Appendix K Bennett Brook Carter's Freshwater Mussel Targeted Survey

Specialists in the ecology and management of rivers and wetlands

16 Claude Street
Burswood WA 6100
T: +61 (08) 9361 4325
ABN: 43 145 831 554

Interoffice Memorandum

To: Jen Longstaff, Principal Environmental Consultant, Eco Logical Australia (ELA)

From: Bonita Clark, Senior Ecologist, Wetland Research & Management (WRM)

CC: Andrew Storey, Director, WRM; Michelle Murtagh, Environmental Consultant, ELA

Date: 27 May 2020

Re: MEL Project 27: Bennett Brook Mussel Targeted Survey, Autumn 2020.

Document number: MEL-MNO-WRM-RPT-0003

Dear Jen,

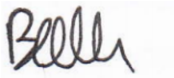
As requested by the METRONET Office, a survey targeting Carter's freshwater mussel (*Westralunio carteri*) was conducted by Wetland Research & Management (WRM) consulting ecologists at eight sites along Bennett Brook on the 30th April and 1st May 2020 (mid-autumn 2020); four sites upstream, and four sites downstream, of the proposed Morley-Ellenbrook Line (MEL) railway bridge across Bennett Brook, with one of the downstream sites located on the proposed rail crossing.

Water was present at three of the eight sites at the time of the survey; one upstream site (BBUS2; Mussel Pool), and two downstream sites (BBDS3 and BBDS4). Specimens of *W. carteri* were collected at Mussel Pool (BBUS2; 1 live specimen), and BBDS4 (31 live specimens). *W. carteri* was not detected at BBDS3, nor any of the sites that were dry (BBUS1, BBUS3, BBUS4, BBDS1 and BBDS2). No water was present within Bennett Brook where it is intersected by the MEL Development Envelope, and no *W. carteri* were detected at this location (i.e. along the transect at site BBDS1). Habitat on Bennett Brook within the MEL Development Envelope did not appear suitable for *W. carteri* with this area lacking any semi-permanent/permanent pools or flowing water, or suitable sandy/silty substrate at the time of sampling.

Construction of the rail bridge will likely require some clearing of riparian vegetation within and adjacent to the brook, which may affect water and habitat quality in downstream receiving environments, where *W. carteri* was detected. However, if appropriate controls are implemented within/adjacent to the construction zone to control drainage and prevent runoff to the brook, the project would be unlikely to directly impact known downstream populations of *W. carteri*, which are approximately 1.7 km downstream of the crossing. Information provided to WRM on the design considerations for the MEL Bennett Brook rail bridge indicate the infrastructure will not impact the physical structure and ecological function of Bennett Brook in 1% AEP flood events, maintaining current conditions for fish passage and associated dispersal of glochidia of *W. carteri*. Based in the design specifications provided, and the distribution of *W. carteri* derived from the current targeted survey, the potential for direct or indirect impacts arising from the MEL project to *W. carteri* within Bennett Brook would appear to be low.

If you have any queries regarding the results presented in this memorandum, please do not hesitate to contact me.

Kind regards,



Bonita Clark

Senior Ecologist

1 BACKGROUND

The Morley-Ellenbrook Line (MEL), a component of the State government's METRONET program to increase the size of Perth's railway network, will connect the existing Midland Line to Perth's northeast suburbs, terminating in Ellenbrook. The development of the MEL project is being led by the METRONET Office, while the Public Transport Authority of Western Australia (PTA) is the project's formal proponent. The proposed rail alignment will cross Bennett Brook via a 20 to 25 m railway bridge structure located to the north of Marshall Road, in the suburb of Bennett Springs (see Figure 1 for survey area overview).

Bennett Brook is a significant tributary of the Swan River, and a system with high Aboriginal heritage and social value, and known ecological value. The MEL project has been referred for environmental approvals under the State *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). To support environmental assessments and gain environmental approvals, Wetland Research & Management (WRM) was engaged by Eco Logical Australia (ELA), on behalf of METRONET, to conduct a targeted survey of Bennett Brook for the conservation listed Carter's freshwater mussel (*Westralunio carteri*). *W. carteri* is currently listed as Vulnerable under the EPBC Act and the state *Biodiversity Conservation Act 2016* (BC Act).

Data on the presence and distribution of *W. carteri* in Bennett Brook; upstream, downstream, and in the immediate vicinity of the proposed railway bridge, was collected during a field survey conducted on the 30th April and 1st May 2020 (mid-autumn). This survey was conducted on short notice at the request of METRONET, to provide input to their imminent Environmental Review Document, and was not the optimum timing for detection of *W. carteri*, given the majority of the Bennett Brook survey area was dry (five of eight survey sites). However, the timing of the survey assisted in the identification of permanent water locations which are more likely to support *W. carteri* throughout the summer and autumn months when the brook is not flowing, as *W. carteri* can only survive short periods of drying (Klunzinger 2012).

2 CARTER'S FRESHWATER MUSSEL

Freshwater mussels (Bivalvia: Unionoida) are a keystone species in freshwater ecosystems due to their filter-feeding ability, the important role they play in nutrient cycling and bio-deposition, as well as the structural habitat and the food source they provide for other organisms (Klunzinger *et al.* 2014, Vaughn and Hakenkamp 2001, Spooner and Vaughn 2008). Despite their immense importance, a number of freshwater mussel species remain endangered throughout the world, with a multitude of threats influencing their persistence and survival (Klunzinger and Walker 2014).

Plate 1. Carter's freshwater mussel (*Westralunio carteri*) found at Mussel Pool within the Bennett Brook study area, April 2020.

W. carteri (Plate 1) is the only native freshwater mussel found in south-western Australia, with a distribution ranging from Moore River in the north, to the south coast, west of Esperance (Klunzinger 2012, Klunzinger *et al*. 2015). This species is currently listed as Vulnerable on state (Biodiversity Conservation Act 2016: September 2018 list), national (EPBC Act 1999), and international (IUCN Redlist) conservation lists (IUCN 2020). *W. carteri* occurs in greatest abundance in slower flowing permanent/semi-permanent stream and riverine habitats with stable sediments and low salinity, living two thirds to almost fully buried in sand and finer sediment

(Klunzinger *et al.* 2010, Klunzinger 2012). Klunzinger (2012) only found *W. carteri* in perennial (permanent/semi-permanent) stream and riverine habitats, and dehydration exposure experiments demonstrated *W. carteri* cannot survive prolonged drying (i.e. 76% mortality occurring under experimental conditions, within five days of exposure to dry conditions in sand filled bath tubs).

The *W. carteri* lifecycle involves an obligate parasitic 'larval' stage, known as glochidia, which attach to host fish for several weeks to complete their development (Bauer and Wächtler 2001, Strayer 2008, Klunzinger *et al*. 2012). The glochidia aids with the distribution of this species, with individuals being dispersed by migrating fish. *W. carteri* is a long-lived species, becoming sexually mature within 6 years at approximately 27 mm shell length, and living for at least 50 years (Klunzinger *et al.* 2014; Plate 2). Despite this known information, there is a distinct knowledge gap with respect to the ecology of *W. carteri*, thereby confounding conservation efforts and status of the species, whilst emphasizing the protection of any known/new populations of the species (Klunzinger *et al.* 2015).

W. carteri is currently under threat across south-western Australia due to secondary salinisation, loss of suitable host species, nutrient pollution, habitat loss, water extraction, as well as sedimentation resulting in increased turbidity. Reservoir dewatering and declining rainfall also appear to have had a negative effect on populations (Klunzinger *et al*. 2012). Klunzinger *et al*. (2015) speculated that the species extent of occurrence (EOO) had declined by 49% in less than 50 years, due primarily to secondary salination, and emphasised the importance of habitat protection where the species persists.

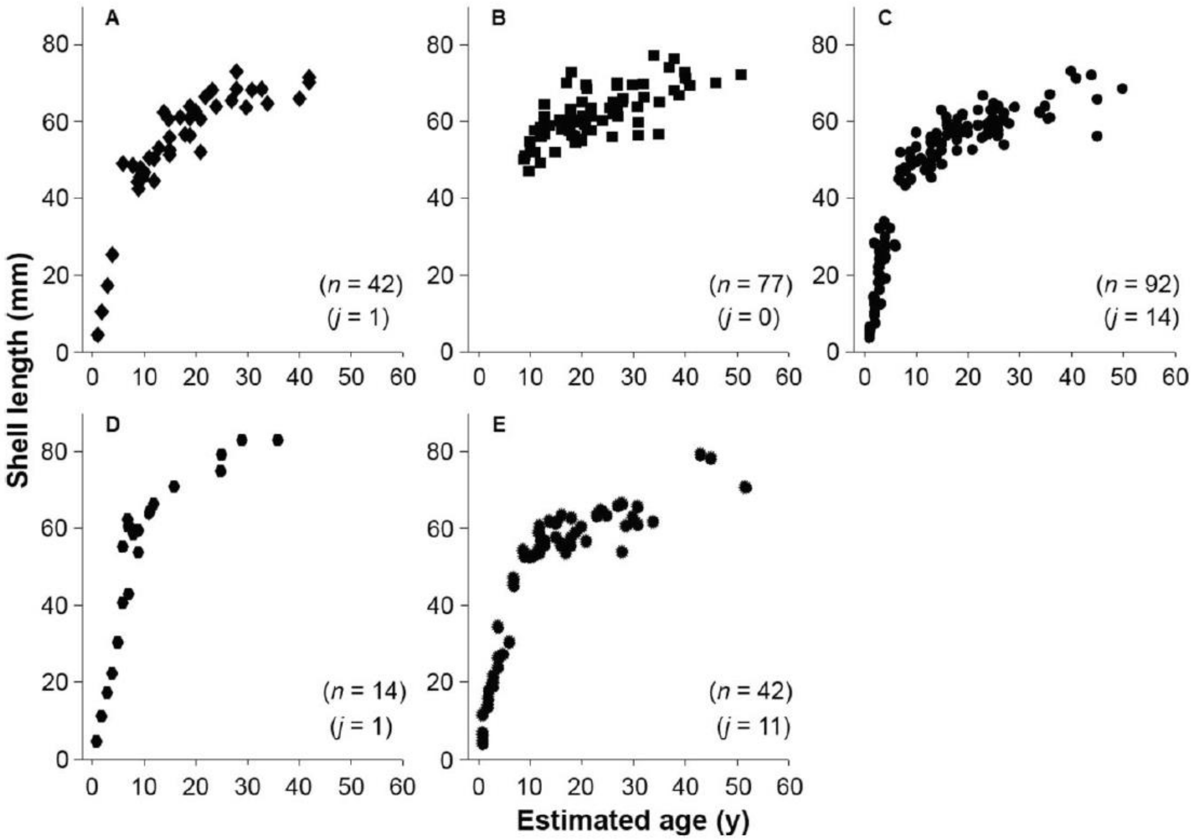


Plate 2. Figure 3 from Klunzinger *et al.* (2014); age-at-length measurements for *W. carteri* at Bennett Brook (A), Brunswick River (B), Collie River (C), Serpentine River, Dog Hill (D), and Serpentine River, Horse Drink (E).

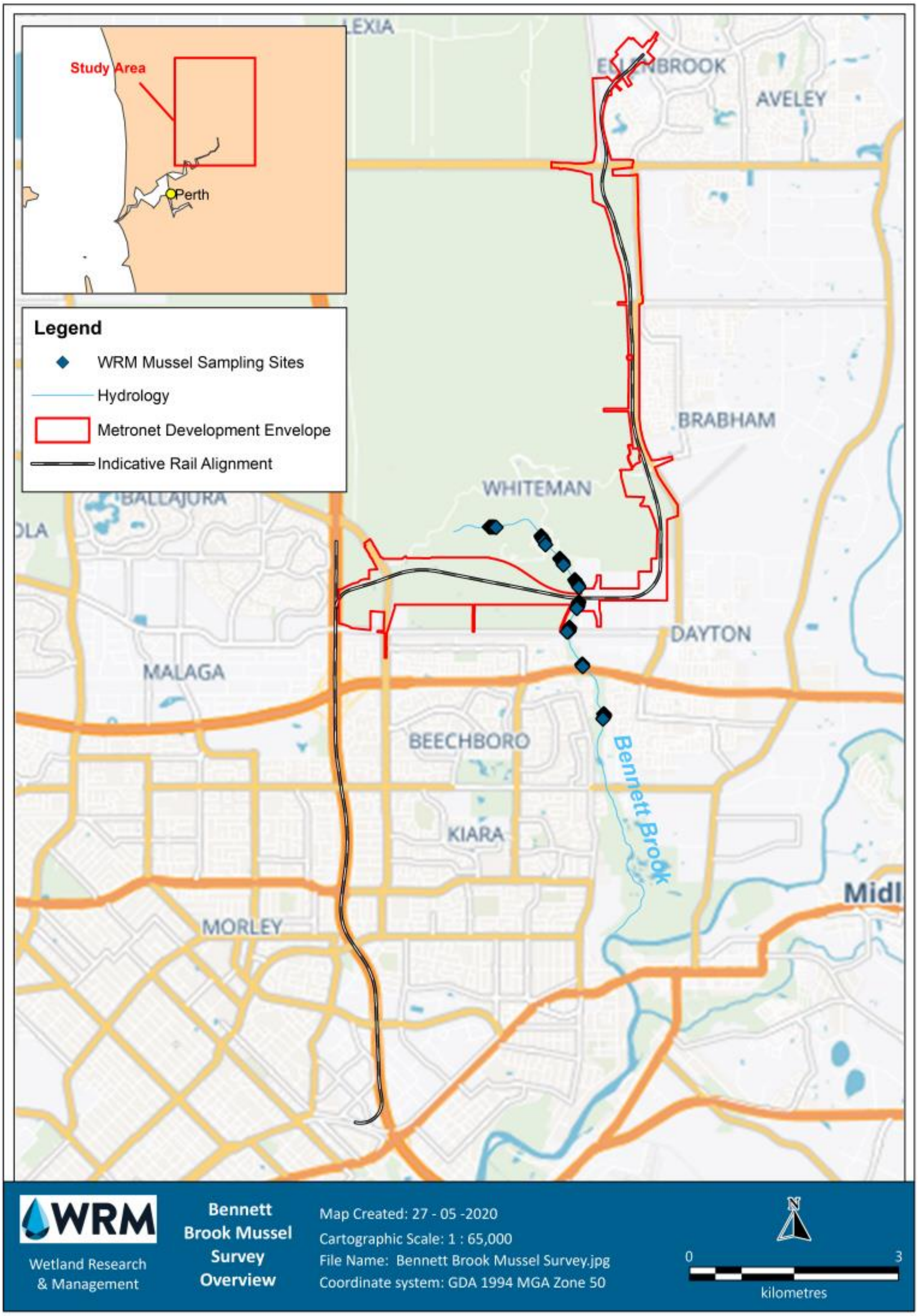


Figure 1. Overview of the MEL Development Envelope, showing Bennett Brook and sites sited for the *W. carteri* targeted survey.

3 SURVEY METHODS

Eight sites along Bennett Brook were surveyed for *W. carteri* in mid-autumn 2020; BBUS1, BBUS2 (Mussel Pool, Plate 3), BBUS3 (Plate 4) and BBUS4 on the 30th April 2020 (Table 1, Figure 2), and BBDS1, BBDS2, BBDS3 (Plate 5) and BBDS4 (Plate 6) on the 1st May 2020 (

Table **2**, Figure 2). Water was present at three of the eight sites during the survey, BBUS2 (Mussel Pool), BBDS3 and BBDS4.

3.1 Transect and quadrat establishment

Visual and hand searches for mussels were conducted by two people, in eight quadrats of 1 m^2 placed along a longitudinal 100m transect (approx. 14 m intervals, running from upstream to downstream) in the brook channel at each site, following methodology of Klunzinger *et al.* (2011)[1] (who's methodology was adapted from Strayer and Smith 2003). Quadrats were named Q1 (at 0 m) upstream, through Q8 downstream (at 100 m; see Table 1 for quadrat coordinates). Areas of most suitable mussel habitat were targeted for the placement of the quadrat, where present, i.e. sand sediment, or areas sheltered by instream habitat, such as beneath/adjacent to large woody debris. The brook channel at most sites was between 1.5 to 2.5 m wide.

However, at Mussel Pool (BBUS2), the channel was approximately 25 m wide. Therefore, the 100 m transect was established longitudinally down the eastern bank, which was the most accessible, with quadrats placed in the water close to the shoreline at 14 m intervals. At BBDS3 (Plate 5), surface water was present as a marsh-like area of inundated grass, bullrush and knotweed. Water could only be sampled where it was clear of vegetation, therefore quadrats were placed in these areas, rather than along a strict 100 m transect.

3.2 Mussel survey methods

At the sites without water, the sediment was raked using a long-handled landscapers rake (1.35 m wooden handle with metal teeth) to a depth of 5 to 10 cm within each quadrat where possible, and visually searched for evidence of mussels (either live or empty shells). Grass and tree/vegetation roots were growing throughout the channel bed at sites BBUS1, BBUS3, BBUS4, BBDS1 and BBDS2 during the targeted surveys, which compacted the sediment and impeded digging to a uniform depth within the quadrats. However, these sites did not contain habitat suitable for *W. carteri*, which is unlikely to persist in dry areas of the brook, where water is only present in the winter months (i.e. seasonally flowing sections, typically August through to November for Bennett Brook; Whiteman Park 2020).

At Mussel Pool (BBUS2) and BBDS4, the search for mussels within each quadrat was conducted by gently raking the sediment, followed by intensive hand searching within the 1 m^2 (methods as per Klunzinger *et al.* 2011, Klunzinger 2012). At BBDS3, sampling with the rake and by hand searching the sediment was significantly impeded by the inundated vegetation, therefore, searching was attempted using a 1mm mesh size D-frame dip net instead.

Any empty mussel shells on the bank within approximately 2 m of the quadrat were noted. Each live captured *W. carteri* was measured for shell length using callipers (Plate 1), and all mussels from each quadrat were photographed as a group, before being promptly returned to the same quadrat from which they were uncovered (Plate 7). Mussel density (individuals/m^2) was recorded for each quadrat and GPS waypoints of quadrats where mussels were discovered were recorded for inclusion in the distribution map for Bennett Brook (Figure 2).

[1] Dr Michael Klunzinger has authored/co-authored over 15 scientific research papers and technical reports on the topic of *Westralunio carteri* biology and ecology, including his 2012 PhD Thesis: *Ecology, life history and conservation status of <u>Westralunio carteri</u> Iredale, 1934, an endemic freshwater mussel of south-western Australia*.


Plate 3. Mussel Poo (BBUS2), 30th April 2020, view looking upstream from the dam, near Q8.


Plate 4. Bennett Brook, 30th April 2020, view looking downstream from BBUS3 Q1.


Plate 5. Bennett Brook at BBDS3, 1st May 2020, view looking downstream from Q3 towards Reid Highway.


Plate 6. Bennett Brook at BBDS4 Q2, 1st May 2020, view looking downstream towards footbridge (end of Patricia Street, Caversham).


Plate 7. *W. carteri* population at BBDS4 (in Q2), 1st May 2020.

Table 1. Bennett Brook sites upstream of the proposed MEL railway bridge. GPS coordinates, mussel presence / absence, status (number of live and empty shells), and mussel measurement statistics for each quadrat.

Site	Quadrat	GPS Coordinates			Mussels	Live				Empty shells
					Present/ Absent	Density 1 m^2	Size (cm)			Density 1 m^2
		Zone	Easting	Northing			Max	Min	Median	
BBUS1	Q1	50 J	399751	6476594	x	0	0	0	0	0
	Q2	50 J	399761	6476593	x	0	0	0	0	0
	Q3	50 J	399775	6476596	x	0	0	0	0	0
	Q4	50 J	399788	6476594	x	0	0	0	0	0
	Q5	50 J	399803	6476596	x	0	0	0	0	0
	Q6	50 J	399815	6476596	x	0	0	0	0	0
	Q7	50 J	399828	6476595	x	0	0	0	0	0
	Q8	50 J	399848	6476591	x	0	0	0	0	0
BBUS2 (Mussel Pool)	Q1	50 J	400496	6476475	✓	0	0	0	0	4
	Q2	50 J	400501	6476454	✓	1	77	77	77	8
	Q3	50 J	400512	6476440	✓	0	0	0	0	8
	Q4	50 J	400525	6476431	✓	0	0	0	0	7
	Q5	50 J	400522	6476422	✓	0	0	0	0	12
	Q6	50 J	400531	6476412	✓	0	0	0	0	2
	Q7	50 J	400541	6476396	✓	0	0	0	0	2
	Q8	50 J	400560	6476351	✓	0	0	0	0	4
BBUS3	Q1	50 J	400767	6476156	x	0	0	0	0	0
	Q2	50 J	400775	6476140	x	0	0	0	0	0
	Q3	50 J	400788	6476129	x	0	0	0	0	0
	Q4	50 J	400798	6476119	x	0	0	0	0	0
	Q5	50 J	400805	6476109	x	0	0	0	0	0
	Q6	50 J	400810	6476096	x	0	0	0	0	0
	Q7	50 J	400814	6476084	x	0	0	0	0	0
	Q8	50 J	400820	6476065	x	0	0	0	0	0
BBUS4	Q1	50 J	400983	6475856	x	0	0	0	0	0
	Q2	50 J	400991	6475837	x	0	0	0	0	0
	Q3	50 J	401001	6475825	x	0	0	0	0	0
	Q4	50 J	401008	6475814	x	0	0	0	0	0
	Q5	50 J	401021	6475799	x	0	0	0	0	0
	Q6	50 J	401026	6475783	x	0	0	0	0	0
	Q7	50 J	401036	6475770	x	0	0	0	0	0
	Q8	50 J	401042	6475749	x	0	0	0	0	0

Table 2. Bennett Brook sites downstream of the proposed MEL railway bridge. GPS coordinates, mussel presence / absence, status (number of live and empty shells), and mussel measurement statistics for each quadrat.

Site	Quadrat	GPS Coordinates			Mussels	Live				Empty shells
					Present/ Absent	Density 1 m^2	Size (cm)			Density 1 m^2
		Zone	Easting	Northing			Max	Min	Median	
BBDS1	Q1	50 J	401045	6475541	x	0	0	0	0	0
	Q2	50 J	401036	6475527	x	0	0	0	0	0
	Q3	50 J	401036	6475514	x	0	0	0	0	0
	Q4	50 J	401034	6475501	x	0	0	0	0	0
	Q5	50 J	401032	6475485	x	0	0	0	0	0
	Q6	50 J	401029	6475474	x	0	0	0	0	0
	Q7	50 J	401024	6475460	x	0	0	0	0	0
	Q8	50 J	401016	6475447	x	0	0	0	0	0
BBDS2	Q1	50 J	400913	6475177	x	0	0	0	0	0
	Q2	50 J	400916	6475164	x	0	0	0	0	0
	Q3	50 J	400910	6475145	x	0	0	0	0	0
	Q4	50 J	400904	6475132	x	0	0	0	0	0
	Q5	50 J	400909	6475122	x	0	0	0	0	0
	Q6	50 J	400901	6475114	x	0	0	0	0	0
	Q7	50 J	400890	6475113	x	0	0	0	0	0
	Q8	50 J	400880	6475109	x	0	0	0	0	0
BBDS3	Q1	50 J	401104	6474654	x	0	0	0	0	0
	Q2	50 J	401098	6474649	x	0	0	0	0	0
	Q3	50 J	401099	6474640	x	0	0	0	0	0
	Q4	50 J	401105	6474636	x	0	0	0	0	0
	Q5	50 J	401110	6474632	x	0	0	0	0	0
	Q6	50 J	401110	6474626	x	0	0	0	0	0
	Q7	50 J	401106	6474624	x	0	0	0	0	0
	Q8	50 J	401110	6474619	x	0	0	0	0	0
BBDS4	Q1	50 J	401415	6473948	✓	4	52	60	57.5	0
	Q2	50 J	401424	6473944	✓	17	48	63	58	0
	Q3	50 J	401426	6473935	✓	4	49	57	53	0
	Q4	50 J	401427	6473918	✓	0	0	0	0	2
	Q5	50 J	401423	6473904	✓	4	48	57	55.5	0
	Q6	50 J	401413	6473890	✓	2	60	50	55	0
	Q7	50 J	401407	6473883	x	0	0	0	0	0
	Q8	50 J	401406	6473875	x	0	0	0	0	0

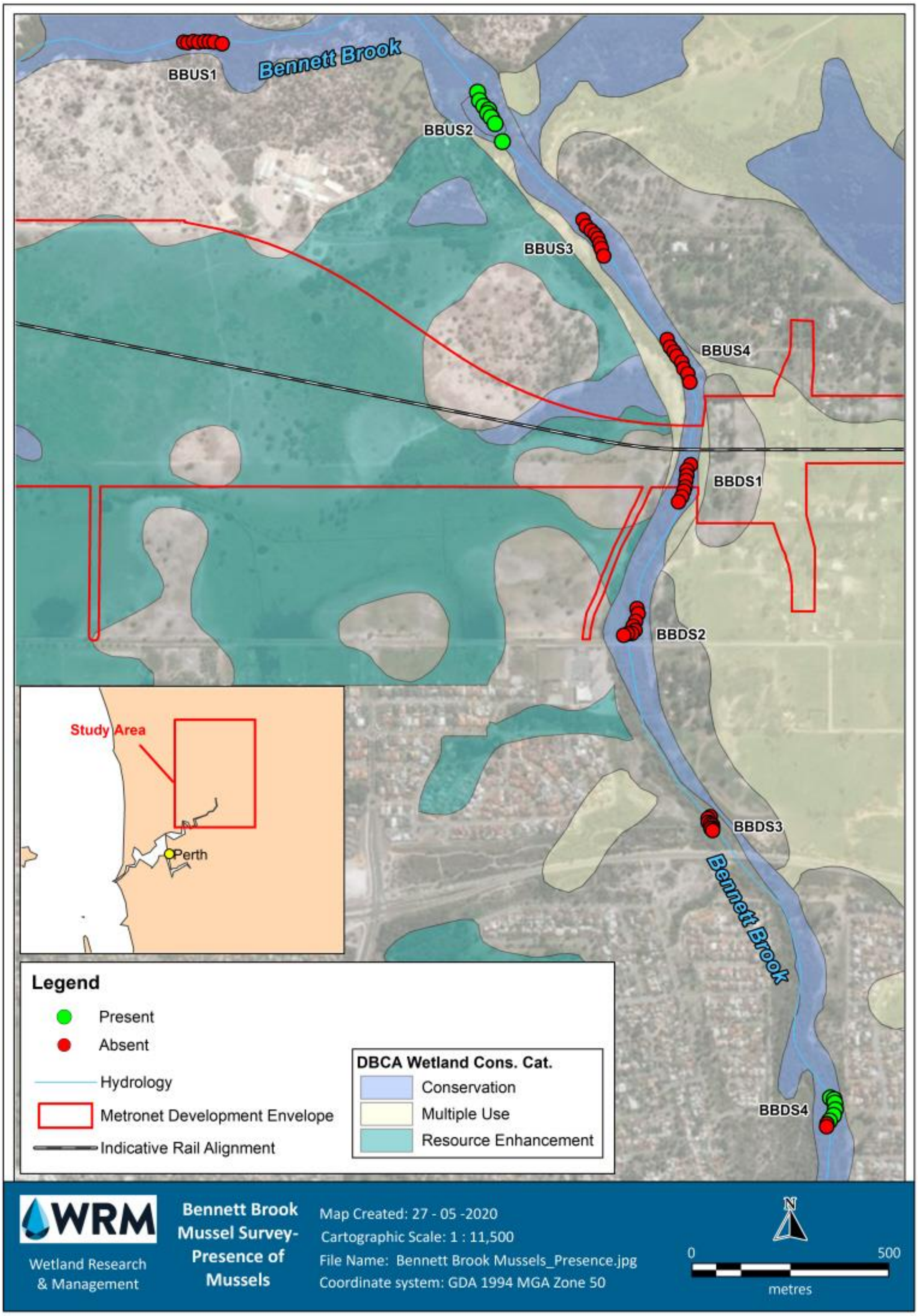


Figure 2. Location of 1 m^2 quadrats at each sampling site on Bennett Brook showing if *W. carteri* were present (live and dead shells), or absent.

4 RESULTS AND DISCUSSION

4.1 Study area and habitat description

Bennett Brook originates in Whiteman Park as a superficial groundwater aquifer, and flows south through the park and suburbs of Bennett Springs, Caversham and Lockridge, joining the Swan River at Bassendean (Figure 1). The section of the brook between WRM's survey site BBUS1 and Marshall Road (includes BBUS1, BBUS2, BBUS3, BBUS4, BBDS1 and BBDS2), which includes the channel area which falls within the MEL Development Envelope (see Figure 2), was almost entirely dry when surveyed on the 30th April/ 1st May 2020, except for water retained in Mussel Pool (BBUS2), a section of creek that has been dammed and retains water through summer (Plate 3). The creek being dry was expected, as this section of the brook only flows seasonally during the winter months after sufficient rainfall has been received within the catchment, typically August through to November. The water level in Mussel Pool (BBUS2) was receded in autumn 2020, due to lack of rainfall, to less than half of its estimated capacity (max depth of approximately 1 m in autumn 2020, see Plate 2). The remaining water inundated a layer of decomposing fine organic matter in a silty, muddy "sludge", which covered the sandy channel bottom.

The Bennett Brook channel at sites BBUS1, BBUS3, BBUS4, BBDS1 and BBDS2, including the area within the Development Envelope (see Figure 2), is shallow (< 1m channel depth to top of bank) and poorly-defined; gently meandering through a paperbark woodland (Plate 4). Roots and grass were growing throughout the channel bed and had compacted the sediment and impeded digging in the quadrats (see methods section). There were no depressions or low lying areas in the creek deeper than ~60 cm, apart from the Mussel Pool dam (BBUS2), and no evidence of recent inundation, such as damp areas, or areas where the leaf litter showed signs of decay from being submerged (i.e. all leaf litter was sitting dry and loose on top of the soil).

Downstream of Marshall Road, between Marshall Road and Reid Highway (which includes BBDS3), surface water was present as a marsh-like reach of inundated grass, bullrush and knotweed, to a depth of approximately 1 m (BBDS3, Plate 5). Sampling using the rake was impeded by the submerged vegetation, fine organic matter and sediment "sludge", and lack of clear areas. A 1mm mesh size D-frame dip net was used to search for mussels in the water. No mussels were detected, however, two Western Pygmy Perch (native fish species; *Nannoperca vittata*) and two mosquitofish (introduced fish species; *Gambusia holbrooki*) were recorded as by-catch.

Downstream of Reid Highway at BBDS4, beneath the footbridge at the end of Patricia Street, Caversham, Bennett Brook was flowing along the bottom of a steep, eastern bank (approximately 2 m high). The width of the inundated channel averaged approximately 1 to 1.5 m, and water depth averaged 0.2 to 0.4 m. The sediment was dominated by sand, with a patchy overlay of silt. The riparian vegetation understory was dense, with a tall overstory of paperbark and flooded gum (Plate 6). Roadworks were underway at the Reid Highway bridge over Bennett Brook, approximately 700m upstream of the footbridge. The patchy siltation observed in the water at BBDS4 may have been related to the Reid Highway roadworks, however, no visual evidence of recent sediment deposition at any point along the BBDS4 transect was observed.

4.2 Distribution of *W. carteri* in Bennett Brook

Live *W. carteri* specimens were recorded at two Bennett Brook sites during the autumn 2020 targeted survey, Mussel Pool (BBUS2) and site BBDS4 (Figure 2, Table 1). All live specimens were sexually mature, exceeding 27 mm in shell length (Klunzinger *et al.* 2014, 2015). *W. carteri* (live specimens or empty shells) was not recorded in any quadrats sampled in the dry sites, and was not detected at BBDS3, the only other site containing water. *W. carteri* may have been present at this site, with sampling efforts impeded by the high density of instream vegetation, or may have been absent, due to lack of preferred sand-silt substrate habitat. No *W. carteri* were detected within Bennett Brook where it is intersected by the MEL Development Envelope (site BBDS1). The habitat in this section appeared unsuitable for *W. carteri*, due to the lack of permanent water and absence of preferred sand-silt substrate habitat.

One live *W. carteri*, at 77 mm shell length, was recorded from Mussel Pool (BBUS2) at Q2 (Table 2). The size of this mussel indicates it may be very old, possibly between 40 to 50 years of age (Klunzinger *et al.* 2014). Empty mussel shells were common along the sandy shoreline of Mussel Pool (BBUS2). At BBDS4, 31 live *W. carteri* were recorded along the 100 m transect, from five out of eight 1 m^2 quadrats. The average population density over 8 quadrats at Mussel Pool (BBUS2) was 0.125 *W. carteri* per 1 m^2, and at BBDS4, 3.875 *W. carteri* per 1 m^2. The high average density recorded at BBDS4 was due to the large number of *W. carteri* recorded at Q2 (17; Plate 7). Excluding this outlying value, the average density of *W. carteri* at BBDS4 was 0.875 per 1 m^2. Shell length at BBDS4 ranged from 48 to 63 mm (all sexually mature individuals, approximately 8 to 50+ years old; see Plate 2), with a median shell length of 57 mm.

The high population density of *W. carteri* at BBDS4, downstream of the Reid Highway roadworks, is of interest, when compared to the apparently low density of living *W. carteri* at Mussel Pool (BBUS2), which is not exposed to upstream earthworks. W. *carteri* were easily seen in the clear flowing water at BBDS4, compared to the turbid water of Mussel Pool (BBUS2), which may have aided detection at the former site by the sampling team. The high number of empty shells observed along the banks of Mussel Pool (BBUS2), containing recently dead and older shells, indicates the resident population may be under stress. It is unknown whether these *W. carteri* died due to exposure to poor water quality, or were victims of predation. No feeding middens, indicating predation by water rats, were observed.

The lower density of living *W. carteri* at Mussel Pool (BBUS2), compared to BBDS4, combined with the high numbers of empty shells along the banks of Mussel Pool (BBUS2), may reflect low water levels experienced over the summer/autumn period and poor water quality as the pool receded (i.e. low oxygen levels, due to the high biochemical oxygen demand of decaying organic matter). Empty shells were not measured for shell length, however, all were at least adult sized (greater than 27 mm in length, Klunzinger *et al.* 2014). The silty/muddy, organic "sludge" covering the sand substrate at Mussel Pool (BBUS2), trapped by the dam, is unlikely to represent a "healthy" habitat for *W. carteri*. Jones and Byrne (2010) found sedimentation and elevated turbidity to be a limiting factor for freshwater hyriids in eastern Australia, with their finding subsequently supported by Klunzinger *et al.* (2012). As filter feeders, high loads of mobilised sediment not only impede filtration and reduce feeding efficiency in freshwater mussels (Klunzinger *et al.* 2015), increased turbidity additionally reduces dissolved oxygen concentration and light penetration to aquatic organisms, including fish hosts of mussel larvae which can influence mussel populations and sustenance. The lower coverage and extent of vegetation in the riparian zone at/surrounding Mussel Pool (BBUS2), compared to BBDS4, may also exacerbate poor water quality through lack of natural stormwater interception (i.e. sedges).

5 POTENTIAL IMPACTS TO *W. CARTERI* ARISING FROM THE MEL PROJECT

No *W. carteri* were detected in Bennett Brook where it is intersected by the MEL Development Envelope, and the habitat in this section appeared unsuitable for *W. carteri*, due to the lack of permanent water and absence of preferred sand-silt substrate habitat. The construction of the rail bridge will likely require some clearing of riparian vegetation within and adjacent to the brook, which may increase runoff of stormwater and increase surface erosion and sedimentation, altering the water and habitat quality of downstream receiving environments, where *W. carteri* was detected. However, if appropriate controls are implemented within/adjacent to the construction zone to control drainage and prevent runoff to the brook, the project would be unlikely to directly impact downstream populations of *W. carteri*, with the nearest known population being approximately 1.7 km downstream of the crossing.

It is not known if construction vehicles will enter and cross the creekline during construction, or if a temporary crossing and culvert will need to be constructed, or if machinery will 'span' the channel when placing the bridge. Any activity that involves physical disturbance of the creek bed during construction will increase the likelihood of erosion, siltation and sedimentation of the brook, and therefore increase the risk to mussel populations downstream, and therefore needs to be appropriately managed. And post-construction, the channel would need to be restored to pre-construction condition, with any fill or culverts removed, and banks stabilised.

Information provided by PTA on the design of the railway bridge that will cross Bennett Brook includes a single span across the brook, and does not include pier placement within the main Bennett Brook channel, or any other structure that would likely pose a barrier to fish passage, and thus dispersal of glochidia of *W. carteri* by fish, within Bennett Brook (ARUP 2019). Flood mapping was conducted to inform the bridge design, with placement of infrastructure suitably placed to prevent significant alterations occurring to the channel structure, in the event of 1% annual exceedance probability (AEP) flood events (ARUP 2019). The bridge design includes multiple relief culverts installed on either side of the bridge span, and large relief culverts installed within the embankments on either side of the bridge span to allow for flow during flood events. These measures will prevent the rail bridge infrastructure from affecting the physical structure and ecological function of Bennett Brook, maintaining current conditions for fish passage and dispersal *of W. carteri* glochidia.

The *W. carteri* at BBDS4, downstream of the Reid Highway bridge roadworks, appeared to be unaffected by this current construction, which is closer in proximity to the population (~700 m upstream) than the proposal MEL rail bridge (~1.7 km upstream). Additionally, the overgrown, dense vegetation growth within the brook at BBDS3, located between the MEL Development Envelope and the *W. carteri* population at BBDS4, may act as a "trap" for suspended sediments and potential contaminants during flowing conditions, thus providing some protection/shelter to the downstream environment at BBDS4. Overall, the potential for direct or indirect impacts arising from MEL project to *W. carteri* within Bennett Brook appears to be low.

6 CONCLUSIONS

A survey targeting Carter's freshwater mussel (*Westralunio carteri*) was conducted at eight sites along Bennett Brook on the 30th April and 1st May 2020 (mid-autumn 2020); four sites upstream, and four sites downstream, of the proposed Morley-Ellenbrook Line (MEL) railway bridge across Bennett Brook, with one site located at the proposed crossing. At each site, eight 1 m^2 quadrats were deployed at 14 m intervals along a 100 m transect and searched for *W. carteri*.

Water was present at three of the eight sites in mid-autumn 2020, at one upstream site (BBUS2; Mussel Pool), and two downstream sites (BBDS3 and BBDS4). *W. carteri* was detected at Mussel Pool (1 live specimen and many empty shells), and BBDS4 (31 live specimens). *W. carteri* was not detected at BBDS3, the only other site containing water, nor any of the sites that were dry (BBUS1, BBUS3, BBUS4, BBDS1 and BBDS2). No water was present within Bennett Brook where it is intersected by the MEL Development Envelope and no *W. carteri* were detected at this location (along the BBDS1 transect).

No habitat suitable/preferable to *W. carteri* was present within Bennett Brook where it passes through the MEL Development Envelope, with this area lacking any semi-permanent/permanent pools or flowing water with a sandy substrate. Construction of the rail bridge will likely require some clearing of riparian vegetation within and adjacent to the brook, which may affect water and habitat quality in downstream receiving environments through erosion, siltation and sedimentation, and this has potential to affect populations of *W. carteri* further downstream. Similarly, any physical alteration of the channel bed during construction has potential to affect downstream populations. However, if appropriate controls are implemented within/adjacent to the construction zone to control drainage and prevent runoff to the brook, prevent erosion and siltation, the project would be unlikely to directly impact downstream populations of *W. carteri*, which are approx. 1.7 km downstream. Information provided to WRM on the design considerations for the MEL Bennett Brook rail bridge indicate the infrastructure will not impact the physical structure and ecological function of Bennett Brook in 1% AEP flood events, maintaining current conditions for fish passage and *W. carteri* glochidia dispersal. Overall, the potential for direct or indirect impacts arising from MEL project to *W. carteri* within Bennett Brook appears to be low.

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