Amphibia** **Hylidae**	Green and Golden Bell Frog	Litoria aurea	☐	E1,P	V	6
Aves **Ciconiidae**	Black-necked Stork	Ephippiorhynchus asiaticus	☐	E1,P		1
Ardeidae	Australasian Bittern	Botaurus poiciloptilus	☐	E1,P	E	1
	Black Bittern	Ixobrychus flavicollis	☐	V,P		1
Accipitridae	Spotted Harrier	Circus assimilis	☐	V,P		1
	Little Eagle	Hieraaetus morphnoides	☐	V,P		18
	Square-tailed Kite	^^Lophoictinia isura	☐	V,P,3		3
Falconidae	Black Falcon	Falco subniger	☐	V,P		2
Rostratulidae	Australian Painted Snipe	Rostratula australis	☐	E1,P	E	5
Cacatuidae	Glossy Black-Cockatoo	^Calyptorhynchus lathami	☐	V,P,2		4
Psittacidae	Little Lorikeet	Glossopsitta pusilla	☐	V,P		6
	Swift Parrot	^^Lathamus discolor	☐	E1,P,3	E	6
Strigidae	Barking Owl	^^Ninox connivens	☐	V,P,3		1
	Powerful Owl	^^Ninox strenua	☐	V,P,3		9
Tytonidae	Masked Owl	^^Tyto novaehollandiae	☐	V,P,3		2
	Sooty Owl	^^Tyto tenebricosa	☐	V,P,3		1
Acanthizidae	Speckled Warbler	Chthonicola sagittata	☐	V,P		18
Meliphagidae	Black-chinned Honeyeater (eastern subspecies)	Melithreptus gularis gularis	☐	V,P		3
Neosittidae	Varied Sittella	Daphoenositta chrysoptera	☐	V,P		41
Petroicidae	Scarlet Robin	Petroica boodang	☐	V,P		6
Estrildidae	Diamond Firetail	Stagonopleura guttata	☐	V,P		2
Mammalia **Dasyuridae**	Spotted-tailed Quoll	Dasyurus maculatus	☐	V,P	E	8
Phascolarctidae	Koala	Phascolarctos cinereus	☐	V,P	V	1
Petauridae	Squirrel Glider	Petaurus norfolcensis	☐	V,P		1

Pteropodidae	Grey-headed Flying-fox	Pteropus poliocephalus	☐	V,P	V	47
Emballonuridae	Yellow-bellied Sheathtail-bat	Saccolaimus flaviventris	☐	V,P		4
Molossidae	Eastern Freetail-bat	Mormopterus norfolkensis	☐	V,P		51
Vespertilionidae	Large-eared Pied Bat	Chalinolobus dwyeri	☐	V,P	V	4
	Eastern False Pipistrelle	Falsistrellus tasmaniensis	☐	V,P		15
	Little Bentwing-bat	Miniopterus australis	☐	V,P		2
	Eastern Bentwing-bat	Miniopterus schreibersii oceanensis	☐	V,P		70
	Southern Myotis	Myotis macropus	☐	V,P		40
	Greater Broad-nosed Bat	Scoteanax rueppellii	☐	V,P		24
Gastropoda **Camaenidae**	Cumberland Plain Land Snail	Meridolum corneovirens	☐	E1		277

APPENDIX 4

The Blacktown City Council Waterway Health Report Card 2013-2014



our waterways

Blacktown City Council

WATERWAY HEALTH REPORT CARD 2013-2014

STATE OF OUR WATERWAYS

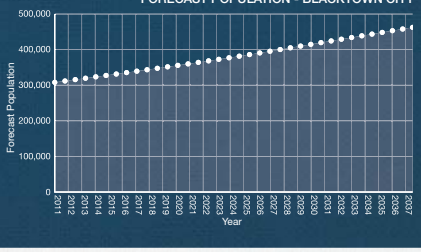
Blacktown City is growing and by 2036 it will be home to almost 500,000 residents. The expansion of the City will result in an increase of hard surfaces such as paths, driveways, roads and car parks. These hard surfaces prevent rainwater from absorbing into the ground which directs large volumes of fast moving "stormwater" to our waterways from the city's drainage pipes. It is this stormwater that washes pollutants from urban areas into creeks, rivers and wetlands which degrades the quality of our waterways.

To combat this issue, Community Vision 2030 outlines Council's intent to "pursue best practice sustainable water management to protect and improve the water quality of the local environment". Council is actively undertaking various projects to protect and enhance our waterways in the face of continued urban development.

Blacktown City Council periodically monitors the quality of our waterways and the results from 2013 to 2014 have been included in this report card. Overall, most urban waterways within Blacktown City are in fair condition however creeks in less developed areas of the city are in good condition.

In the west of the City lies a small tributary of Little Creek. This Creek is in excellent condition and surrounded by undisturbed bushland which is home to over 300 species of native wildlife and endangered plants.

FORECAST POPULATION - BLACKTOWN CITY



ROPES CREEK - NORTH
C

High nutrient concentrations adversely affect water quality, reflected by low macroinvertebrate diversity. High cover of weeds in the riparian zone.

SOUTH CREEK
B

Improved water quality with reduced nutrient concentration throughout the year was reflected by substantial improvement to the macroinvertebrate community. Largely intact riparian vegetation community enhances creek condition.

LITTLE CREEK TRIBUTARY
A

Excellent water quality with rich macroinvertebrate community and undisturbed native vegetation.

BELLS CREEK
C

Poor macroinvertebrate community with variable water quality. Degraded riparian vegetation is affecting the condition of this creek.

EASTERN CREEK - NORTH
B

Poor macroinvertebrate diversity reflects variable water quality throughout the year. Mixed riparian vegetation community of natives and weed species.

BREAKFAST CREEK
C

Poor macroinvertebrate community and variable water quality often with high nutrient concentration. Narrow riparian buffer with remnant native vegetation.

QUAKERS HILL CREEK
C

Degraded macroinvertebrate community reflects variable water quality. Riparian vegetation community is re-establishing following rehabilitation works.

BLACKTOWN CREEK
C

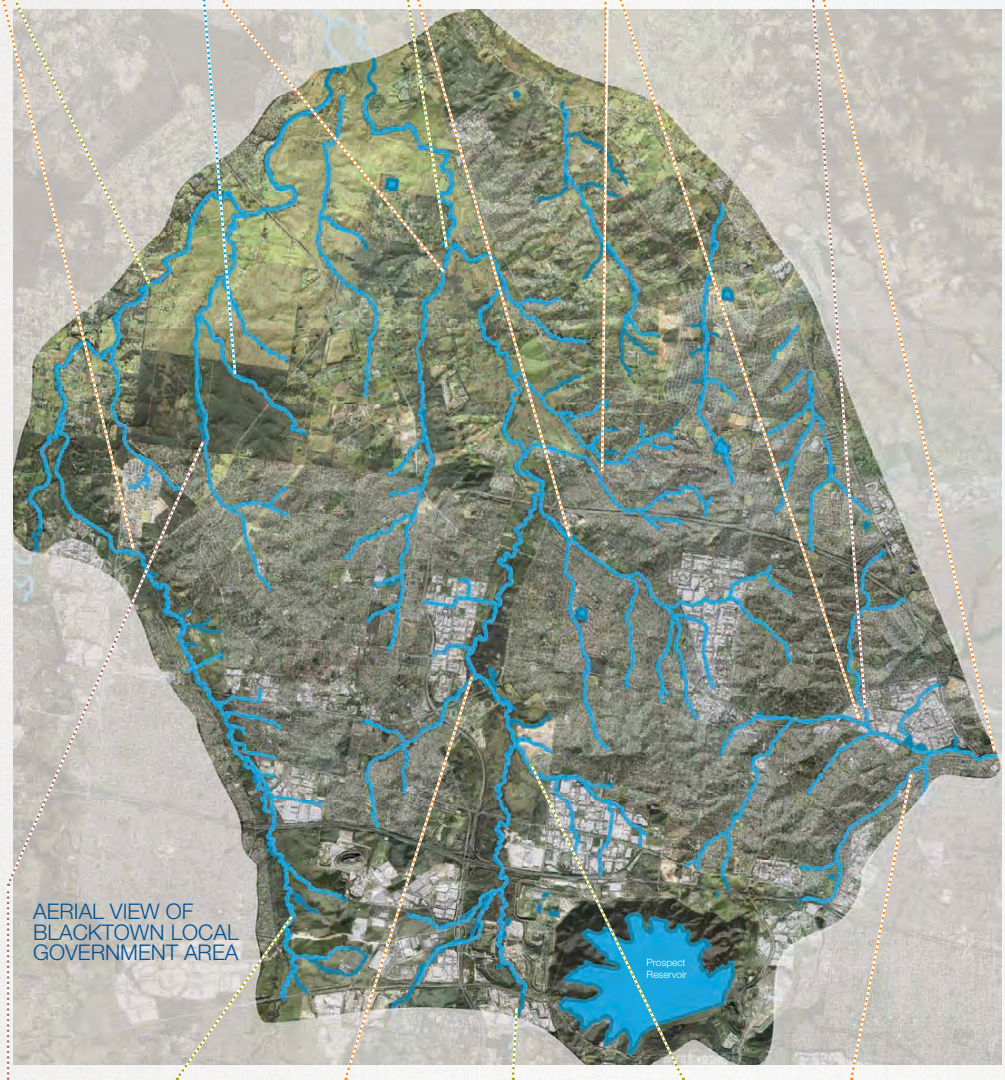
Absence of pollution sensitive macroinvertebrate community reflects variable water quality often with high nutrients. Narrow riparian buffer with remnant native vegetation.

LALOR CREEK
D

Absence of pollution sensitive macroinvertebrate reflects of variable water quality and highly degraded riparian vegetation.

TOONGABBIE CREEK
C

Poor macroinvertebrate diversity reflects variable water quality throughout the year. Mixed riparian vegetation community of natives and weed species.



LITTLE CREEK
D

Variable water quality often with high nutrient content, highly degraded macroinvertebrate community and lack of riparian vegetation.

ROPES CREEK - SOUTH
B

Diverse macroinvertebrate community with pollution sensitive species present. Mostly intact riparian vegetation community. However degraded water quality affects creek condition.

ANGUS CREEK
C

Absence of pollution sensitive macroinvertebrate reflects poor water quality and degraded riparian vegetation community.

EASTERN CREEK - SOUTH
B

Variable water quality with elevated salinity and nutrients. Decline of the macroinvertebrate community was recorded during the monitoring period. High percentage of native vegetation enhances the overall condition of this site.

BUNGARRIBEE CREEK
B

Poor macroinvertebrate diversity reflects degraded water quality. Intact vegetation community with a high cover of native species enhances the overall condition of this site.

GREYSTANES CREEK
C

This creek has a diverse ecological community however pollution sensitive species are absent due to variable water quality and degraded riparian zone.

WATERWAY HEALTH

WHAT DO WE MONITOR AND WHY?

The health of a waterway is measured using a variety of methods. The report card scores rely on three key indicators to assess the condition of Blacktown City's creeks which include:

- Water quality (physical and chemical factors)
- Waterbugs (macroinvertebrates)
- Creek bank (riparian) vegetation

WATER QUALITY

Water quality is an important factor associated with aquatic ecosystem health. Blacktown City Council regularly monitors water quality in many waterways throughout the local area. We measure pH, salinity, nutrients and turbidity.

WATERBUGS

Waterbugs, or aquatic macroinvertebrates, form an important part of the aquatic ecosystem and are widely used as indicators of waterway health. Certain waterbugs are more tolerant to water pollution and environmental change than others so by monitoring the waterbug communities we gain more than a snapshot of current waterway health.

VEGETATION

Native vegetation along creek banks is beneficial to maintaining water quality, bank stability and regulating water temperature. Native vegetation provides important habitat and a major role in the food chain of creek ecosystems.

GRADING SYSTEM

A	EXCELLENT	Creeks have good water quality, complex habitat structure and support a diverse macroinvertebrate community.
B	GOOD	Most indicators equivalent to reference conditions and comply with regional guidelines.
C	FAIR	Numerous indicators outside regional guideline limits. Periodic episodes of poor water quality are likely and the macroinvertebrate community and creek habitat are degraded.
D	POOR	Most indicators are non-compliant with regional guidelines. Creeks have degraded water quality and poor habitat reflected by a macroinvertebrate community dominated by pollution-tolerant species.
E		
F		

BLACKTOWN CITY: CREATING A WATER SENSITIVE CITY


Blacktown Showground

BLACKTOWN SHOWGROUND

The Blacktown Showground Precinct was recently upgraded to provide community facilities, including outdoor event spaces, a café, recreation space, community gardens and a water play park. A major focus of the redevelopment was the restoration of Breakfast Creek and construction of a bioretention system and wetlands to treat stormwater before it enters Breakfast Creek.

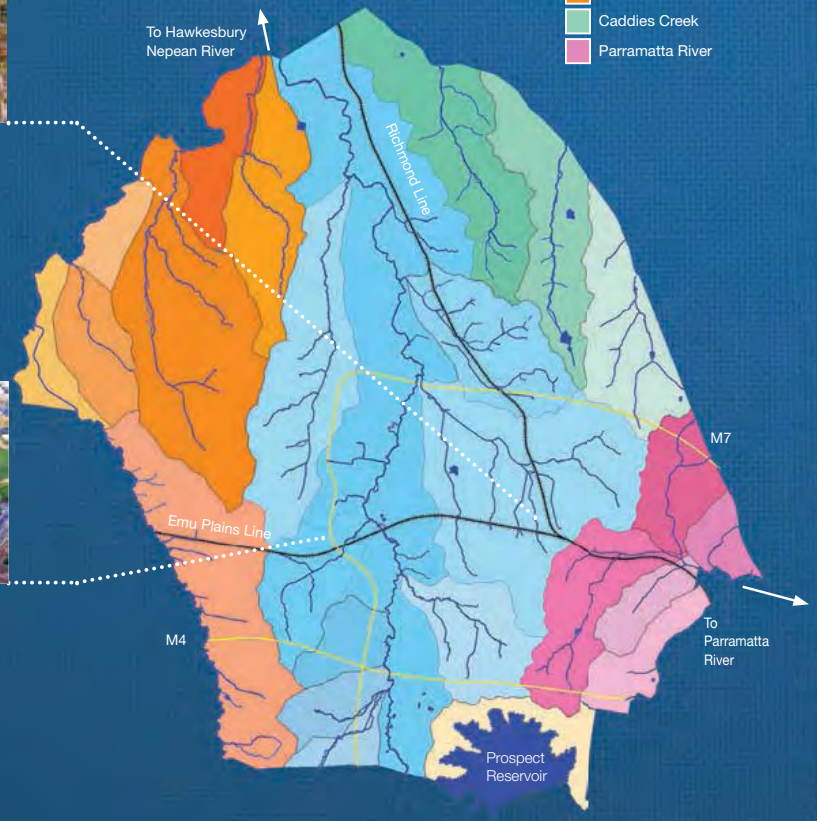

Blacktown International Sportspark

STORMWATER HARVESTING

Council has a number of stormwater harvesting and recycling schemes in place. The Blacktown Showground collects stormwater from the Blacktown Central Business District and the surrounding residential areas, which is filtered through a bioretention system and after further treatment is used for toilet flushing and irrigation.

By late 2014, an additional 200 million Litres per year of stormwater will be harvested from Angus Creek and used to irrigate playing fields at Blacktown International Sportspark.

CREEK CATCHMENTS OF BLACKTOWN LOCAL GOVERNMENT AREA




Local school visit

ENGAGEMENT PROGRAM

Council has developed a stormwater education strategy to raise awareness across the many different groups within our diverse community. The aim of the strategy is to raise awareness of what residents can do to reduce water pollution. Council has built a creek catchment model to demonstrate the sources of pollution and the effects of stormwater on creek ecosystems.


A full pollution control device

POLLUTION CAPTURING DEVICES

Council strategically installs and maintains pollution control devices in stormwater pipes across the City. These devices capture large amounts of sediment and litter that is washed into our drains on rainy days. Currently over 250 devices within Blacktown prevent approximately 800 tonnes of rubbish entering local creeks each year.


A bioretention system

INDUSTRIAL AUDITING

Council has developed a Water Sensitive Urban Design Auditing Program which focuses on ensuring stormwater improvement devices held in private ownership are maintained to achieve best practice outcomes.


Pearce Reserve, Kings Langley

CREEK RESTORATION

Blacktown Council is working on restoring many of our creeks to a more natural and stable state. Creek restoration creates habitat for local wildlife, reduces flood impacts and provides natural places for local residents to enjoy.

Recent creek restoration projects include:
Angus Creek, Rooty Hill
Lalor Creek at Troubadour Reserve, Kings Langley
Waller Creek at Morgan Powell Reserve, Kings Langley


Plumpton Wetland

WETLAND CONSTRUCTION AND MAINTENANCE

Council maintains many wetlands that have been designed to capture and treat stormwater. The treatment of stormwater reduces the amount of pollutants entering Blacktown waterways.


Capacity building workshop at Blacktown Showground

WATER SENSITIVE URBAN DESIGN

To ensure the long term sustainability of our waterways Council has adapted a water sensitive approach to urban design. This includes a range of measures that aim to protect and restore our creeks, re-use stormwater, cool our urban areas, and reduce stormwater flooding. Within Council we are working to build our capacity to improve the sustainable management of our waterways.

Acknowledgments: BCC Waterway Health Report Card was developed by T. Ahmed, C. Tippler and P. Birtles and is modelled on the following existing programs: EHMP (2008) Ecosystem Health Monitoring Program 2006-07 Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane. Centre for Environmental Management, Central Queensland University.

Printed on paper manufactured from sustainable resources.

WHAT CAN I DO TO PRESERVE OUR WATERWAYS

To reduce stormwater pollution we can stop it entering the drain in the first place. Here's how:

HOME

- Carry shopping in reusable bags. Plastic bags are a common pollutant, they can take a long time to break down, animals can be smothered, tangled or choked in them.
- Put rubbish in the bin. Rubbish takes a long time to break down.
- Use phosphorous-free detergents by looking out for the NP (no phosphorous) sign on packaging.
- Keep paint, turps and solvents clear of gutters and drains, re-use turps once the paint has settled and allow unused paint to dry out and then put it in the bin or take it to your yearly local chemical cleanout, see Council's website for details.
- Pick up your dog's droppings with a plastic bag and put it in the bin.

GARDEN

- Sweep gutters and driveways rather than hose them down.
- Put leaves in the compost or on the garden as mulch.
- Rake up grass clippings then mulch or compost. Composting helps prevent the drains from becoming blocked and causing local flooding.
- Cover piles of soil, sand or mulch to stop them washing away on rainy days.
- Use natural fertiliser only when necessary. Excess nutrients in the water encourage waterweed and algae growth.

CAR

- Use a car wash that recycles water or wash your car on the grass and use as little detergent as you can.
- When cleaning under the car check for any fluid leaks and get them repaired.

STREET

- Put your cigarette butts and other rubbish in the bin, pitch in and help clean up littered areas.
- If there is no bin handy, hold onto your rubbish until you find one, carry a container for your cigarette butts.
- Pick up your dog droppings when you're out and about.

FOR MORE INFORMATION CONTACT:

Blacktown City Council
Asset Design Services

Phone: 9839 6000

Email: council@blacktown.nsw.gov.au

www.blacktown.nsw.gov.au/Environment/Water_Catchments

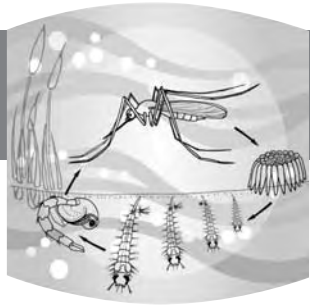
Twitter: @blacktowncc

Facebook: I Love Blacktown City Council

APPENDIX 5

Water Watch Field Manuals Guide to Macro-invertebrate Surveys

SECTION 10



Water bug (macroinvertebrate) survey

Water bugs, or macroinvertebrates, are small creatures with no backbone that can be seen with the naked eye. Different kinds of water bugs have different tolerances to pollution and can therefore provide an indication of the health of your waterway. A healthy waterway will have an abundance and wide diversity of macroinvertebrates.

Regular water bug surveys take place in Spring and Autumn. You can take part in these and use the results to ascertain the health of your creek or river and contribute valuable data on the changes in the health of our waterways.

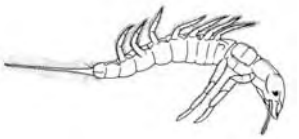
Included in this section: *Page*

Note: The *Senior Waterwatch Teachers' Guide* and the *Community/Land Manager Waterwatch Guide* contain further background information relating to macroinvertebrates and their usefulness as an additional indicator of water quality.

10.1 Doing a water bug (macroinvertebrate) survey

What are water bugs?

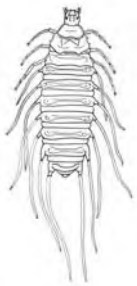
Water bugs, or aquatic macroinvertebrates, are small creatures that have no backbone and can be seen with the naked eye. They live all or part of their life in water, providing a food source for larger animals such as fish, frogs and birds. Macroinvertebrates include snails, beetles, dragonflies, yabbies and worms.



> **Note:** Macro = visible to the naked eye
> Invertebrate = animal without a backbone

Macroinvertebrate sampling can provide a rapid assessment of the condition of a site at a particular time. When compared to other locations, these studies can provide useful information about the health of the aquatic ecosystem.

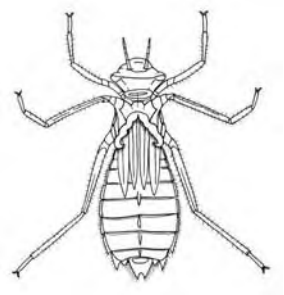
Designing a macroinvertebrate study



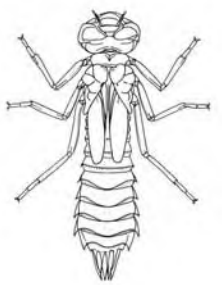
Step 1: Identify the sampling objectives

Identify the purpose of your study as this will determine sampling sites and methods. Some studies may be conducted to:

- gain a better understanding of the different types of macroinvertebrates
- compare the site with other sites in their natural condition
- estimate changes over time in the composition and abundance of water bugs
- compare changes in macroinvertebrates over time following management actions.



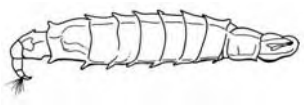
Step 2: Monitoring plan



Where in the catchment should I place my monitoring sites?

Select sites that meet the objectives of your study. This may involve the selection of more than one site if comparative studies are required.

Where should I sample in the stream?



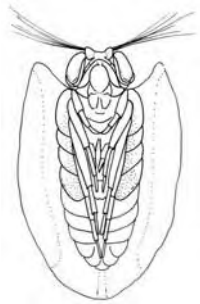
Within the stream, sample a range of habitats, including under stones, logs, fringing vegetation and pools and riffles.

Sample in roughly the same place each time you visit so that comparisons can be made between data collected at different times.

What equipment should I use?

Waterwatch prefers nets with a triangular frame and fine net dip bag. See tips for students at the end of this section.

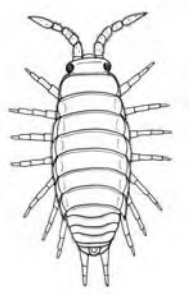
When should I sample?



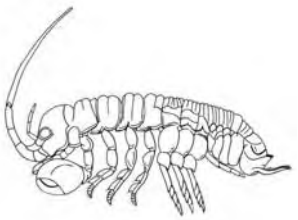
Sampling should occur twice a year, preferably in spring (October) and autumn (March).

Step 3: Type of sampling

There are two basic methods used to collect samples of water bugs: sweep sampling and kick sampling. Sweep sampling is generally done from the water's edge, while kick samples are taken from riffles. Refer to more detailed procedures below.



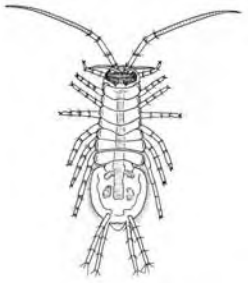
Collecting and identifying macroinvertebrates



Collecting a sample

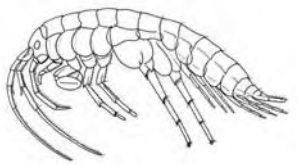
General procedure for both sweep and kick sampling

Time: 5–10 minutes



1. Pour clear stream water into a large white sorting tray to about 2 cm deep and put the tray close to the edge of the water.

Note: Where is it difficult to lie the tray flat at the water's edge, use a bucket and transfer the water into trays after sampling.



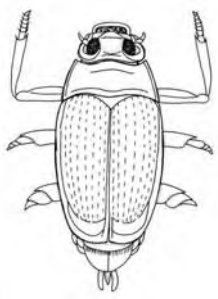
2. Use a short upward-sweeping motion to sweep the net through the stream.

3. Stop regularly to transfer the macroinvertebrates gently into the tray. Turn the net inside out and wash its tip in the tray to transfer the bugs.

4. Rinse any mud or fine silt from your net. The sample should be free of sediment prior to sorting.

5. Spread the sample out in the tray and allow the water to settle so small macroinvertebrates can be seen.

> ***i*** **Testing tip: Make sure nets are disinfected with bleach and water between sampling events to prevent the transfer of sediment, seeds, bacteria, viruses or other unwanted materials between sites.**



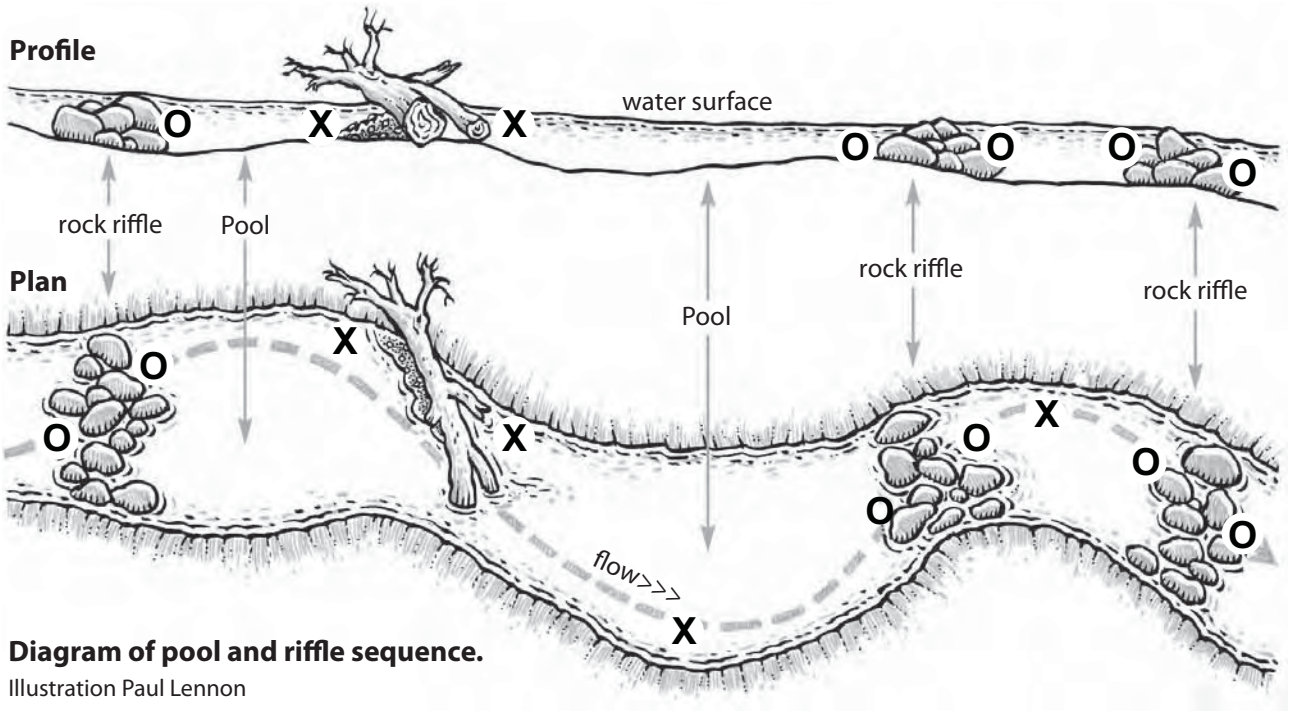


Diagram of pool and riffle sequence.
Illustration Paul Lennon

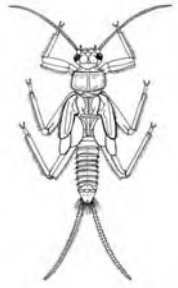
X sweep sampling **O** riffle sampling

Procedure for sweep sampling

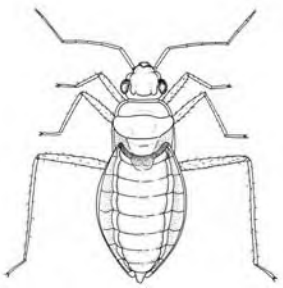
Sweep sampling can occur along the edge of the stream and should include a range of habitats such as under logs and tree roots, and in fringing vegetation. Sample the top, edge and bottom of the water along at least 10 metres of stream.

Procedure for kick sampling

In riffles, use a technique called kick sampling. Wearing rubber boots, stand in calf to knee deep water facing downstream. Hold the net in front of you with the opening facing upstream. Disturb the rocks underfoot by vigorously shuffling and kicking. The current will sweep dislodged macroinvertebrates into the net. Move slowly upstream while you do this to sample a 10 metre length of the streambed.



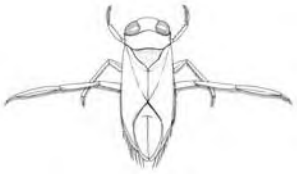
Sorting the sample



Time: 30–40 minutes

1. Observe the water bugs in the large white sorting tray.

> ***i*** **Testing tip: Aim to collect at least 50 macroinvertebrates per sampling area and as many types as possible.**
> **It is not possible to calculate the stream pollution index unless you have at least 50 macroinvertebrates.**

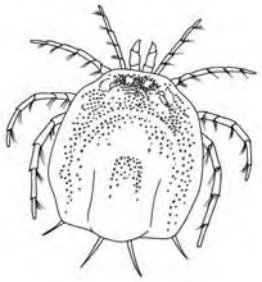


2. Each group should fill an ice block tray with a small amount of water.

3. Transfer bugs to the ice block trays using plastic spoons, pipettes and paint brushes.

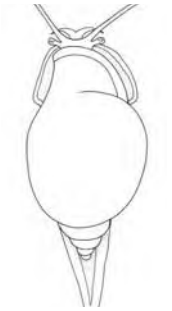
4. Sort the macroinvertebrates into the cubes in the tray using a different cube for each type of bug.

Identifying the species and recording the results



1. A person trained in macroinvertebrate identification should be invited to assist. This may be a Waterwatch coordinator, professional person such as a CMA or local government staff member, or a teacher trained in water bug identification.

2. Use the *Water Bug Detective Guide* to help you identify the species.



3. Count the number of macroinvertebrates and the number of types.

4. Record the information on the recording sheet provided (refer to Section 10.3). This will give an indication of the health of your waterway based on the scores provided for each bug type and the number of macroinvertebrate types collected. The sensitivity score provides an indication of the tolerance of each macroinvertebrate to pollution and is sometimes called a SIGNAL score.

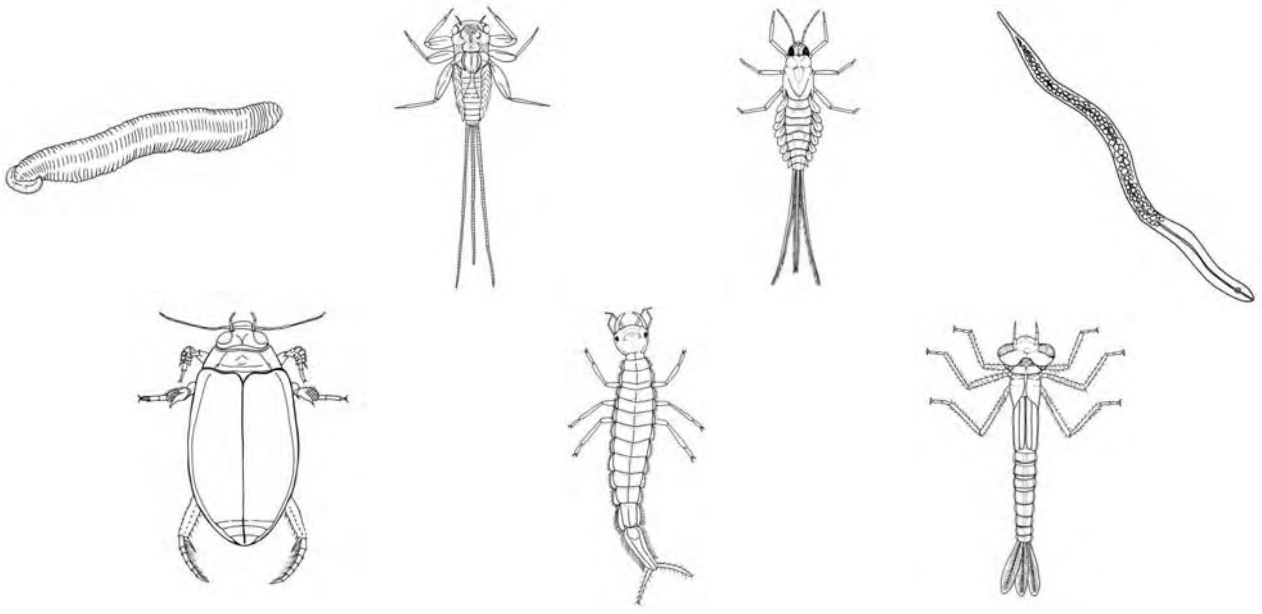
5. Gently return the macroinvertebrates to the water once you have finished, as close to the collection site as possible.

Classification of common macroinvertebrates

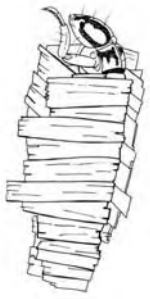
Phylum	Class	Order (suborder)	Family	Common name
Arthropoda	Insecta	Coleoptera	Elmidae	Riffle beetles
			Dytiscidae	Diving beetles
			Hydrophilidae	Scavenger water beetles
			Gyrinidae	Whirligig beetles
			Psephenidae	Water pennies
		Odonata (Zygoptera)		Damselflies
		(Anisoptera)		Dragonflies
		Hemiptera	Notonectidae	Backswimmers
			Corixidae	Water boatmen
			Nepidae	Water scorpions
			Hydrometridae	Water measurers
			Gerridae	Water striders
			Veliidae	Small water striders
		Diptera	Simuliidae	Black fly larvae
			Culicidae	Mosquitoes
			Chironomidae	Chironomids
			Ceratopogonidae	Biting midges
			Tipulidae	Craneflies
		Plecoptera		Stonefly larvae
		Ephemeroptera		Mayfly nymphs
		Trichoptera		Caddisfly larvae
		Megaloptera		Dobsonflies/ Alderflies
	Collembola			Springtails

Phylum	Class	Order (suborder)	Family	Common name
Arthropoda (continued)	Crustacea	Decapoda	Parastacidae	Freshwater crayfish
			Atyidae	Freshwater shrimp
			Palaemonidae	Freshwater prawn
			Sundathelphusidae	Freshwater crab
		Amphipoda		Sideswimmers
		Isopoda		Freshwater slater
	Arachnida	Acarina		Water mites
Annelida	Hirudinea			Leeches
	Oligochaeta			Segmented worms
Mollusca	Gastropoda			Snails
			Ancylidae	Limpets
	Bivalvia			Bivalve mussel
Platyhelminthes	Turbellaria			Flatworms
Nematoda				Roundworms
Cnidaria		Hydrozoa	Hydridae	Hydra

Source: Chessman 2003



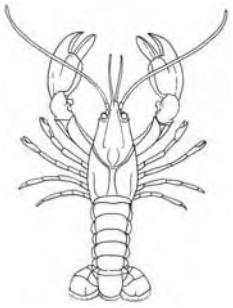
What do your results mean? – SIGNAL 2 and the stream pollution index (SPI)



The water quality of a river, creek or pond, sometimes called its 'ecological health' or 'river health', can be assessed on the basis of the presence or absence of animals living in the water. This indicates the ability of the water to sustain animal life.

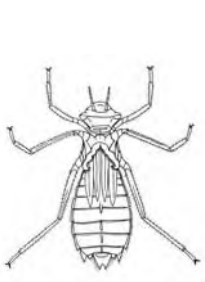
A system called SIGNAL2 has been developed to score the 'health' of the water, using aquatic macroinvertebrates (or water bugs). SIGNAL2 stands for Stream Invertebrate Grade Number Average Level. SIGNAL2 gives each type of macroinvertebrate a sensitivity rating from 1-10 to indicate their level of pollution tolerance.

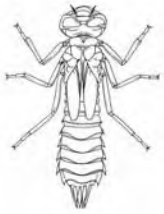
'Pollution' can mean high levels of salinity, turbidity, nutrients (nitrogen or phosphorus) or a decrease in oxygen. This sensitivity rating, together with the number of types of bugs found, is used to create a Stream Pollution Index (SPI) for the river, creek or pond. Sites with high SPI scores are likely to have high levels of dissolved oxygen with low levels of pollution.



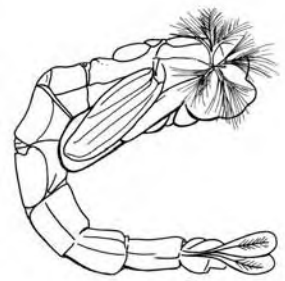
Still waters (wetlands, ponds and dams), inland and slow-flowing coastal rivers will always produce a lower SPI score because thier physical habitat and chemical levels are naturally different. Few macroinvertebrate types that are rated as very sensitive occur naturally in still waters or slow flowing lowland waters. By using the SPI score and considering the number of macroinvertebrate types found at your site, SIGNAL2 can provide an indication of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community. In order for an SPI score to be calculated for your site, your sample MUST have at least 50 individual 'bugs'.

> ***i*** **Note: For further information about calculating the SPI, see the worked example in Section 10.4.**





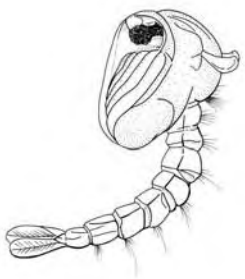
Tips for student macroinvertebrate sampling



Nets: These can be made from a kitchen strainer attached to a broom handle, stick or piece of dowel. This net is ideal for bugs as it will last many trips to the river and is inexpensive to make.

Scooping: Divide the class into groups of 4–5 students. Each group is to work in a specified location and remain there.

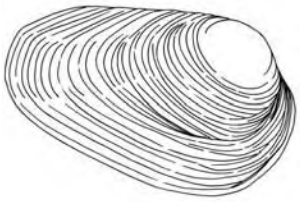
Sorting: After 10 minutes of scooping, students put the nets down and carry their trays away from the water's edge for sorting. This will ensure that students concentrate on the sorting of the bugs.



Identifying the species: Invite a trained person to assist with identification. Direct students to colour, shape, position of the legs and the number of tails. A two-way microscope or magnifying glass may assist with identification.

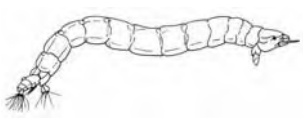
Calculating the stream pollution index (SPI): Add all group results together for a combined result. By entering the results of your bug survey on the Waterwatch website, the stream pollution index for your site and the number of macroinvertebrate types will be calculated. A description of your site will be provided **based on the macroinvertebrates you have collected**.

> ***i*** **Note: For more information check the website: www.waterwatch.nsw.gov.au**



Note: Reducing the risk of spreading chytrid fungus when sampling macroinvertebrates

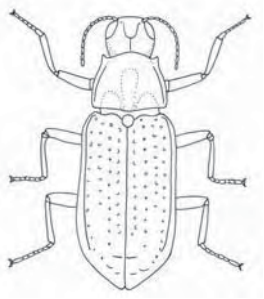
The chytrid fungus attacks keratin which is embedded within the sensitive skin of frogs and is often fatal. Chytrid can be transferred from one site to another by water and moist soil. It is possible to spread the fungus by contaminated nets and moist soil on car tyres and on the soles of shoes. To reduce the risk of spreading the fungus, spray nets, shoes and car tyres with a mixture of 50% bleach and 50% water to disinfect them prior to departure from a site. Never transfer water or bugs between sites.



10.2 Water bug survey: teacher field checklist

Date: ..... Class: .....

Item	Checked
TEACHER ORGANISATION	
Permission notes	☐
Class list	☐
Special needs student list	☐
Risk assessment sheet for completion	☐
Buses (if applicable)	☐
First aid kit	☐
Sunscreen	☐
Student medications	☐
Mobile phone	☐
STUDENTS CLOTHING	
Hats	☐
Closed toe shoes	☐
Drinking water	☐
FIELD EQUIPMENT	
Bucket	☐
Large trays	☐
Ice cube trays	☐
Spoons, pipettes, brushes	☐
Magnifying glass (optional)	☐
Macro nets	☐
RECORDING AND ID SHEETS	
Pencil case	☐
Marker pens	☐
Folder of result sheets + info	☐
Clipboards	☐
Camera	☐
Bug identification laminates	☐
Gambusia information sheet	☐



10.3 Water bug survey: SIGNAL 2 field recording sheet

Sampler group name:.....

Number in group:.....

Survey period: ☐ Spring ☐ Autumn ☐ Other .....

Date: ..... Time: ..... Time taken (hours): .....

Location of water body:

☐ western NSW river or stream <300 metres asl ☐ other rivers and streams ☐ wetland

Note: The rating of your stream pollution index (SPI) will be affected by the location of the sampling.

Habitats sampled:

Habitat *(tick the boxes where you sampled)*	**Still water**	**Moving water**
Silt and sand	☐	☐
Stones	☐	☐
Water plants	☐	☐
Leaves and twigs	☐	☐
Logs, branches, tree roots	☐	☐

Note: The more habitats sampled the greater the expected number of bug types.

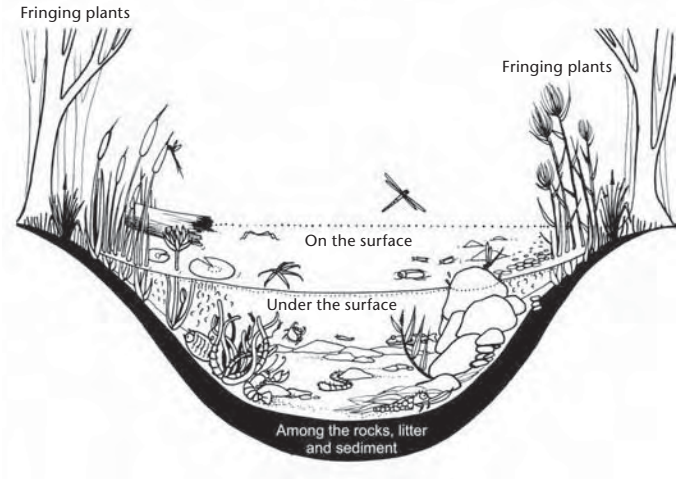
Sampling methods: *(tick the boxes)*

☐ sweep ☐ kick

Identification of bug species confirmed by a trained person: .....

.....

(e.g. Waterwatch coordinator, professional staff of council or agency, experienced teacher or community member)



Water bug survey: SIGNAL2 result sheet

Survey site name: .....

Step 1: Tick the bug type if present (see the Detective Guide in Section 10.5).
Step 2. Enter the number of each bug found in Column B.
Step 3: Refer to the weight table for the correct Weight factor for the number found.
Step 4: Enter the correct Weight factor for each bug in Column C.
Step 5: Multiply the Sensitivity rating (Column A) by the Weight factor (Column C) and enter the answer in Column D.
Step 6: Add up Column C (Weight factors).
Step 7: Add up Column D (Sensitivity rating x Weight factor).
Step 8: Add up the number of bug types.

WEIGHT TABLE	
No. of each bug found (Column B)	Weight Factor (Column C)
1-2	1
3-5	2
6-10	3
11-20	4
>20	5

Water bug recording table

MACROINVERTEBRATE TYPES			A	B	C	D
Sensitivity rating	**Taxa richness (bug types)**	**Tick if present**	**Sensitivity rating**	**Number of bugs**	**Weight factor**	**Column A X Column C**
Very sensitive	Stonefly nymph	☐	10			
	Mayfly	☐	9			
Sensitive bugs	Alderfly larva	☐	8			
	Caddisfly larva	☐	8			
	Riffle beetle & larva	☐	7			
	Water mite	☐	6			
Tolerant bugs	Beetle larva	☐	5			
	Dragonfly nymph	☐	4			
	Water strider	☐	4			
	Whirligig beetle & larva	☐	4			
	Freshwater yabby/crayfish	☐	4			
	Damselfly nymph	☐	3			
	Fly larva & pupa	☐	3			
	Midge larva & pupa	☐	3			
	Freshwater mussel	☐	3			
	Nematode	☐	3			
	Freshwater sandhopper	☐	3			
	Freshwater shrimp	☐	3			
	Water scorpion/needle bug	☐	3			
Very tolerant bugs	Diving beetle	☐	2			
	Flatworm	☐	2			
	Hydra	☐	2			
	Water treader	☐	2			
	Freshwater slater	☐	2			
	Water boatman	☐	2			
	Freshwater worm	☐	2			
	Backswimmer	☐	1			
	Bloodworm	☐	1			
	Leech	☐	1			
	Mosquito larva & pupa	☐	1			
	Freshwater snail	☐	1			
	TOTALS	☐				

Did you catch *Gambusia* at your site? ☐ Yes ☐ No ☐ Did not look

10.4 Calculating the health of your site

Step 1: Count the number of bug types (taxa richness). **No. of bug types:** ☐

Step 2: Calculate the SPI = $\frac{\textbf{Total Column D}\ \square}{\textbf{Total Column C}\ \square} = \square$

Step 3: Classify the number of bug types and stream pollution index (SPI) as high or low based on your site description and the levels in the rating table below:

Taxa richness (number of bug types) = ☐ **High** ☐ **Low**

SPI = ☐ **High** ☐ **Low**

Bug type and SPI rating table

Site description	SPI		Taxa richness (bug types)	
	Low	High	Low	High
Wetlands	0–3.1	>3.1	0–14	>14
Western NSW rivers or streams <300 metres asl	0–3.1	>3.1	0–11	>11
Other rivers and creeks	0–3.5	>3.5	0–15	>15

Step 4: Identify the site conditions based on your bug count.

SIGNAL 2 Scoring table

SIGNAL 2 scoring	Taxa richness	Site conditions based on the macroinvertebrate sample
High	High	Good water quality and a diversity of habitats. It may be a well-managed site, natural bushland or a national park.
Low	High	Water quality may be slightly affected by human activity or natural factors. There may be higher levels of salinity and/or nutrient levels at the site.
High	Low	Water quality is affected by a pollution source upstream or there are few habitats due to harsh physical conditions.
Low	Low	Water quality is affected by human use such as urban, industrial or agricultural pollution or by the downstream effects of dams.
Unable to calculate	Unable to calculate	Unable to calculate an SPI score as there are fewer than 50 macroinvertebrates in the sample. This may indicate poor sampling technique, or that your site is under stress. There may be poor habitat diversity and/or water quality. Make sure you sample in all habitats and keep an eye on the site.

Step 5: If the table does not represent your site, what other factors may influence water quality at your site? .....

.....

Note: These may change over time and may include rainfall, river flow, land use, drains, condition of banks and riparian vegetation.

Upload your results to the Waterwatch website at www.waterwatch.nsw.gov.au. The online database will calculate the stream pollution index (SPI) and provide a description of your site based on the bugs collected.

Worked example

Enter your results in the recording table and complete Column C by referring to the weight factor table (see blank recording sheet). Complete Column D by multiplying the sensitivity rating by the weight factor. For example, 3–5 bugs has a weight factor of 2. Multiply the sensitivity rating (Column A) by the weight factor (D). For stonefly in the example below, this is 10 x 2 = 20.

Extract from a water bug recording table

Bug type			**A**	**B**	**C**	**D**
Sensitivity rating	**Taxa richness (bug types)**	**Tick if present**	**Sensitivity rating**	**Number of bugs**	**Weight factor**	**Column A X Column C**
Very sensitive	Stonefly nymph	✓	10	3	2	20
Sensitive	Water mite	✓	6	20	4	24
Tolerant	Whirligig beetle & larva	✓	4	11	4	16
	Freshwater yabby/crayfish	✓	4	2	1	4
	Damselfly nymph	✓	3	5	2	6
	Freshwater shrimp	✓	3	30	5	15
Very tolerant	Water boatman	✓	2	16	4	8
	Freshwater worm	✓	2	15	4	8
	Mosquito larva & pupa	✓	1	12	4	4
	Freshwater snail	✓	1	33	5	5
	TOTALS	10		147	35	110

Calculate the stream pollution index (SPI).*

Step 1: Calculate the SPI = $\frac{\text{total of column D}}{\text{total of column C}} = \frac{110}{35} = 3.2$

Step 2: Count the number of bug types: Bug types = 10

Step 4: Classify as high or low the number of bug types using the table provided

Step 5: Based on your SPI and the number of invertebrate types, the condition of your site may be classified as:

SPI rating	**Number of bug types**	**Site conditions based on the macroinvertebrate sample**
Low	Low	Your results may indicate that water quality is affected by human use such as urban, industrial or agricultural pollution or by the downstream effects of dams.

If the table does not represent your site, what other factors may influence water quality at your site?

Note: These may change over time and may include rainfall, river flow, land use, drains, condition of banks and riparian vegetation.