Preliminary
Terrestrial & Aquatic Fauna study

Bob Campbell Oval and surrounds, Greenwich NSW

Prepared for **Lane Cove Council**

By **applied ecology** Pty Ltd

September 2020

38 Bridge Street, RYDALMERE, NSW 2116 P 02 63377229
7/150 Keppel Street, BATHURST, NSW 2795 M 0422857086
PO BOX 397, KATOOMBA, NSW 2780 M 0428131796
contact@appliedecology.com.au www.appliedecology.com.au

Applied Ecology Pty Limited reserves all legal rights and remedies in relation to any infringement of its rights in respect of its confidential information.

DOCUMENT VERIFICATION

Document Title	**Fauna study Bob Campbell Oval and surrounds, Greenwich NSW**
Client	**Lane Cove Council**
Client contact	**Jeff Culleton**

Submitted Revisions	**Prepared by**	**Reviewed by**	**Date**
DRAFT 1	**Anne Carey & Dr Meredith Brainwood**	**Internal**	**04/09/2020**
DRAFT 2	**Anne Carey**	**Council**	**10/09/2020**

DISCLAIMER

This report is prepared by APPLIED ECOLOGY Pty Limited for its clients' purposes only. The contents of this report are provided expressly for the named client for its own use. No responsibility is accepted for the use of or reliance upon this report in whole or in part by any third party. This report is prepared with information supplied by the client and possibly other stakeholders. While care is taken to ensure the veracity of information sources, no responsibility is accepted for information that is withheld, incorrect or that is inaccurate. This report has been compiled at the level of detail specified in the report and no responsibility is accepted for interpretations made at more detailed levels than so indicated.

ACKNOWLEDGMENTS

APPLIED ECOLOGY Pty Limited wishes to thank all representing organisations and individuals who assisted with fieldwork and contributed to the production or commented on the content of this report.

Table of Contents

Introduction

Lane Cove Council has commissioned a detailed fauna study of Bob Campbell Oval and surrounds to assist with understanding impacts of the proposed works at the oval.

The study includes both terrestrial and aquatic environments and involves the collection of data over 9-10 weeks period in August – October 2020 with the final report available in November.

This report is a preliminary report that includes the collation of fauna records from previous studies, Council's fauna database and public databases (BioNet, ebird, Birdlife); and results from initial field investigations.

The study area

Bob Campbell Oval is located within Gore Creek Reserve and is a mixed-use open space. Existing facilities include:

- BBQ facilities
- Picnic facilities
- Playground
- Outdoor fitness equipment
- Parking (limited)
- Toilets
- Small kiosk
- Cricket pitch
- Soccer posts, nets and marked field

Figure 1 Looking south across the oval towards the carpark 24/08/2020

Access is via St Vincents Road in the village of Greenwich. The study site includes the E2 zoned lands surrounding the oval and extends from Standish Street in the north (near River Road) to Ford Street in the south (Figure 2).

Figure 2 Study area

Proposed works

Works include the replacement of the natural grass surface of the playing field with artificial turf, changes to lighting , demolition of existing amenities and clubhouse and construction of new facilities, fenced dog off-leash area and relocation and replacement of playground and fitness equipment. The layout of the proposed works is provided in Figure 3.

Figure 3 Layout of proposed works

Methodology for full survey.

Remote cameras

Motion detecting black flash cameras are set at baiting stations with appropriate attractants such as universal bait and anchovies (targeting Rakali) in the intertidal zone and with universal bait in terrestrial habitats.

For preliminary report sampling undertaken from 24th August to 2nd September

Bat ultrasonic (Anabat) call recording

The method requires the recording and identification of high frequency, echolocation calls made by bats, which, except for one or two species, are ultrasonic, that is, inaudible to humans.

The recording equipment consists of Anabat Express® detectors deployed in fixed locations. Anabat recordings are transferred onto computer and sent to an expert in this field for analysis. Identification will be designated as either: definite, probable or possible, following the methodology of Parnaby (1992).

For preliminary report sampling undertaken from 24th August to 2nd September

Spotlighting Survey

Spotlighting (at night) is undertaken for all terrestrial and arboreal mammals, aquatic fauna, amphibians and nocturnal birds within the study area. Spotlighting is undertaken by observers on foot using hand-held spotlights. All fauna heard or observed during spotlighting transects will be recorded.

For preliminary report sampling undertaken on the 24th August

Diurnal Bird Census

Good records for birds exist in a variety of databases and from the recent fauna survey for the subject site. Bird surveys are both targeted and opportunistic whilst undertaking other survey activities. Systematic surveys designed to capture peak activity (dawn chorus, morning, and late afternoon) are undertaken. Any birds sighted or heard calling during other survey activities will also be recorded separately.

For preliminary report sampling undertaken on the 24 & 25th August, 2nd September

Herpetofauna Search

Reptiles and amphibians are surveyed within the study area by targeted diurnal and nocturnal searches in suitable areas. Rocks, logs, debris and other material, which provides suitable cover for herpetofauna, will be investigated and any species observed recorded.

For preliminary report sampling undertaken on the 24 & 25th August,

Remote frog recording

During the evening calling frogs are identified on the basis of their characteristic call. This is often best done fairly early in the evening. A Song Meter© is deployed along Gore Creek for the duration of the survey period. Call playback will also be used for threatened species at suitable breeding sites to stimulate male frog calls.

For preliminary report sampling undertaken from 24th August to 2nd September

Fauna Habitat Assessment

During the surveys, assessment of habitat areas is carried out. Whilst traversing the study area features important for the existence of fauna are recorded. Features include mature tree hollows, rocks, fallen timber, connectivity to habitat outside the study sites and the general condition of the tree, shrub and ground layers.

Searches for Evidence

Characteristic signs, tracks, and scats and other indirect evidence of fauna species from all fauna groups are recorded when observed. Scats of predator species and owl pellets, if found, are collected for analysis and identification.

Aquatic fauna and habitat assessment

Water Quality

Three snapshot surveys of water quality in Gore Creek at Bob Campbell Oval are to be undertaken to inform the freshwater aquatic fauna survey and provide baseline data to Council. Parameters tested are:

- pH
- Conductivity (microsiemens/cm)
- Temperature C
- Dissolved Oxygen mg/L
- Reactive phosphates ppm
- Alkalinity ppm
- Turbidity NTU

These water quality parameters will be measured in the field using a Hach kit/ portable colorimeter and a Hydrolab Quanta multi parameter sonde.

For preliminary report sampling was undertaken on the 24th August

Intertidal habitat

Sediment samples are taken from the mudflats and epifauna and infauna identified. Surveys are undertaken for evidence of zonation (eg. sediment properties and presence of biogenic structures such as oyster beds or mussel beds) and mapped. Sediment characteristics are qualitatively described in the field based on feel of sediment; grain size (clay, sand), colour, smell and firmness (sinking depth). Assessment of the depth of the oxic layer in each mudflat zone is undertaken to determine the depth to which benthic organisms are living inside the sediments. Field observations also record presence of seagrass, wrack, and bird presence.

For preliminary report sampling undertaken on the 2nd September

Aquatic fauna

Mudflat/intertidal zone- Small hand nets are used to survey the creek and around the bay for macroinvertebrates and fish. Freshwater sites are scored using SIGNAL2 (Chessman 2003[1]). 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.

For preliminary report sampling undertaken on the 24th August

Results

Desktop Results

Databases was obtained from BioNet (free to public), eBird (free on request from Cornell University), and Birdlife Australia. A total of 177 species have been recorded in the study area. Many of bird species are very uncommon - recorded only once or twice across all databases. A total of 10 threatened species have been recorded. These species are listed in Schedule 2 of the NSW Biodiversity Conservation Act 2016 (BC Act) and/or Federally in Section 178 of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999). A further 17 species are considered regionally significant (DECCW 2008). The full list of species recorded in the study area from desktop searches is available in Appendix A of this report.

Water quality testing and macroinvertebrate surveys undertaken by others in the study area (if any) are not publicly available.

Preliminary Field Survey Results

Terrestrial Fauna

For the purposes of the terrestrial fauna surveys the survey area was broken into four zones that reflect areas where impacts of the proposal will differ. These zones and sampling locations are provided in Figure 5. A total of 41 species have been detected in the preliminary survey. Results are presented in Table 1.

Figure 4 White-faced heron on the mudflats 02/09/2020

[1] New sensitivity grades for Australian river macroinvertebrates
Bruce C. Chessman Marine and Freshwater Research 54(2) 95 – 103 Published: 04 June 2003

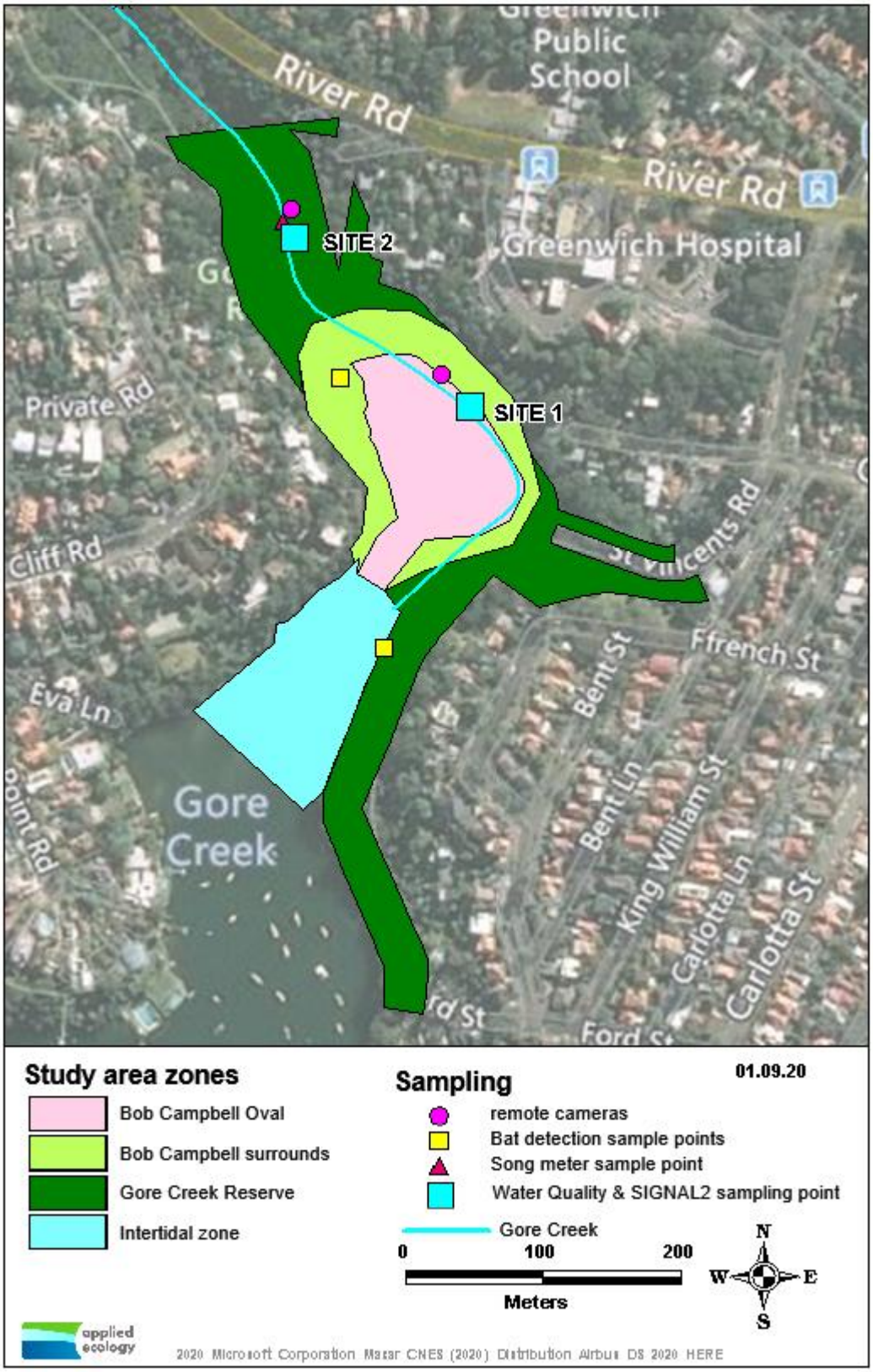

Figure 5 Study area zones and sampling locations

Song meter nocturnal recording – The Common Froglet was the only amphibian recorded. The Grey-headed Flying-fox was recorded on most nights. The Australian Boobook was also recorded several times, calling strongly.

Remote cameras – Black Rat prevalent with Red Fox (Figure 6) present on several nights.

Spotlighting - Common Brushtail Possums were observed and heard around Bob Campbell Oval with an individual vocalising loudly from trees near the play equipment. Common Ringtail Possums were observed foraging in the mid-storey particularly around the viaduct on the eastern side. Grey-headed Flying-foxes were heard and observed feeding on the west facing slope between the Oval and St Vincents Road. Broad-tailed geckoes were also observed on exposed sandstone faces and in crevices in this location. An Australian Boobook called strongly late during the spotlighting session from trees towards St Vincent Road above the oval. A Tawny Frogmouth was observed hunting near the play equipment (Figure 7). Numerous fish (~5 morpho species) were observed in the freshwater section of the creek line.

Bat ultrasonic recording – calls from fixed detectors have been sent to an expert in the field for analysis. A Goulds Wattled Bat was observed and recorded on a handheld recorder (Anabat SD2) at dusk feeding over the mudflats just prior to the spotlighting session on the 24th of August.

Bird Surveys

Table 1 Species list vertebrate fauna - preliminary surveys

Number of surveys		**3**	**3**	**2**	**3**
SPECIES	**SCIENTIFIC NAME**	**Bob Campbell Oval**	**Bob Campbell surrounds**	**Gore Creek Reserve**	**Intertidal zone**
AVES					
Australian Boobook	*Ninox novaehollandiae*		1		
Australian Brush-turkey	*Alectura lathami*	1			
Australian King-Parrot	*Alisterus scapularis*		4		
Australian Magpie	*Cracticus tibicen*	6	1		
Australian Raven	*Corvus coronoides*		1	1	
Australian White Ibis	*Threskiornis molucca*				1
Brown Gerygone	*Gerygone mouki*			2	
Brown Goshawk	*Accipiter fasciatus*		1	1	
Chestnut Teals	*Anas castanea*		2		
Eastern Whipbird	*Psophodes olivaceus*		3	2	
Fairy martin	*Petrochelidon ariel*			10*	
Golden Whistler	*Pachycephala pectoralis*			1	
Grey Butcherbird	*Cracticus torquatus*			1	
Laughing Kookaburra	*Dacelo novaeguineae*		2	3	
Little Black Cormorant	*Phalacrocorax sulcirostris*				1
Magpie-lark	*Grallina cyanoleuca*				1
Masked Lapwing	*Vanellus miles*	1			6
Noisy Miner	*Manorina melanocephala*	5	40	20	1

Number of surveys		3	3	2	3
SPECIES	**SCIENTIFIC NAME**	**Bob Campbell Oval**	**Bob Campbell surrounds**	**Gore Creek Reserve**	**Intertidal zone**
Pied Currawong	*Strepera graculina*		3	2	
Rainbow Lorikeet	*Trichoglossus haematodus*		25	20	
Silver Gull	*Chroicocephalus novaehollandiae*				6
Striated Heron	*Butorides striata*				3
Sulphur-crested Cockatoo	*Cacatua galerita*		25	10	
Tawny Frogmouth	*Podargus strigoides*		2		
Welcome Swallow	*Hirundo neoxena*	4			13
White-browed Scrubwren	*Sericornis frontalis*		1	5	
White-faced Heron	*Egretta novaehollandiae*				1
Introduced Birds					
Rock Dove	*Columba livia*		6		
MAMMALS					
Common Brushtail Possum	*Trichosurus vulpecula*	1	1		
Common Ringtail Possum	*Pseudocheirus peregrinus*		2	3	
Gould's Wattled Bat	*Chalinolobus gouldii*				1
Grey-headed Flying Fox	*Pteropus poliocephalus*		5	5	
Introduced Mammals					
Black Rat	*Rattus rattus*		x		x
Red Fox	*Vuples vulpes*		x		x
AMPHIBIANS					
Common Froglet	*Crinia signifera*			x	
Geckoes					
Broad-tailed gecko	*Phyllurus platurus*		2		
Eastern Water Skink	*Eulamprus quoyii*			1	
FISH					
Common Galaxias (Common Jollytail)	*Galaxias maculatus*		20+		
Longfin Eel	*Anguilla reinhardtii*		4		
Striped Gudgeon	*Gobiomorphus australis*		20+		20+ (juveniles)
Smooth Toadfish	*Tetractenos glaber*				5+

* potentially Tree Martins – they were hawking above the canopy on the upslope on the western side of Gore Creek making a firm ID very difficult.

Figure 6 Red Fox on the mudflats 25/08/2020

Figure 7 Tawny Frogmouth at the north end of Bob Campbell Oval 24/08/2020


Figure 8 Eastern Whipbird 25/08/2020 (left) and a pair of Chestnut Teals 24/08/2020 (right)


Figure 9 Broad-tailed Gecko (left) and Common Ringtail Possum 24/08/2020


Figure 10 Golden Whistler 25/08/2020 (left) and Striated Heron 02/09/2020 (right)

Figure 11 Tawny Frogmouth pair near the playground equipment 25/08/2020

Aquatic fauna - Freshwater sampling

Freshwater sampling was undertaken at two sites along Gore Creek (map - Figure 5, site images Figure 12 and Figure 13).

Figure 12 Freshwater Site 1

Figure 13 Freshwater Site 2

Abiotic - Water quality

Water quality testing was undertaken on the 24th of September. With the exception dissolved oxygen parameters were within normal range. Water quality testing will be undertaken on two more occasions.

Table 2 Water quality results 24/08/2020

GORE CREEK 24-8-2020	**SITE 1**	**SITE 2**	**ANZECC, 2000.** **Estuary Normal range**	**ANZECC, 2000.** **Lowland River normal range**
pH	6.5	6.0	7.0-8.5	6.5-9
Conductivity (microsiemens/cm)	440	420	NA	200
Temperature C	12	10	NA	NA
Dissolved Oxygen mg/L	4.2	5	NA	NA
DO (%saturation)	39.1	44.4	60-120	60-120
Reactive phosphates ppm	0.05	0.02	<50	<100
Alkalinity ppm(mg/L)	44	46	>20mg/L	>20mg/L
Turbidity NTU	<10	<10	6	6

Biotic - Macroinvertebrate sampling SIGNAL2

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.

Macroinvertebrate sampling was undertaken on the 24th of August 2020. Macroinvertebrate surveys are best done in autumn thus the timing of this survey is not ideal for consigning SIGNAL2 scores to a waterway. This survey will be repeated in late October. The preliminary survey had low to moderate diversity and consisted of macroinvertebrates with generally low SIGNAL2 scores (meaning they are less sensitive to a range of stressors including poorer water quality). The SIGNAL2 scores are plotted against diversity (Figure 15).

Figure 14 Some macroinvertebrates from Freshwater Site 1- many damselfy and dragonfly larvae (left) are fairly tolerant with lower SIGNAL2 scores (Odonata 3) while Dobsonfly larvae (right) have a high SIGNAL2 score (Megaloptera = 8)

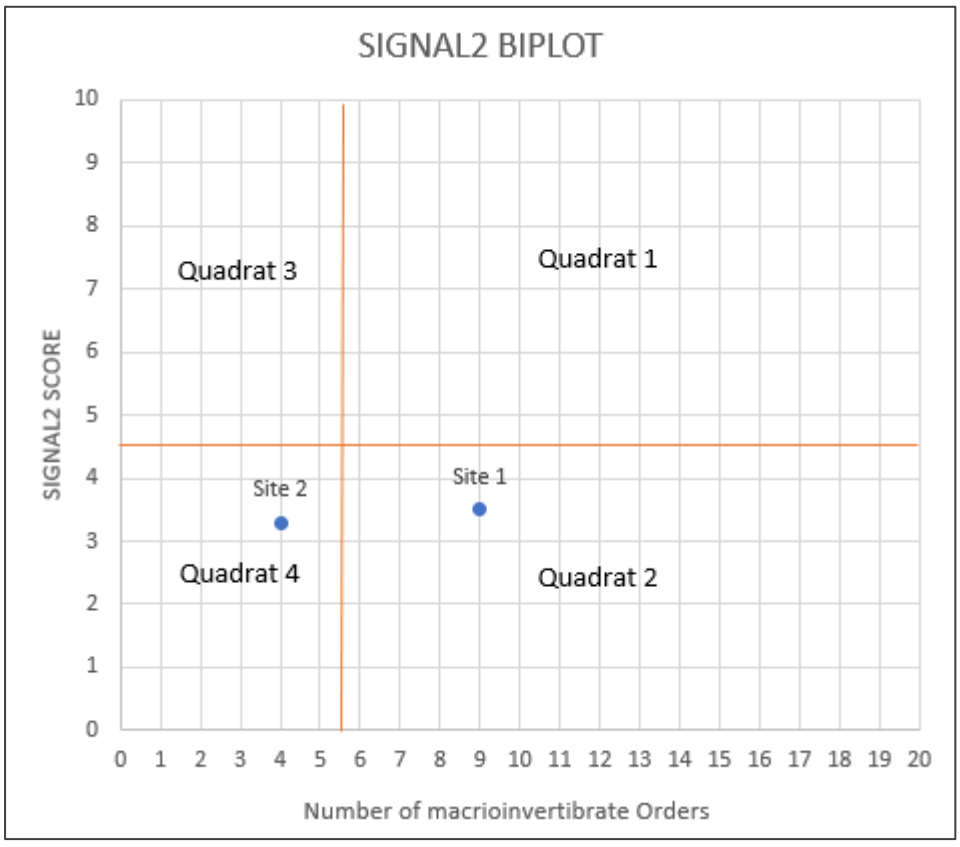

Figure 15 Biplot of diversity vs sensitivity

The sampling site higher along the creek line (Site 2) falls within into Quadrant 4. Sites in this quadrat represents low values of both the SIGNAL2 score and the number of invertebrate types. Most sites falling into this quadrant will be suffering from one or more forms of human impact.

The site adjacent to Bob Campbell Oval (Site 1) falls within Quadrant 2. Sites in this quadrant have lower SIGNAL 2 scores and a high diversity of macro-invertebrate types. Sites falling in this quadrant are likely to have higher levels or turbidity, salinity or nutrients than those in quadrant 1, as suggested by the lower SIGNAL 2 score. These levels may be high either naturally, because of local geology and soil types, or as a result of human activities. The high number of macro-invertebrate types suggests that physical conditions are still benign and toxic chemicals are not present in large amounts. Many agricultural streams without severe impacts fall into this quadrant (Chessman, 2003).

Biotic - Dip netting

Dip netting was undertaken at Site 1 on the 2nd of September. Four species of fish were present with two species netted and identified (Figure 16 and Figure 18) and one, the Longfin Eel (Figure 17) easily identified without need for netting. No fish were present at Site 2.

Figure 16 Adult Striped Gudgeons were common in the creek adjacent to the oval 24/08/2020

Figure 17 Longfin Eels are common in the creek adjacent to the oval 02/09/2020

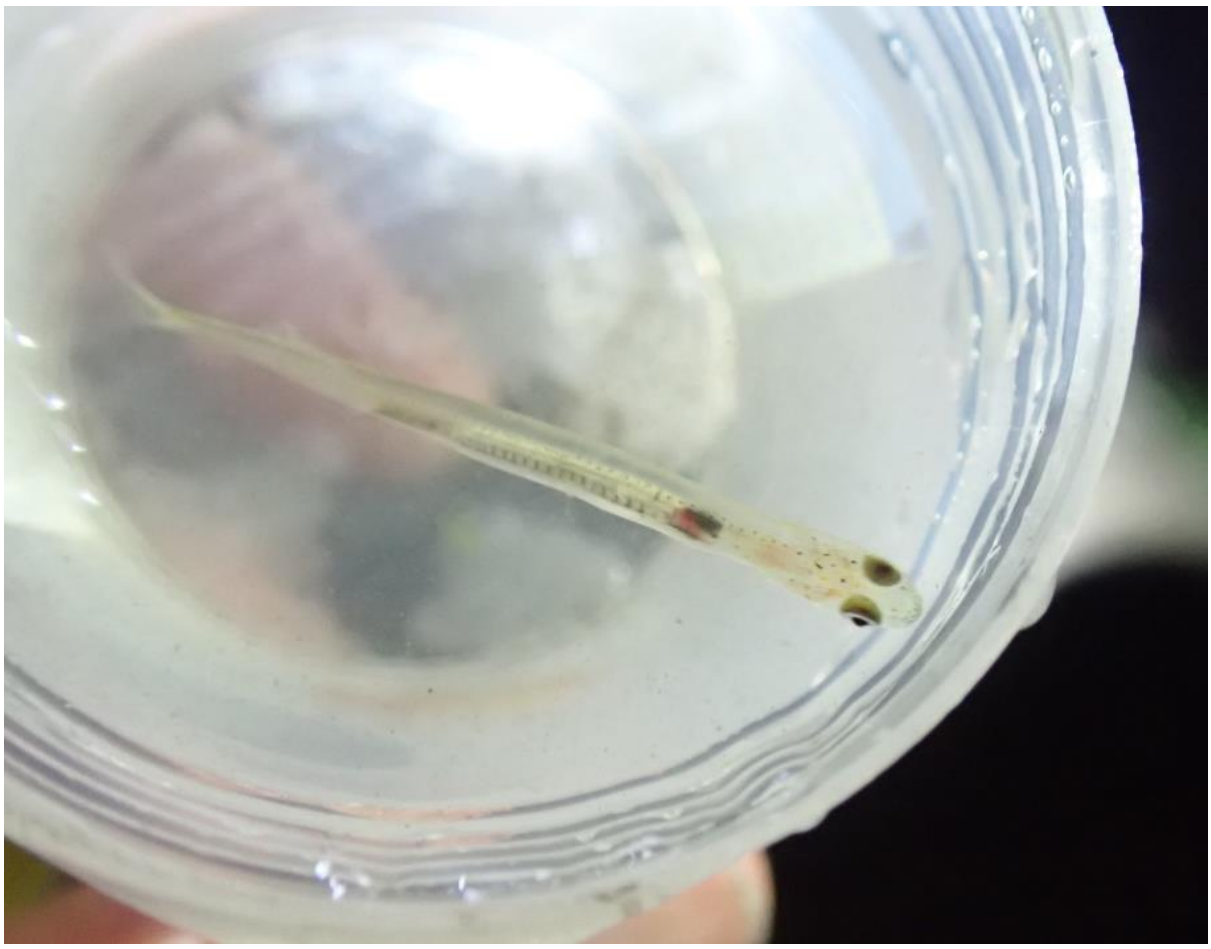

Figure 18 Common Jollytail whitebait were very common around freshwater sampling site 1 and the section of creek with a bedrock bed

Aquatic fauna in the intertidal zone

Mudflats were mapped on the 2nd of September during low tide at approximately 2pm. Location of sampling points in relation to zones are illustrated in Figure 19.

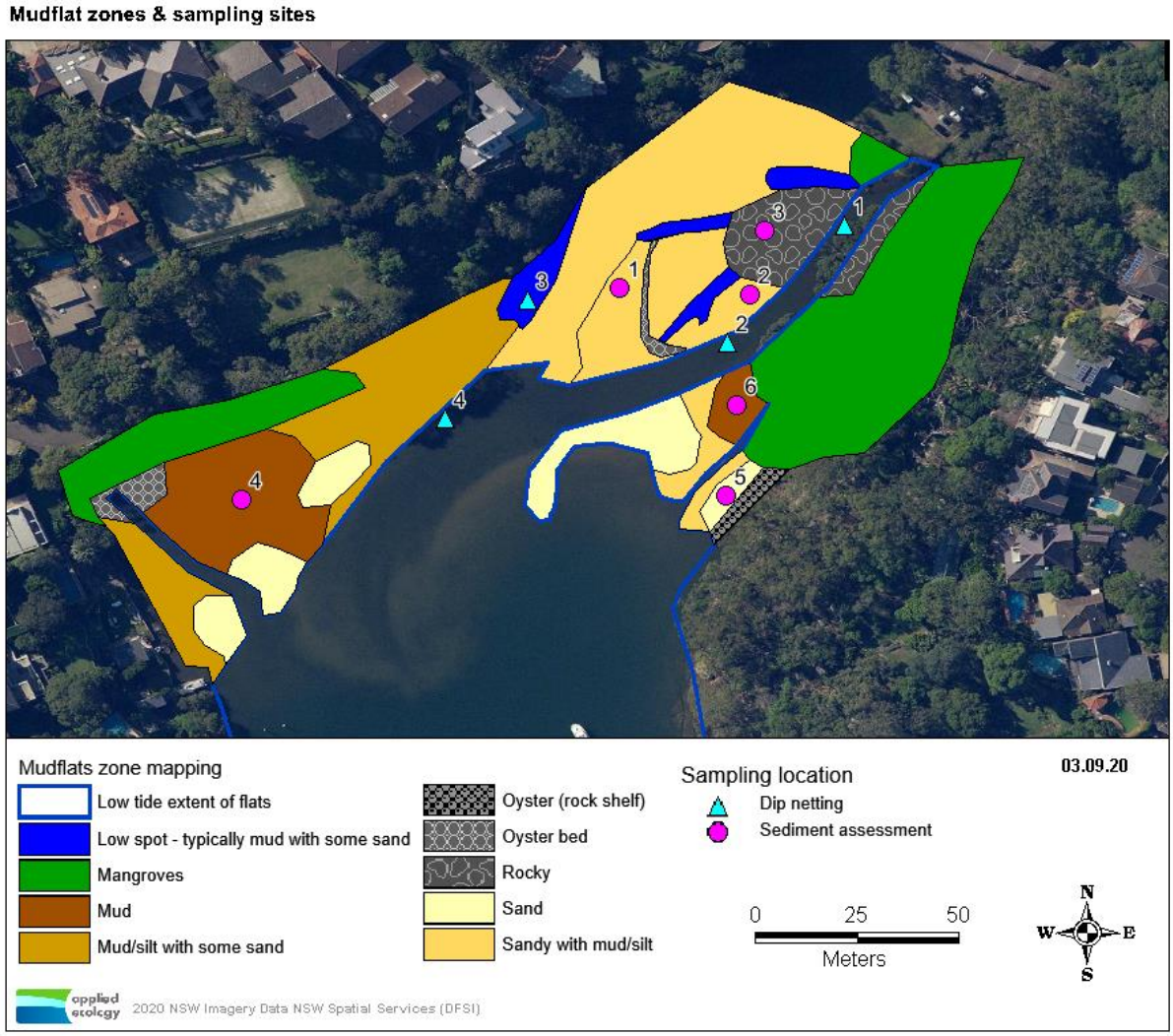

Figure 19 Mudflat zones and sampling points

Description of intertidal zone

The tidal mudflats are characterised by several quite distinct zones that are readily visible at low tide (Figure 20). There are variations in topography that can be seen with shallow depressions that have surface water present even at low tide (Figure 21). Substrates in these areas are typically dominated by fine silts with a smaller portion of fine sands also present. Mangroves have become established in areas higher on the flats (Figure 22), and generally closer to high water level, including immediately below the sandstone retaining wall at the mouth of the creek. Oyster 'beds' are present in several locations, including across the centre of the flats in areas where there is some solid substate to provide a point of attachment (Figure 23). Rocky beds are located on both sides of the creek's discharge channel, and consist of large pebbles and cobbles, with occasional small boulders to around 30cm diameter (Figure 24). Often this is overlain by a fine sediment layer that is predominantly silty. Most of the tidal flats consist of a mixture of fine sands and silts in varying ratios (Figure 25), ranging from more sandy to more silt. These are differentiated from areas of fine silty mud and areas that are almost entirely sandy (Figure 26). In general, the sand banks form comparatively stable points on the flats, and often nearest their seaward edge. Tidal flushing may

have washed the fine silts from these areas, or the sand is deposited from the sea rather than the creek's sediment loads.

Figure 20 Tidal flats adjoining Bob Campbell Oval have distinct zones that are clearly visible at low tide

Figure 21 Shallow depressions have surface water even at low tides, and generally have sediments dominated by silts

Figure 22 Several areas of mangroves have become established, including along terrestrial shores and near the creek mouth

Figure 23 Oyster 'beds' are present in areas that have objects that provide a hard substrate in slightly deeper waters

Figure 24 Beds of small rocks are present on both sides of the creek channel below the sandstone retaining wall

Figure 25 Areas with mixed fine sands and silts in varying ratios are common throughout the flats

Figure 26 Several higher areas with sand deposits built up over time provide stable points along the seaward edge of the flats

Sample Points

Point #1

Located in a predominantly sandy bed with mostly medium to fine grained sand and less than 10% silt, all well mixed to 150mm. Below that a second layer with fine sand and dark silt. Sinking depth 5 to 8cm. Numerous crab holes, no marine snail shells.

Fauna present: Soldier crab, 10+ beach worm casts

Point #2

Located in the sparse part of the oyster bed with around 50% fine silt and 50% fine sand, well mixed to 150mm. Several small clods of clay were also present. Sinking depth >10cm. Numerous crab holes, no marine snail shells.

Fauna present: Semaphore crab *Heloecius cordiformis* and one smaller unidentified crab, one red benthic worm (Polychaeta).

Point #3

Located within the main rocky area with some oysters present on rocks. Several clear layers present: top layer around 5-8mm deep with black silt/clay covered by a thin layer of fine filamentous algae, possibly binding the silt together. Underneath well mixed coarse and medium sand with some small gravel (not sandstone) and medium sized clods of clay. Sinking depth 5-8cm. Numerous crab holes, no marine snail shells.

Fauna present: two tiny soldier crabs, 3 worm casts, 1 old small spiral shell

Point #4

Located in predominantly black silt with some fine sand <20%. Sinking depth 15 to 20cm. Some crab holes, no marine snail shells.

Fauna present: 1 worm cast, one large spiral shell, empty

Point #5

Located in black silt with very little fine sand. Sinking depth 15 to 20cm. Few crab holes, no marine snail shells.

Fauna present: broken oyster shells

Marine dip netting

Dip netting was undertaken at 4 sites on the 2nd of September at low tide. The sites with rocky substrate and some woody debris (Dip netting sites 1 and 2 - Figure 27) had numerous juvenile Striped Gudgeons present (Figure 28). Juveniles of this species are common in estuaries and it is thought that juveniles are carried downstream and migrate back upstream later in life (McDowall 1996). Smooth Toadfish (Figure 29) were present around all dip netting sites albeit in low numbers.

Figure 27 Looking north along dipnetting sites 1 and 2. Fish were common around the woody debris and rocky substrate.

Figure 28 Juvenile Striped Gudgeon were common in the rocky channel in the mudflats.

Figure 29 Smooth Toadfish 25/08/2020

Discussion

Summary

In summary, impacts on species utilising the existing grassed surfaces will be high; species utilising the immediate surrounds may be impacted by changing patterns of usage including increased noise, physical disturbance and light spill; species in adjoining areas of Gore Creek Reserve are less likely to be impacted although slight shifts in assemblages around the oval may have flow on impacts up and downstream; and the freshwater section of Gore Creek adjacent to the oval and the intertidal area which may be impacted by any changes to site hydrology and the environmental impacts of crumb rubber and leachates (see below).

Direct impact on fauna

Six threatened nocturnal species have been recently recorded utilising the study area. Threatened species (highlighted in green) and other nocturnal species recorded in 2019-2020 are listed below (Table 3). Microbats species listed were recorded by a bat detector deployed intermittently near sampling site 2 of this current study.

Table 3 Nocturnal species recorded in the study area (Applied Ecology 2019-2020)

Common Name	**Scientific Name**	#nights present n=14	% night present
Mammals- microbats			
Gould's Wattled Bat	*Chalinolobus gouldii*	13	93
Chocolate Wattled Bat	*Chalinolobus morio*	5	36
Large-footed Myotis	*Myotis macropus*	4	29
Ride's Free-tailed Bat	*Ozimops ridei*	2	14
Long-eared Bat	*Nyctophilus sp.*	4	29
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	6	43
Little Bent-wing Bat	*Miniopterus australis*	1	7
White-striped Free-tailed Bat	*Austronomus australis*	4	29
Little Forest Bat	*Vespadeulus vulturnus*	1	7
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	2	14
Mammals- other			
Common Brushtail Possum	*Trichosurus vulpecula*	Common/Resident	
Common Ringtail Possum	*Pseudocheirus peregrinus*	Common/Resident	
Grey-headed Flying Fox	*Pteropus poliocephalus*	Common	
Reptiles			
Broad-tailed gecko	*Phyllurus platurus*	Resident - breeding	
Nocturnal Aves			
Australian Boobook	*Ninox novaehollandiae*	Common/Resident?	
Powerful Owl	*Ninox strenua*	Seasonal/Occasional	
Tawny Frogmouth	*Podargus strigoides*	Resident - breeding	

Impacts are not limited to vertebrate nocturnal species but also to diurnal species that roost and breed in the area (See Appendix A) and invertebrate species.

Light spill

Interactions between vertebrate assemblages and invertebrates are extremely complex and will change if lighting regimens change (to what degree is unknown) at the study site.

The lighting study for the proposal (Lighting, Art + Science, 2020), assessed the impact on wildlife and the site surrounding bushland by creating a horizontal lighting calculation illuminance grid to demonstrate the area of potential light spill. This was compared to existing levels of light spill. The modelling illustrated that upgrades to the field lighting would reduce light spill into adjoining bushland. The Australian Standard (AS 2560) for sports lighting recommends that the minimum lighting required for sports ground ranges from 50 to 1000 lux depending on sport type and the level of play and this is 167–3333 times the lux levels of a full moon (Newport *et al*. 2015). When considering this light spill note that a full moon generally ranges up to 0.3 lux illumination, with starlight 0.0011 lux[2]. The existing and projected light spill into the surrounding bushland is many magnitudes greater than this for the bushland slopes on the east and west of the oval and extends to the intertidal area in the south and across the proposed dog off leash area and into the bushland north of the oval. The oval is currently used for training on some nights with existing lighting creating spill into adjoining areas (Figure 30 - Figure 32). Council has indicated that there would not be an increase in the number of nights per week that the oval would be illuminated nor would the duration on each night of use be extended later into the night.

Light spill has a variety of impacts on wildlife, some of which are poorly understood. Some species show a noticeable response to artificial light in the wild, while others show no response at all (Beier, 2006). Under moonlight, for mammals, there may be fewer but more successful prey encounters. Predatory diurnal birds such as Laughing Kookaburras and Pied Currawongs can exploit the twilight conditions created by light spill to hunt nocturnal and crepuscular species while some species, such as the Rainbow Lorikeet, roost near lighting as a strategy to assist in detecting nocturnal predators such as the Powerful Owl (Debus, 2015).

The majority of threatened species and mammals currently recorded in the study area are microbats and microbats would be impacted by changes to lighting regimens. Impacts on bats and their prey depend on the light spectra produced by lights. Ultraviolet (UV) wavelengths attract more insects and consequently insectivorous bats (Rowse et al, 2016). Relationships between bat species and artificial illumination may be very complex and reflect differences in, for example, the type of light source (e.g. mercury vapour vs. sodium vapour lights), bat ecology and landscape context. While certain light sources attract insects and subsequently foraging bats, artificial illumination can disrupt bat foraging behaviour and flight paths.

Insectivorous bats that hunt in open spaces above the canopy (open-space foragers) or along vegetation edges (edge foragers) are the most tolerant of artificial lighting (Jung and Threlfall 2016). When foraging at streetlights, open-space foragers typically fly above the lamps, diving into the light cone to catch insects. Edge foragers tend to be more manoeuvrable than open-space foragers, and some conduct circuits inside the light cone when hunting insects at streetlights (Jung and Kalko 2010).

For forest dwelling bats (eg Vespadelus species), their morphology only allows slow flight speeds, which renders them more vulnerable to predators when flying in a sphere of light and away from protective vegetation cover. Most forest-dwelling bat species emerge from their roosts relatively

[2] Engineering ToolBox, (2004). *Illuminance - Recommended Light Level*. [online] Available at: https://www.engineeringtoolbox.com/light-level-rooms-d_708.html [Accessed Day Mo. Year]

late in the evening, presumably to minimise predation risk from diurnal birds of prey and so may be 'hard-wired' to be light-averse. Furthermore, slow-hawking bats use echolocation calls that are adapted for short-range prey detection among clutter, and so these may not be suitable for orientation in semi-open habitats where most streetlights are positioned.

Noise

With no increase in events or hours of operation proposed noise impacts on wildlife should remain unchanged post construction. Ambient noise influences the availability and use of acoustic information in animals in many ways – it can impact predator/prey interactions, foraging and reproductive strategies and success. For example frogs calling from the creek near the oval may need to change the pitch of their calls to be heard over noise generated in the evening by park users which may impact reproductive success (Parris *et al.* 2009). Several studies, on birds in particular, show that as the noise levels increase in an area, abundance and species richness significantly decreased (Newport *et al.* 2014). For some threatened microbat species, for example *Myotis macropus* are part of an especially vulnerable group of gleaning bats that rely on listening for prey rustling sounds to find food. This strategy of 'passive listening' is adopted by bat species specialized to glean arthropods from vegetation or the ground where prey echoes are masked by overlapping, strong background echoes. For such 'passive listening' bats, any significant environmental noise interferes with the detection of prey. As these bats use echolocation for spatial orientation, the reception of relevant echoes could potentially be impaired by noise as well (Gillam and McCracken, 2007).

Artificial Turf

Council has commissioned a technical report that addresses the potential environmental impacts of crumb rubber and leachates and should be read in conjunction with this report.

Areas of artificial turf do not provide any resources for fauna. Burrowing taxa cannot access the soil below (for example, dung beetles), soil dwellers (for example, segmented earth worms) are starved of food beneath, and species that have burrowing larvae (for example, cicadas) are unable to emerge after metamorphosis through artificial turf. Reduced invertebrate assemblages would impact the species that currently forage directly on the grassed open space (for example, Australian Magpies, Masked Lapwings) and over the grassed open space (for example,

Welcome Swallows, some microbat species). Reduced invertebrate assemblages would also impact nutrient cycling of matter deposited directly on the turf including plant matter and native fauna/dog faecal matter.

https://oehha.ca.gov/risk-assessment/synthetic-turf-studies

Off field impacts are dependent on the movement of crumb rubber and leachates from the area of artificial turf. Generally crumb rubber infill breaks down to larger particles that are moved by water and smaller particles that can become airborne. Stormwater that moves through the crumb rubber matrix has potential to absorb and mobilise leachates from the car tyre material. This has the potential for environmental impacts in terrestrial ecosystems through smothering; freshwater ecosystems through leachates and micronized particles; and in marine ecosystems through

smothering as tidal mudflats are a likely resting place for larger particles and micronized particles. Particles can become bound with algae and fine organic and inorganic sediments. The result is likely to be a smothering layer with potential to increase heat within the mudflats which can result in localised warming of seawater which would impact on marine organisms and freshwater species that com,plete part of their lifecycle in the estuary (for example Striped Gudgeons that migrate up Gore Creek from the bay as they mature). Ingestion of micronized particles is still poorly understood but is now recognised as a major problem for marine animals, and is likely to also affect freshwater organisms (Halle et al, 2020).

Preliminary recommendations

- Investigate the use of part-night lighting (PNL), dimming, directed lighting, and motion-sensitive lighting on carpark lights, and amenities building that may have more beneficial consequences for light-averse species
- Investigate optimal shielding to reduce light spill into bushland through monitoring post construction
- Continue to restrict hours of illuminance of the sports field to early evening
- Restrict noisy time keeping devices such as airhorns during sporting events
- Monitor aquatic systems for crumb drifts and clean up as required
- Brushmatt/close informal tracks that lead into bushland on the eastern and western slopes

Figure 30 Existing lighting -looking east across the oval – 02/09/2020 18:15.

Figure 31 Existing lighting -looking south across the oval – 02/09/2020 18:30.

Figure 32 Existing lighting -looking north along the creek line from the oval – 02/09/2020 18:30

References

Cheng, H., Hu, Y., and Reinhard, M. (2014). Environmental and health impacts of artificial turf: a review. *Environ. Sci. Technol.* 48, 2114–2129. doi: 10.1021/es4044193

Debus, S. (2015) Possible impact of artificial night lighting on the Powerful Owl, www.kppa.org.au

Halle, L. L., Palmqvist, A., Kampmann, K., and Khan, F. R. (2020). Ecotoxicology of micronized tire rubber: past, present and future considerations. *Sci. Total Environ.* 706:135694. doi: 10.1016/j.scitotenv.2019.135694

Halsband, C., Sorensen, L., Booth, A.M., (2020). Car tire crumb rubber: does leaching produce a toxic chemical cocktail in coastal marine systems? Frontiers in Environmental Science, vol 8 https://www.frontiersin.org/articles/10.3389/fenvs.2020.00125/full#B18

Hartwell, S. I., Jordahl, D. M., and Dawson, C. E. O. (2000). The effect of salinity on tire leachate toxicity. *Water Air Soil Pollut.* 121, 119–131.

McDowall, R (ed) (1996). Freshwater fishes of south-eastern Australia. Reed Books, Chatswood.

Newport, J., Shorthouse, D.J. and Manning, A.D. (2014), The effects of light and noise from urban development on biodiversity: Implications for protected areas in Australia. Ecol Manag Restor, 15: 204-214. doi:10.1111/emr.12120

Parris K. M., Velik-Lord M. and North J. M. A. (2009) Frogs call at a higher pitch in traffic noise. Ecology and Society 14, 25

Redondo-Hasselerharm, P. E., De Ruijter, V. N., Mintenig, S. M., Verschoor, A., and Koelmans, A. A. (2018). Ingestion and chronic effects of car tire tread particles on freshwater benthic macroinvertebrates. *Environ. Sci. Technol.* 52, 13986–13994. doi: 10.1021/acs.est.8b05035

Schroer, Sibylle & Hölker, Franz. (2017). Impact of lighting on flora and fauna. 10.1007/978-3-319-00176-0_42.

Appendix A Desktop survey results

Table 4 Combined records for the study area

Threatened Species

Regionally significant species (DECCW 2007)

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surrounds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
AVES								
Australasian Darter	*Anhinga novaehollandiae*					X		
Australasian Figbird	*Sphecotheres vieilloti*						X	
Australian Boobook	*Ninox novaehollandiae*	X	X			X	X	
Australian Brush-turkey	*Alectura lathami*	X	X		X	X	X	
Australian King-Parrot	*Alisterus scapularis*	X	X	X	X	X	X	
Australian Magpie	*Cracticus tibicen*	X	X	X	X		X	
Australian Pelican	*Pelecanus conspicillatus*					X	X	
Australian Raven	*Corvus coronoides*	X	X				X	
Australian White Ibis	*Threskiornis molucca*	X	X			X	X	
Australian Wood Duck	*Chenonetta jubata*				X	X	X	
Azure Kingfisher	*Ceyx azureus*					X	X	
Barking Owl	*Ninox connivens*						X	
Bar-tailed Godwit	*Limosa lapponica*					X	X	
Bell Miner	*Manorina melanophyrs*						X	
Black Falcon	*Falco subniger*						X	
Black Swan	*Cygnus atratus*				X			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	X		X	X	X	X	
Black-faced Monarch	*Monarcha melanopsis*		X				X	
Black-shouldered Kite	*Elanus axillaris*					X		
Brown Cuckoo-Dove	*Macropygia amboinensis*						X	
Brown Falcon	*Falco berigora*					X	X	
Brown Gerygone	*Gerygone mouki*	X	X				X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Brown Goshawk	*Accipiter fasciatus*	X	X	X	X	X	X	
Brown Thornbill	*Acanthiza pusilla*	X		X	X	X	X	
Buff-banded Rail	*Gallirallus philippensis*						X	
Buff-rumped Thornbill	*Acanthiza reguloides*						X	
Cattle Egret	*Ardea ibis*		X			X	X	
Channel-billed Cuckoo	*Scythrops novaehollandiae*	X			X	X	X	
Chestnut Teal	*Anas castanea*		X		X	X	X	
Collared Sparrowhawk	*Accipiter cirrocephalus*						X	
Common Bronzewing	*Phaps chalcoptera*		X					
Crested Pigeon	*Ocyphaps lophotes*		X				X	
Crested Shrike-tit	*Falcunculus frontatus*						X	
Crested Tern	*Thalasseus bergii*		X			X	X	
Crimson Rosella	*Platycercus elegans*		X	X			X	
Dollar Bird	*Eurystomus orientalis*		X	X		X	X	
Double-barred Finch	*Taeniopygia bichenovii*						X	
Eastern Barn Owl	*Tyto delicatula*						X	
Eastern Koel	*Eudynamys orientalis*		X	X	X	X	X	
Eastern Osprey	*Pandion cristatus*					X	X	
Eastern Rosella	*Platycercus eximius*			X	X	X	X	
Eastern Spinebill	*Acanthorhynchus tenuirostris*			X	X			
Eastern Whipbird	*Psophodes olivaceus*	X	X	X	X	X	X	
Eastern Yellow Robin	*Eopsaltria australis*		X	X			X	
Fairy martin	*Petrochelidon ariel*						X	
Fan-tailed Cuckoo	*Cacomantis flabelliformis*						X	
Galah	*Eolophus roseicapilla*				X	X	X	
Golden Whistler	*Pachycephala pectoralis*		X	X			X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Great Cormorant	*Phalacrocorax carbo*					X	X	
Great Egret	*Ardea alba*					X		
Grey Butcherbird	*Cracticus torquatus*	X		X	X		X	
Grey Fantail	*Rhipidura albiscapa*	X	X	X	X		X	
Grey Goshawk	*Accipiter novaehollandiae*						X	
Grey Shrike-thrush	*Colluricincla harmonica*		X				X	
Grey Teal	*Anas gracilis*					X	X	
Horsfield's Bronze Cuckoo	*Chalcites basalis*					X	X	
Jacky Winter	*Microeca fascinans*						X	
Laughing Kookaburra	*Dacelo novaeguineae*	X	X	X	X	X	X	
Leaden Flycatcher	*Myiagra rubecula*			X			X	
Lewin's Honeyeater	*Meliphaga lewinii*				X		X	
Little Black Cormorant	*Phalacrocorax sulcirostris*	X			X	X		
Little Corella	*Cacatua sanguinea*	X				X	X	
Little Egret	*Egretta garzetta*						X	
Little Pied Cormorant	*Microcarbo melanoleucos*					X	X	
Little Wattlebird	*Anthochaera chrysoptera*						X	
Long-billed Corella	*Cacatua tenuiostris*						X	
Magpie-lark	*Grallina cyanoleuca*	X	X		X	X	X	
Masked Lapwing	*Vanellus miles*	X	X	X	X	X	X	
Mistletoebird	*Dicaeum hirundinaceum*						X	
Musk Lorikeet	*Glossopsitta concinna*			X		X	X	
Nankeen Kestrel	*Falco cenchroides*					X	X	
Nankeen Night Heron	*Nycticorax caledonicus*		X				X	
New Holland Honeyeater	*Phylidonyris novaehollandiae*						X	
Noisy Friarbird	*Philemon corniculatus*		X				X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Noisy Miner	*Manorina melanocephala*	X	X	X	X	X	X	
Olive-backed Oriole	*Oriolus sagittatus*						X	
Pacific Black Duck	*Anas superciliosa*				X	X	X	
Pallid Cuckoo	*Cacomantis pallidus*				X	X	X	
Peregrine Falcon	*Falco peregrinus*		X			X		
Pheasant Coucal	*Centropus phasianinus*						X	
Pied Butcherbird	*Cracticus nigrogularis*						X	
Pied Cormorant	*Phalacrocorax varius*					X	X	
Pied Currawong	*Strepera graculina*	X	X	X	X	X	X	
Powerful Owl	*Ninox strenua*	X	X	X	X		X	
Rainbow Lorikeet	*Trichoglossus haematodus*	X	X	X	X	X	X	
Red Wattlebird	*Anthochaera carunculata*	X	X	X			X	
Red-browed Finch	*Neochmia temporalis*		X				X	
Red-rumped Parrot	*Psephotus haematonotus*						X	
Rose Robin	*Petroica rosea*			X			X	
Rufous Fantail	*Rhipidura rufifrons*	X	X	X	X		X	
Rufous Whistler	*Pachycephala rufiventris*						X	
Sacred Kingfisher	*Todiramphus sanctus*		X		X	X	X	
Satin Bowerbird	*Ptilonorhynchus violaceus*	X		X	X	X	X	
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*				X		X	
Scarlet Robin	*Petroica boodang*						X	
Shining Bronze-cuckoo	*Chrysococcyx lucidus*						X	
Silver Gull	*Chroicocephalus novaehollandiae*	X	X		X		X	
Silvereye	*Zosterops lateralis*		X	X			X	
Spangled Drongo	*Dicrurus hottentottus*			X			X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Spotted Pardalote	*Pardalotus punctatus*	X	X	X	X	X	X	
Straw-Necked Ibis	*Threskiornis spinicollis*					X	X	
Striated Heron	*Butorides striata*	X	X	X	X	X	X	
Striated Pardalote	*Pardalotus striatus*		X					
Striated Thornbill	*Acanthiza lineata*						X	
Sulphur-crested Cockatoo	*Cacatua galerita*	X	X		X	X	X	
Superb Fairy-wren	*Malurus cyaneus*		X	X	X		X	
Superb Lyrebird	*Menura novaehollandiae*				X		X	
Tawny Frogmouth	*Podargus strigoides*	X				X	X	
Topknot pigeon	*Lopholaimus antarcticus*			X	X		X	
Variegated Fairy-wren	*Malurus lamberti*						X	
Welcome Swallow	*Hirundo neoxena*	X	X		X		X	
White-bellied Sea-eagle	*Haliaeetus leucogaster*	X	X	X			X	
White-browed Scrubwren	*Sericornis frontalis*	X	X	X	X	X	X	
White-cheeked Honeyeater	*Phylidonyris niger*			X			X	
White-faced Heron	*Egretta novaehollandiae*	X	X		X	X	X	
White-headed Pigeon	*Columba leucomela*					X	X	
White-naped Honeyeater	*Melithreptus lunatus*					X		
White-necked Heron	*Ardea pacifica*					X		
White-plumed Honeyeater	*Lichenostomus penicillatus*						X	
White-throated Gerygone	*Gerygone albogularis*						X	
White-throated Needletail	*Hirundapus caudacutus*					X	X	
White-throated Tree-creeper	*Cormobates leucophaea*		X	X			X	
White-winged Triller	*Lalage tricolor*						X	
Willie Wagtail	*Rhipidura leucophrys*					X	X	
Yellow-billed Spoonbill	*Platalea flavipes*					X	X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Yellow-faced Honeyeater	*Lichenostomus chrysops chrysops*						X	
Yellow-tailed Black-cockatoo	*Calyptorhynchus funereus*			X		X	X	
Introduced Birds								
Common Blackbird	*Turdus merula*						X	
Common Myna	*Acridotheres tristis*		X				X	
Common Starling	*Sturnus vulgaris*		X				X	
House Sparrow	*Passer domesticus*						X	
Mallard	*Anas platyrhynchos*					X		
Red-whiskered Bulbul	*Pycnonotus jocosus*		X	X		X	X	
Rock Dove	*Columba livia*					X	X	
Spotted Turtle-Dove	*Streptopelia chinensis*		X	X		X	X	
MAMMALS								
Microbats								
White-striped Free-tailed Bat	*Austronomus australis*	X						
Gould's Wattled Bat	*Chalinolobus gouldii*	X				X		
Chocolate Wattled Bat	*Chalinolobus morio*	X						
Little Bent-wing Bat	*Miniopterus australis*	X						
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	X						
Large-footed Myotis	*Myotis macropus*	X					X	
Long-eared Bat	*Nyctophilus sp.*	X						
Ride's Free-tailed Bat	*Ozimops ridei*	X						
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	X						
Little Forest Bat	*Vespadeulus vulturnus*	X						
Other Native mammals								
Common Brushtail Possum	*Trichosurus vulpecula*	X					X	
Common Ringtail Possum	*Pseudocheirus peregrinus*	X					X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Grey-headed Flying Fox	*Pteropus poliocephalus*	X					X	
Short-beaked Echidna	*Tachyglossus aculeatus*							**2017 record**
Introduced Mammals								
Black Rat	*Rattus rattus*	X					X	
Red Fox	*Vuples vulpes*	X					X	
Cat		X						
Dog		X						
AMPHIBIANS								
Bleating Tree Frog	*Litoria dentata*						X	
Brown-Marsh Frog	*Limnodynastes peronii*	X					X	
Common Froglet	*Crinia signifera*	X					X	
Green Stream Frog, Leaf-green Tree Frog	*Litoria phyllochroa*	X					X	
Green Tree Frog	*Litoria caerulea*						X	
Perons Tree Frog	*Litoria peronii*	X						
REPTILES								
Dragons								
Eastern Water Dragon	*Intellagama lesueurii*	X				X	X	
Geckoes								
Broad-tailed gecko	*Phyllurus platurus*	X					X	
Lesueur's Velvet Gecko	*Amalosia lesueurii*						X	
Legless Lizards								
Burton's Snake-lizard	*Lialis burtonis*						X	
Skinks								
Barred-sided Skink	*Concinnia tenuis*						X	
Copper-tailed skink	*Ctenotus taeniolatus*						X	
Dark-flecked garden sun skink	*Lampropholus delicata*	X					X	
Eastern Blue-tongue Lizard	*Tiliqua scincoides*					X	X	
Eastern Water Skink	*Eulamprus quoyii*	X					X	
Elegant snake-eyed skink	*Cryptoblepharus pulcher*						X	

COMMON NAME	SCIENTIFIC NAME	AE 2019-2020 survey	Birdlife 1998-2020		ebird 2006-2020	Council Database all years		BioNet other BC surronds
		Covers the Gore Creek Corridor	Bob Campbell and immediate surrounds	Gore Creek Reserve (south of River Road)	Gore Creek Reserve (south of River Road)	Gore Creek Foreshore	Gore Creek Reserve/ Valley	
Pale-flecked garden sun skink	*Lampropholis guichenoti*						X	
Pale-lipped Shadeskink	*Saproscincus spectabilis*	X					X	
Red-throated Skink	*Acrintoscincus platynotum*						X	
Three toed Skink	*Saiphos equalis*						X	
Weasal Skink	*Saproscincus mustelinus*						X	
Snakes								
Red-bellied Black Snake	*Pseudechis porphyriacus*						X	
Golden-crowned Snake	*Cacophis squamulosus*						X	
Blackish Blind Snake	*Anilios nigrescens*						X	
Turtles								
Eastern Long-necked Turtle	*Chelodonia longicollis*						X	
FISH (freshwater)								
Longfin Eel	*Anguilla reinhardtii*	X						
Striped gudgeon	*Gobiomorphus australis*	X						
Gambusia	*Gambusia holbrooki*	X						
	TOTAL	64	52	40	42	66	153	