

406800

407000

407200

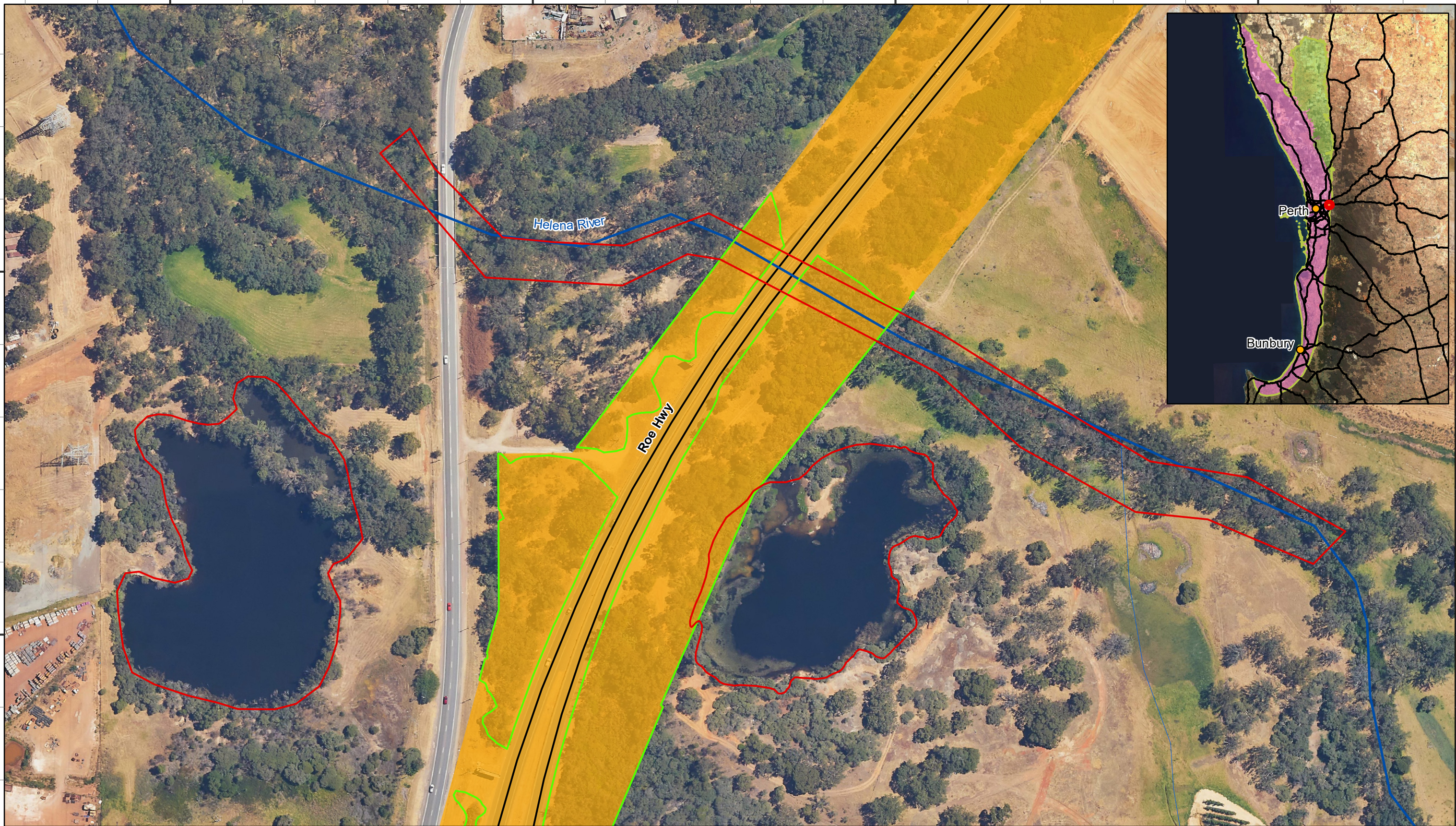
407400

6469600

6469600

6469400

6469400



**Legend**

- Survey Area
- NVCP Area
- Development Envelope
- State Road

**Surface Hydrology**

- Minor
- Major

**IBRA Region**

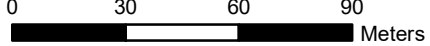
- Swan Coastal Plain

**IBRA Subregion**

- Dandaragan Plateau
- Perth



Scale: 1:2,000



Coordinate System: GDA2020 MGA Zone 50  
 Projection: Transverse Mercator  
 Datum: GDA2020 Created 23/11/2022



**MAIN ROADS WA**  
**Great Eastern Highway Bypass Interchanges Project: Targeted Carter's Freshwater Mussel Survey**

**Figure 1.2: Survey Area and regional location**

## 1.2 Carter's freshwater mussel

Carter's freshwater mussel (*Westralunio carteri*) is an Australian hyriid mussel endemic to south-west Western Australia. Until recently, it was considered the only species of Hyriidae which inhabits this region, and the only member of the genus *Westralunio* to occur in Australia. Molecular and morphometric analyses has since found three evolutionary significant units within populations of this species (Klunzinger & Kirkendale, 2022). As a result, *Westralunio carteri* was redescribed from western coastal drainages, while *Westralunio inbisi* sp. nov. has now been described, representing two subspecies (*Westralunio inbisi inbisi* from southern coastal drainages, and *Westralunio inbisi meridiemus* from the southwestern corner) (Klunzinger & Kirkendale, 2022).

Carter's freshwater mussel is currently listed as Vulnerable on State, Federal and International conservation lists (WA *Biodiversity Conservation Act 2016*, *Environment Protection and Biodiversity Conservation Act 1999*, and IUCN Red List of Threatened Species) (see Appendix A for a description of conservation categories). However, this is likely to change in light of the recent taxonomic changes and subsequent reduction in range of *Westralunio carteri*.

Historically, the distribution of Carter's freshwater mussel extended from the Moore River in the north, inland to the Avon and Blackwood Rivers, and south to the Bow River (Klunzinger, 2012). This historic range has reportedly reduced by 49%, with its distribution lying between Gingin Brook in the north and the Kent River in the south (Klunzinger *et al.*, 2015), and two outlying populations existing in the Goodga and Waychincup Rivers. The redescription of Carter's freshwater mussel has since reduced this range, with its current distribution between Gingin and to the north and west of the Blackwood River, within 150 km of the coast (Klunzinger & Kirkendale, 2022). The reduction in range and continuing population decline led to its current conservation listing as Vulnerable (Klunzinger & Walker, 2014), though it is expected this conservation listing will require reassessment.

Like other freshwater bivalves, Carter's freshwater mussel is a slow-growing, long-lived species. Maximum age is 52 years and sexual maturity is reached at approximately six years (and ~27 mm in length). Maximum size has been reported to be 82.8 mm in some populations (Klunzinger *et al.*, 2014).

Carter's freshwater mussel are typically dioecious, though hermaphrodites have occasionally been recorded (Klunzinger *et al.*, 2014). They have an obligate parasitic larval stage (glochidia), which attach to host fish and are transported and deposited into suitable sediment as post-parasitic juvenile mussels. As such, mussels are only recorded where fish are present. Little is known about the juvenile stage, though they would require stable sediment to avoid being swept away by currents (Klunzinger, 2012). Carter's freshwater mussels require sediment that is firm but penetrable (i.e., sand). They are generally absent from sediments that are too soft or too compact (i.e., clay and bedrock).

The greatest threats to Carter's freshwater mussel come from salinisation and drying of water systems. Carter's freshwater mussels have an acute sensitivity to salinity, with a maximum tolerance of 3.5 ppt under lab conditions and are rarely found in water greater than 1.6 ppt (Klunzinger, 2012; Klunzinger *et al.*, 2012b; Klunzinger *et al.*, 2015). Carter's freshwater mussel also cannot survive exposure to direct

sunlight or heat, and do not aestivate, so cannot persist in non-perennial water systems (Klunzinger, 2012). These threatening processes also adversely impact native fish populations in the south-west (Beatty *et al.*, 2011; Morgan *et al.*, 1998; Morgan *et al.*, 2003), leading to further decline in mussel populations due to loss of host fish species (Klunzinger, 2012). High turbidity and suspended solids can also negatively impact the filtration ability of freshwater mussels (Klunzinger, 2012).

## 2 METHODS

### 2.1 Assessment of Occurrence

The likelihood of Carter's freshwater mussel occurrence within the Survey Area was assessed using a decision matrix (Table 2.1). The decision matrix considers habitat suitability and proximity of previous records. This information was used to assign a likelihood of occurrence.

**Table 2.1: Carter's freshwater mussel likelihood of occurrence decision matrix.**

		Habitat categories (within Survey Area)			
		Core/critical habitat present	Feeding /Dispersal habitat present	Marginal/ intermittent habitat present	No suitable habitat present
Range/occurrence categories	Recorded in Survey Area	Confirmed	Confirmed	Confirmed	Confirmed
	Recorded within < 2 km	Highly Likely	Likely	Possible	Possible
	Recorded within 2-5 km	Likely	Possible	Possible	Unlikely
	Recorded within 5 -20 km	Possible	Possible	Unlikely	Unlikely
	Recorded > 20 km	Possible	Unlikely	Unlikely	Highly Unlikely
	Species considered locally/regionally extinct	Unlikely	Unlikely	Highly Unlikely	Highly Unlikely

### 2.2 Legislation and guidance

There is currently (November 2022) no technical guidance in Australia applicable to targeted surveys for freshwater mussels, but surveys undertaken by Biologic follow best practice and employ sampling design, methods, and general approaches consistent with the following:

- Recommended Methodology for Monitoring Freshwater Mussels (provided to Main Roads by DWER);
- New Zealand Regional Guidelines for Adult Freshwater Mussel Monitoring (Catlin *et al.*, 2017);
- Australian and New Zealand Guidelines for Fresh and Marine Water (ANZG, 2018);
- Environmental Factor Guideline, Inland Waters (EPA, 2018);
- Technical Guidance, Sampling of SRE Invertebrate Fauna (EPA, 2016a);

- Technical Guidance, Terrestrial Fauna Surveys (EPA, 2016b); and
- Similar mussel surveys, including (Klunzinger *et al.*, 2011), Klunzinger *et al.* (2012a) and WRM (2020), as well as previous Biologic surveys for Main Roads (Biologic, 2020, 2021).

## 2.3 Field survey

### 2.3.1 Survey team

The targeted survey was conducted by Principal Aquatic Ecologist Jess Delaney, Senior Aquatic Ecologist Kim Nguyen, and Aquatic Ecologist Siobhan Paget. Jess and Kim have a combined experience of over 30 years undertaking aquatic ecosystem surveys throughout Western Australia, including targeted fauna surveys in the Perth Metropolitan Area and south-west region. Fauna sampling was conducted under a DBCA Authorisation to Take or Disturb Threatened Species (TFA 2223-0045) (Appendix D), and a DPIRD Instrument of Exemption to the *Fish Resources Management Act 1994 Section 7 (2)* (EXEM 3386), both issued to Jessica Delaney.

### 2.3.2 Survey timing and weather

An initial visit to the Survey Area on the 10<sup>th</sup> of August 2022 found the river in flood, with turbid, fast-flowing water. Conditions were deemed unsuitable for sampling at this time. Therefore, the field survey was rescheduled to the 31<sup>st</sup> of August 2022 to allow sufficient time following heavy winter rainfall and flooding throughout the area. Maximum ambient temperature at the time of survey was 21.0 °C, which was 1.9 °C warmer than the long-term average for August (BoM, 2022). There was no rainfall on the day or immediately preceding the survey; however, 7 mm was recorded the week prior (BoM, 2022). Water levels had dropped considerably by the time of the targeted survey.

### 2.3.3 Water quality

In situ water quality was measured using a portable YSI Pro Plus multimeter. Parameters recorded included pH, redox potential (redox; mV), electrical conductivity (EC;  $\mu\text{S}/\text{cm}$ ), dissolved oxygen (DO; mg/L and % saturation), and water temperature (°C). Spot measurements were taken from five locations within the Helena River, four locations within Wetland West, and three locations in Wetland East. Water quality measurements were undertaken in quadrats where mussels were recorded, as well as in other areas to provide adequate coverage of the Survey Area and water quality characteristics throughout.

### 2.3.4 Habitat assessment

As Carter's freshwater mussel are often found partially to fully submerged in fine sediment, a visual assessment of benthic sediment characteristics was undertaken within the Survey Area. Percentage cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt, and clay was recorded. Sediment data assisted in explaining distribution patterns and the presence/ absence of mussels. Observations of the presence of vegetation in-stream (submerged and emergent macrophytes), water depth, and overhanging riparian vegetation were also made.

### 2.3.5 Mussel sampling

Carter's freshwater mussels were targeted using several methods to increase the likelihood of recording individuals, if present, with factors such as access, water depth, and salinity taken into account. Sampling methods included hand searching, mussel raking and dip nets, targeting areas of optimum habitat (Plate 2.1). Sampling was undertaken throughout the approximate 500 m stretch of the Helena River (including ~215 m upstream and ~200 m downstream of the NVCP application area), up to wadable depth, checking benthic sediments, especially in and around large woody debris, for evidence of mussels. The areas beneath the Roe Highway and Military Road were included in the Survey and searched extensively. Within each wetland, the perimeter was searched in all areas that were safely accessible. The south-western edge of Wetland West was unable to be successfully searched due to the steep banks and high water depth in this area. GPS track logs were recorded during the survey to attest to sampling effort expended (see Figure 3.2 in section 3.2).



**Plate 2.1: Using a mussel rake to search within a quadrat at Wetland East (left), and hand searching for mussels in the Helena River (right).**

A minimum of ten 1 m<sup>2</sup> quadrats were deployed per site (Helena River, Wetland West, and Wetland East) on benthic sediments. Where present, mussel density (individuals/m<sup>2</sup>) was determined using established methods to quantify density and population structure of Carter's freshwater mussel in south-west Western Australian rivers (Klunzinger *et al.*, 2012a; Klunzinger *et al.*, 2012b). Habitat assessments were undertaken within each quadrat.

All mussels recorded were measured for maximum length (ML) and maximum width (MW) using vernier callipers (Plate 2.2). While growth rates can be highly variable across populations of different river systems, field observations reported by others indicate sexual maturity at 27 mm ML (Klunzinger *et al.*, 2014). Therefore, individuals greater than 27 mm ML were considered to be adults in the current study. All mussels were returned alive at the site of capture. Empty shells (i.e., dead mussels) were recorded, but not included in abundance counts or density calculations.



**Plate 2.2: Measuring Carter's freshwater mussel (ML in mm).**

## 2.4 Data analysis

### 2.4.1 Water quality

In situ water quality data were compared against the ANZG (2018) default guideline values (DGVs) for the protection of aquatic ecosystems in the south-west of Western Australia (see Appendix B for default values). The primary objective of the guidelines is to “provide authoritative guidance on the management of water quality in Australia and New Zealand .... and includes setting water quality and sediment quality objectives designed to sustain current, or likely future, community values for natural and semi-natural water resources” (ANZG, 2018). DGVs are provided for a range of parameters designed to protect aquatic systems at a low level of risk. Water quality was compared against the existing DGVs for lowland rivers and/or wetlands within the south-west (ANZG, 2018). Water quality data provides information on the suitability of habitats within the Survey Area to support Carter's freshwater mussel.

## 2.5 Assumptions and limitations

The survey was undertaken by qualified personnel with considerable experience in targeted aquatic fauna surveys. Potential limitations and constraints are summarised in Table 2.2.

**Table 2.2: Summary of assumptions and limitations in relation to the current survey.**

Potential limitation or constraint	Constraint (Yes / No)	Applicability to this survey
Experience of personnel	No	The Principal and Senior Aquatic Ecologists who undertook the survey have a combined experience of over 30 years undertaking targeted invertebrate fauna surveys, with direct and relevant experience leading surveys in the southwest region. The team leader has over 20 years' experience in aquatic invertebrate surveys, including targeted surveys for freshwater mussels.
Scope (faunal groups sampled and whether any constraints affect this)	No	<p>The scope was to undertake a field survey to determine the presence of Carter's freshwater mussel within the vicinity of proposed development envelope for the GEHB Interchanges Project.</p> <p>The survey was undertaken over a short period, limiting the survey effort to a single search event. A third zoologist provided field assistance to ensure adequate coverage of the Survey Area within the short time frame. Therefore, coverage of available habitat was not considered a limiting factor.</p>
Proportion of aquatic fauna identified	No	No constraint.
Sources of information (recent or historic) and availability of contextual information	No	All relevant databases and literature were previously consulted by Main Roads. Additional desktop work was not part of the current scope.
Proportion of the task achieved	No	<p>The upstream section of the Helena River was not surveyed as originally proposed due to time restrictions; however, this was not considered a constraint. This is because the inclusion of this reference site was only necessary in the event that Carter's freshwater mussel was not recorded within the Survey Area, to confirm the lack of records was due to absence of the target fauna from the area, and not due to lack of survey effort.</p> <p>The south-western edge of Wetland West was unable to be successfully searched due to the steep banks and high water depth in this area. This was considered a minor constraint, as the majority of the task was still able to be achieved.</p>

Potential limitation or constraint	Constraint (Yes / No)	Applicability to this survey
Disturbances (e.g. fire or flood)	No	There were no recent fires which posed a constraint to sampling effort. The survey was originally scheduled for early to mid-August, but the Helena River was in flood at that time, with high flows impeding access for sampling. Therefore, the survey was rescheduled to a later date, when conditions were more conducive to sampling. When the targeted survey was undertaken in late August, the river and wetlands had receded sufficiently to allow access to the majority of the Survey Area, though some sections were still quite high from recent flooding. Despite this, recent fires and floods were not considered to pose a limitation to the survey given Carter's freshwater mussel were recorded. It may, however, have limited the ability to accurately assess total abundance within the Survey Area.
Intensity of survey	No	Search effort for Carter's freshwater mussel was considered sufficient throughout the Survey Area, particularly as an epifaunal species that sits on or just beneath the benthic surface. Survey timing was not considered a limitation, as Carter's freshwater mussel are not highly mobile and require permanent water to persist. This is unlike other freshwater fauna in the south-west, such as fish that are more likely to be detected during seasonal inundation of pools, or during very specific breeding periods.
Completeness of survey	No	The survey was adequately completed to meet the requirements of a targeted aquatic fauna survey.
Resources (e.g., degree of expertise available)	No	All resources required to complete the survey were available.
Remoteness or access issues	No	There were no access restrictions at GEHB. Although a gate key could not be provided to access Wetland West at the time of the survey, the wetland was safely accessed by crossing underneath the bridge at Military Road on foot.



### 3 RESULTS

#### 3.1 Likelihood of Occurrence

Results from the desktop assessment by Biota (2021), and findings by DWER (via Main Roads, pers. comms.), were used to assess the likelihood of occurrence of Carter's freshwater mussel in the Survey Area. Nearby previous records from surveys relevant to the Survey Area (Klunzinger *et al.*, 2011; WRM, 2010, 2011) and recent database results (DBCA, 2020; DWER, 2022) have been provided in Figure 3.1 for context. Nearby survey sites where mussels were not recorded (Biologic, 2020; DWER, 2022) have also been provided to show indicative survey effort within the Helena system. Likelihood of occurrence was considered Highly Likely at all sites based on distance to the nearest historical record, age of record, and potential for suitable habitat (Table 3.1). Although confirmed records exist for Wetland East, a more current assessment was required to confirm that Carter's freshwater mussels were still present, given the last known records were nine years old.

**Table 3.1: Likelihood of occurrence for Carter's freshwater mussel at each site.**

Site	Within Current Known Distribution	Distance to Nearest Record - Year	Potential Habitat Within Survey Area	Likelihood of Occurrence
Helena River	Yes	~60 m – 2013 (Wetland East)	Yes	Highly Likely
Wetland West	Yes	~275 m – 2013 (Wetland East)	Yes	Highly Likely
Wetland East	Yes	Within Site – 2013	Yes	Highly Likely

#### 3.2 Survey

##### 3.2.1 Survey effort

The Survey Area included the banks of Wetland East and Wetland West, and throughout the approximate 500 m stretch of the Helena River, up to wadeable depth. Track logs from the survey show the areas assessed and sampling effort expended (Figure 3.2). A total of 13 quadrats were undertaken within the Helena River, ten within Wetland East, and 13 within Wetland West. Opportunistic searches (hand searching and mussel raking) were undertaken across all areas which were able to be safely accessed outside of the quadrats, across the Survey Area.

At the time of survey, recent flooding within the river had receded, though the water level was still high in some sections. At Wetland West, the south-west margins could not be surveyed due to the steep banks which precluded safe access. Where possible, steeper sections were searched from dry land using mussel rakes.