Fauna Management Plan for the Vasse Diversion Drain Upgrade

August 2020

Bamford Consulting Ecologists

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2. Introduction

Water Corporation intends to upgrade the Vasse Diversion Drain (VDD) for flood mitigation in Busselton from November 2020 until June 2020. The drain diverts water from the Vasse and Sabina Rivers. This widening will alter the drain itself, some fringing remnant vegetation and associated fauna which inhabit this area, including species of conservation significance.

As the *Terrestrial Fauna Subject Matter Experts* for the project, Bamford Consulting Ecologists (BCE) has been asked to prepare a Fauna Management Plan (FMP) to provide guidance for the mitigation of impacts upon the fauna assemblage. Mitigation of impacts is consistent with the objective of the WA Environmental Protection Authority (EPA) with respect to development and fauna which is to: "*protect terrestrial fauna so that biological diversity and ecological integrity are maintained*" (EPA, 2018). BCE has extensive fauna management experience in this area, particularly with the Critically Endangered Western Ringtail Possum (WRP).

2.1. Site Description

The VDD was constructed in the 1920s to improve drainage and increase arable land in the catchment. The drains current, primary purpose of the drain is for flood protection for the City of Busselton. The VDD runs from north of the Busselton golf course which lies south-east of Busselton, through farmland and then into urban areas, under the Bussell Highway and entering the ocean approximately 5km west of Busselton town centre (Figure 1).

Two sections of the drain have been the focus of fauna investigations and can be considered the project area (Figure 2). These are areas where native vegetation is present in varying condition.

- The south-eastern section lies in farmland and is at the confluence of the Vasse River, a culvert exists between the Diversion drain and the Lower Vasse River There is some remnant riparian vegetation along the Vasse River, and some limited upland vegetation (primarily trees over a completely degraded understorey) along the drain.
- The northern area lies between the Busselton Bypass and Bussell Highway, passing through an urban landscape, with remnant native vegetation both along the drain and in adjacent blocks. Vegetation along the drain is most extensive on the south side of the drain. Adjacent blocks of remnant vegetation are largest close to the Busselton Bypass Road (south of the drain), and in two locations north of the drain. One of these northern blocks neighbours a light industrial area and provides connectivity to The Broadwater, while the other (further west) connects with bushland in the grounds of a school providing some connectivity to vegetation along The Broadwater.

The main components of the VDD upgrade works relevant to the FMP are:

- Reconstruction and upgrade of the Vasse Diversion Dam (VDD).
- Construction of an overflow structure upstream of the VDD, identified as the Vasse River Overflow Structure (VROS).
- Full reconstruction of the VDD levee banks with compacted clay-core levee.

The project location is shown in Figure 1.

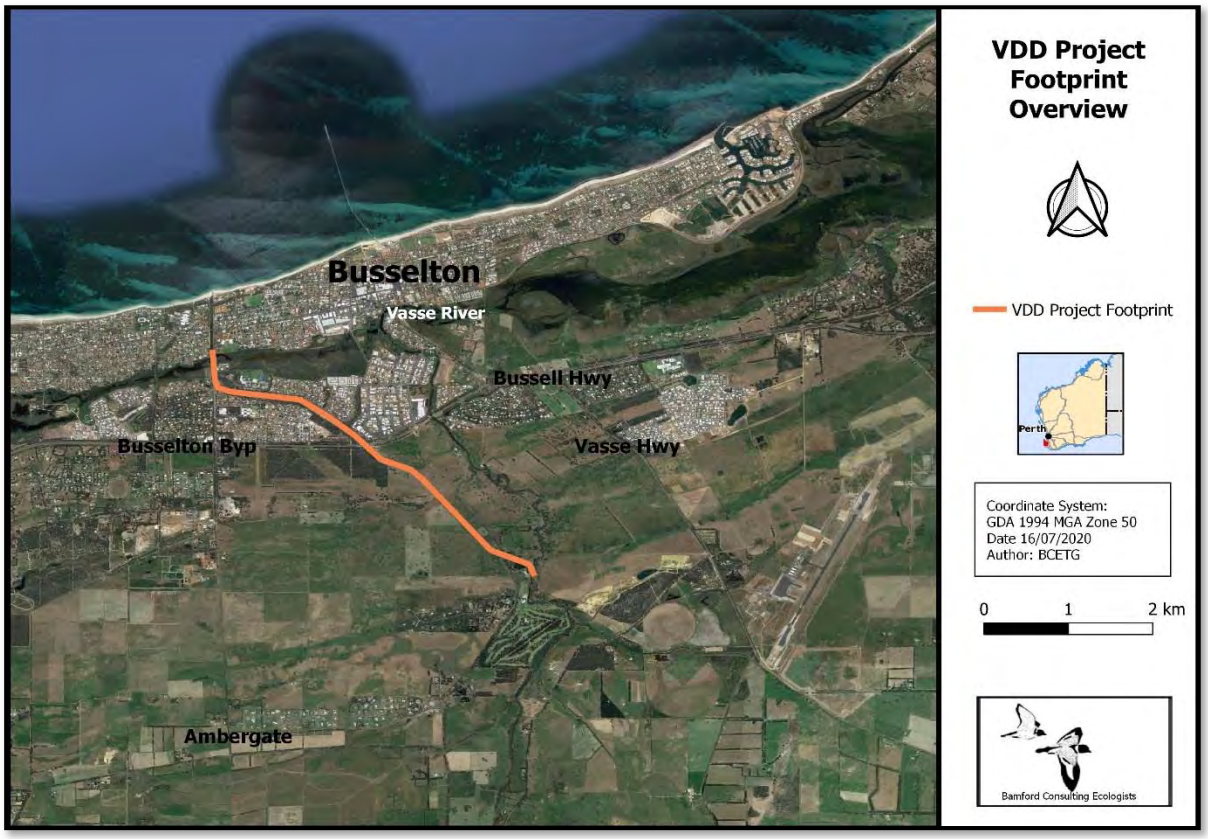

Figure 1. The Vasse Diversion Drain upgrade (orange line) works in relation to Busselton.

Figure 2. The Vasse Diversion Drain. Fauna investigations were carried out in the areas encircled by red; referred to as the northern area and the south-eastern area in the text.

2.2. Relevant Legislation/Definitions

Protection of fauna in Western Australia and the objectives of the EPA are guided by the *WA Biodiversity Conservation Act (2016)* (WABC Act). In addition, the management of and the assessment of impacts on some species comes under the Federal *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act), where species are listed as Matters of National Environmental Significance (MNES). The WA Department of Biodiversity, Conservation and Attractions (DBCA) also has a list of Priority species which are species of some conservation interest or concern but which are not currently considered to warrant formal listing under legislation. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

'Conservation significant fauna' and 'threatened fauna' are defined as those listed as critically endangered, endangered, vulnerable or migratory under the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act), or as a Scheduled species in accordance with the *Biodiversity Conservation Act (2016)* (WABC Act). As there are multiple categories under legislation, and four levels of Priority, it is useful to recognise two classes of conservation significance:

- Conservation Significance (CS) 1: species listed under State or Commonwealth Acts. Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. *Biodiversity Conservation Act (2016)* (WABC Act) uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).
- Conservation Significance (CS) 2: are species listed as Priority by the DBCA but not listed under State or Commonwealth Acts. There are four levels of priority.

Species of national conservation significance listed under the EPBC Act are classified as:

- Critically Endangered - If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future.
- Endangered - If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
- Vulnerable - If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.
- Four classes (Schedules 1-4) of rare and endangered fauna are recognised under the WABC Act. Three other classes (Schedules 5-7) recognised under the Act are relevant to this plan. These are:
- Schedule 1: Fauna that is rare or likely to become extinct as critically endangered fauna (CR).
- Schedule 2: Fauna that is rare or likely to become extinct as endangered fauna (EN).
- Schedule 3: Fauna that is rare or likely to become extinct as vulnerable fauna (VU).
- Schedule 4: Fauna presumed to be extinct (EX).
- Schedule 5: Migratory birds protected under an International Agreement (IA).
- Schedule 6: Fauna that is of special conservation need as conservation dependent fauna (CD).

- Schedule 7: Other specially protected fauna (OS).

2.3. Project Specific Conditions of Approval

This project has been assessed Bilaterally by the DWER Native Vegetation branch under Part V of the EP Act [WA] and by AWE under the EPBC Act 1999 [cwth].

2.3.1. *Environmental Protection and Biodiversity Conservation Act 1999* [Cwth]

The project was referred under the *EPBC Act* (Cwth). The project is a '*Controlled Action*,' all activities must be undertaken in compliance with conditions set in the EPBC 2017/7932 Approval Conditions.

Table 1: EPBC 2017/7932 environmental approval conditions specific to fauna

Ref	Requirement	Comments
1	To minimise impacts to EPBC Act listed species, the approval holder must: a. not clear more than 2.16 hectares (ha) of Western Ringtail Possum habitat within the project area (hatched blue in Attachment A); b. comply with and implement the conditions of the clearing permit CPS 8191/1 or as varied from time to time; and c. notify the Department in writing of any variations of the conditions of clearing permit CPS 8191/1 within 10 business days of such a change being approved by the State Government.	See the *Construction Environmental Management Framework* *CD00116 - Vasse Diversion Drain Upgrade* (Water Corporation 2020)
2	To avoid and mitigate impacts to the Western Ringtail Possum, the approval holder must: a. Implement condition 13 (a) of the clearing permit CPS 8191/1 and identify all dreys within the project area to be cleared. The approval holder must provide the Department within 2 months of all clearing activities being completed the records identified in condition 13 (c) of the clearing permit CPS 8191/1 including the location of all dreys to be cleared; b. implement condition 15 of the clearing permit CPS 8191/1 by installing a minimum of 12 nest boxes suitably designed and constructed for use by Western Ringtail Possum for at least 10 years. If the action results in the removal of more than six dreys as identified in condition 2 (a), the approval holder must install another two nest boxes suitably designed, constructed and installed for use by Western Ringtail Possum for at least 10 years for each additional drey removed. Installation and placement of the of nest boxes must be in accordance with written advice from a suitably qualified ecologist; c. implement condition 14 of the clearing permit CPS 8191/1 by installing a minimum of six rope bridges. The installation and placement of the rope bridges must be in accordance with written advice from a suitably qualified ecologist;	The Corporation has engaged BCE to assist with compliance with this condition.

Ref	Requirement	Comments
	d. reposition rope bridges and nest boxes in accordance with written advice from a suitably qualified ecologist if they are not being utilised by Western Ringtail Possum within six months of installation; and e. annually inspect the condition, monitor use by Western Ringtail Possum and, as advised by a suitably qualified ecologist, maintain and repair for at least 10 years any rope bridge and/or nest box that is not currently suitable for use by Western Ringtail Possum.	
3	The approval holder must maintain the following records and provide them to the Department within two months of the completion of installation and repositioning of rope bridges and nesting boxes: a) the dates and locations where all rope bridges and nest boxes for Western Ringtail Possum (required under condition 2 and the clearing permit CPS 8191/1) were installed or repositioned; b) an in-situ photograph of each rope bridge and nest box installed or repositioned; and c) evidence that the design, installation and placement of each rope bridge and nest box is in accordance with the written advice of suitably qualified ecologist. The approval holder must include in each compliance report required under condition 14 details of the findings of each inspection of the installed and repositioned rope bridges and nest boxes and any repairs or maintenance undertaken and the level of use of each by Western Ringtail Possum.	The Corporation has engaged BCE to assist with compliance with this condition.
4	The approval holder must notify the Department within two business days if any Western Ringtail Possum is killed or injured and requiring care as a result of the action.	The Corporation has engaged BCE to assist with compliance with this condition.
8	To compensate for the residual significant impacts on the Western Ringtail Possum, the approval holder must implement condition 17 of the clearing permit CPS 8191/1.	Outside the scope of this document. See *Vasse Diversion Drain Upgrade: Revegetation Plan* Tranen Revegetation Southwest (2020).

2.3.2. Part V, *Environmental Protection Act 1986* [WA]

The Corporation has been granted a Purpose Permit under Part V of the *EP Act* (WA) for project activities. All activities must be undertaken in compliance with conditions set in the DWER Purpose Permit CPS 8191/1.

Table 2: Environmental conditions specific to DWER Purpose Permit CPS8191/1

Ref	Requirement	Responsibility
11	**Fauna Management – Other approvals** Prior to clearing, the Permit Holder must provide to the CEO: a) a copy of the fauna licence(s) obtained under the *Biodiversity Conservation Act 2016* for the relocation and/or translocation of Carter's Freshwater Mussel (*Westralunio carteri*) and the dispersion of Western Ringtail Possum (*Pseudocheirus occidentalis*) individuals; and b) a copy of the approved exemption from the Department of Primary Industries and Regional Development under the *Fish Resources Management Act 1994* and *Fish Resources Management Regulations 1995* for the collection of Carter's freshwater mussel for translocation.	Permits will be obtained by qualified Subject matter experts on behalf of the Corporation.
12	**Fauna management – Carter's Freshwater Mussel** a) Prior to commencement of any clearing activities authorised under this Permit, the Permit Holder must submit a Carter's Freshwater Mussel (*Westralunio carteri*) Management Plan to the CEO for approval. The management plan must contain the following: (i) Removal, transportation and relocation method, and where required, temporary storage method; (ii) ii) Location of the relocation site, including a field assessment confirming the suitability of the relocation site; (iii) iii) Stocking densities; and (iv) iv) The success rate monitoring plan.	Refer to *Vasse Diversion Drain Upgrade Project Westralunio carteri Management Plan (*IndoPacific 2020)
13	Fauna management – western ringtail possum a. In relation to the area cross-hatched yellow on attached Plans 8191/1a and 8191/1b, the Permit Holder must engage a fauna specialist to inspect that area, including all trees and tree hollows present, within 24 hours prior to, and for the duration of clearing, for the presence of Western Ringtail Possum(s) (*Pseudocheirus occidentalis*). b. Clearing must cease in any area where fauna referred to in condition 13(a) above are identified until the western ringtail possum(s) has moved out of the development area to adjoining suitable habitat(b). c. Where fauna is identified under condition 13(a) of this Permit, the Permit Holder must provide the following records to the CEO as soon as practicable: (i) the number of individuals identified; (ii) the date each individual was identified; (iii) the location where each individual was identified recorded using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees; (iv) (iv) the number of individuals displaced; (v) the relevant qualifications of the fauna specialist undertaking the displacement; (vi) the date each individual was displaced; (vii) the method of dispersal; (viii) the date each individual was dispersed;	The Corporation has engaged BCE to assist with compliance with this condition.

Ref	Requirement	Responsibility
	(ix) the location where each individual dispersed to, recorded using a GPS unit set to GDA94, expressing the geographical coordinates in Eastings and Northings or decimal degrees; and (x) details pertaining to the circumstances of any death of, or injury sustained by, an individual.	
14	Fauna management – Western Ringtail Possum rope bridges Prior to commencement of any clearing activities authorised under this Permit, the Permit Holder must at a minimum install six rope bridges within the area cross-hatched red on the attached Plan 8191/1c, in accordance with the following requirements: (i) the end of each rope bridge must be connected to at least two mature trees, or two different locations in the canopy of a single mature tree, at a height of at least three metres above ground level; (ii) the rope bridges must be placed in areas that provide canopy connectivity for western ringtail possum movement across the local area, i.e. across roadways and other gaps in the canopy; (iii) be monitored annually and maintained for a period of at least ten years; and (iv) Within two months of undertaking any clearing authorised under this Permit within the combined areas cross-hatched yellow on Plan 8191/1a and 8191/1b, the Permit Holder must provide to the CEO, the locations where each rope bridge was placed using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees.	The Corporation has engaged BCE to identify suitable locations. Tranen Revegetation Southwest will facilitate the installation of the rope bridges.
15	Prior to commencement of any clearing activities authorised under this Permit, the Permit Holder must, at a minimum, install 12 nest boxes within the area cross-hatched red on the attached Plan 8191/1c, in accordance with the following requirements: (ii) be designed and placed in accordance with the specifications detailed in the Project Revegetation Plan required by condition 17(a); (iii) be placed at least three metres above ground level in a mature tree facing the shadiest side of the tree; (iv) be monitored annually and maintained for a period of at least ten years; and (v) within two months of undertaking any clearing authorised under this Permit within the combined areas cross-hatched yellow on Plan 8191/1a, the Permit Holder must provide to the CEO, the locations where each nest box was placed using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees.	The Corporation has engaged BCE to identify suitable locations. Tranen Revegetation Southwest will facilitate the installation of the fauna shelters.
16	Within 12 months of the commencement of clearing, the Permit Holder must undertake revegetation within 0.55 hectares of the area hatched red on attached Plan 8191/1d in accordance with condition 17 of this permit.	Outside the scope of this document. See *Vasse Diversion Drain Upgrade: Revegetation Plan* Tranen Revegetation Southwest (2020).

Ref	Requirement	Responsibility
17 (c) (ii)	Offset – revegetation and rehabilitation c) The Project Revegetation Plan must include the following: (ii) deliberate planting of native vegetation that will provide suitable habitat(b) for western ringtail possum;	Outside the scope of this document. See *Vasse Diversion Drain Upgrade: Revegetation Plan* Tranen Revegetation Southwest (2020).

2.3.3. *Biodiversity Conservation Act 2016* [WA]

In addition to approval under the EP Act, fauna disturbance and relocation proposed in this Fauna Management Plan requires Ministerial Authorisation under section 40 of the *Biodiversity Conservation Act 2016* (BC Act) to relocate Western Ringtail Possums, and a Fauna taking (relocation) licence under regulation 28 of the *Biodiversity Conservation Regulations 2018* to relocate non-threatened fauna (Quenda, Rakali and herpetofauna).

2.3.4. Other Legislation

The project is not considered to trigger referral to the Environmental Protection Authority under Section 38, *EP Act* (WA). The project is not considered likely to generate significant risk of causing environmental harm.

3. Existing Studies and Investigations

Several studies into the fauna of the VDD (Figure 2) have been undertaken; key investigations have been carried out by GHD (2017) and Bamford Consulting Ecologists (2019). The focus of these investigations was on species of conservation significance and species found to be present or predicted to be present based upon environmental assessment and known distributions. These are discussed in Section 3.1 to 3.6.

Additional surveys to determine the distribution and density of *Westralunio carteri* (Carter's Freshwater Mussel) were undertaken by Murdoch University (2019) and IndoPacific (2019). A separate management plan has been prepared for the management and relocation of Carter's mussels in the drain (IndoPacific 2020).

3.1. Western Ringtail Possum (*Pseudocheirus occidentalis*)

(Critically Endangered under the EPBC Act and Schedule 1 (Critically Endangered) under the WABC Act).

Western Ringtail Possums were found to be common in adjacent vegetation during the Bamford Consulting Ecologists (2019) investigations. In the northern area, 206 dreys and at least 66 possums were found during the day, and a density of 5.8 possums/ha was calculated from spotlighting over several small areas. Densities as high as 20 possums per hectare have been determined in some remnants of the Busselton Peppermint stands compared with about four adults per hectare in the jarrah forest (Jones 2004).

Dreys and possums were concentrated in areas of complex vegetation and feeding records were concentrated in Marri *Corymbia calophylla* and Coojong *Acacia saligna*, with some animals observed foraging in Saltwater Paperbark *Melaleuca cuticularis*. This is consistent with a recent study (citation¸2020) that found the species feeds on a range of plant species and does not forage mainly on the much more abundant Peppermint *Agonis flexuosa* as is sometimes suggested (Mathieson *et al.* 2020). There were few dreys in areas where large eucalypts provided hollows as an alternative shelter. Possums were more abundant in the northern compared with the south-eastern area.

The possum population in the northern area was estimated at around 170 animals, and 10-20 animals were thought to be at risk from impact due to clearing for the drain widening project based on the original clearing footprint. This footprint has now been almost halved but that figure did not include the small number of possums found in the south-eastern area; therefore the total number of possums that may be at risk remains at 10-20 animals. A population viability analysis study (Yokochi *et al.,* 2015) found that the studied population of WRP in Busselton has an alarmingly high risk of extinction in the next 20 years, and mitigating Fox predation and road deaths were seen as the critical management options. BCE regards the common themes to WRP survival to be high nutrient foliage availability for food, suitable structures for protection/nesting, and canopy continuity to avoid/escape predation and other threats.

3.2. Black-Cockatoos (*Calyptorhynchus spp*.)

(Forest Red-tailed Calyptorhynchus banksia naso *(Vulnerable under the EPBC Act and Schedule 3 (Vulnerable) under the WABC Act), Carnaby's* Calyptorhynchus latirostris *(Endangered under the EPBC Act and Schedule 2 (Endangered) under the WABC Act) and*

Baudin's Calyptorhynchus baudinii *(Vulnerable under the EPBC Act and Schedule 3 (Vulnerable) under the WABC Act) Black-Cockatoos.*

All three Black-Cockatoo species may be present. Foraging signs of the Forest Red-tailed Black-Cockatoo were found in both areas of the VDD, and a separate study by Kirkby (2019) recorded a potentially active or recently active nesting tree outside the construction footprint in the south-eastern area near the golf course. Small numbers of large trees possibly suitable for breeding were found throughout.

3.3. Quenda (*Isoodon fusciventer*)

(Recognised as Priority 4 by the DBCA but not listed under legislation).

Evidence of this species (foraging holes) was found at several locations in the northern area by Bamford Consulting Ecologists (2019).

3.4. Rakali (Water-Rat) (*Hydromys chrysogaster*)

(Recognised as Priority 4 by the DBCA but not listed under legislation).

Not recorded in the project area but known from nearby, and species may be present at least occasionally.

3.5. Migratory waterbirds

The drain provides some habitat for migratory waterbirds (listed as Migratory under the EPBC Act and as Schedule 5 (Migratory) under the WABC Act), and passes through The Broadwater, an area of known importance for waterbirds (including migratory species).

The only record of migratory waterbird species was of a single Eastern Osprey *Pandion cristatus* observed in 2016 (GHD 2017); the bird was perched. Very small numbers of other migratory waterbirds, such as sandpipers, may occasionally be present, but the availability of habitat suitable for such species is limited (M. Bamford *pers. obs*.).

3.6. Other terrestrial native fauna

Further to species of conservation significance, the VDD has some functional conservation significance; providing both a corridor for fauna movement in an urban landscape (vegetation along the drain) and a barrier for the movement of terrestrial fauna.

4. Potential Impacts

Of the fauna values identified above, some are of concern with respect to the proposed VDD upgrade. Possible impacts to species, groups of species or functions are:

- **Western Ringtail Possum**. Mortality risk during construction and some long-term loss of habitat, predicted to affect 10-20 animals. Likely reduced connectivity along the drain due to loss of habitat.
- **Black-Cockatoos**. Possible disturbance/loss of potential nest trees, and some loss of foraging habitat.
- **Quenda**. Mortality risk during construction and some long-term loss of habitat. Evidence of Quenda was limited during the 2019 assessment (Bamford Consulting Ecologists 2019), so unless abundance levels change dramatically the number of animals at risk from mortality during clearing or habitat loss is very low; perhaps one or two individuals. Likely reduced connectivity along the drain.
- **Rakali.** The species has not been confirmed and appears not to be present regularly, but it is expected to be at least an irregular visitor (dispersing individuals) and therefore there may be some loss of connectivity. The existing drain has emergent vegetation along much of its length, providing cover for any Rakali moving along the system, and the widened drain will presumably lack such cover, at least initially.
- **Migratory waterbirds**. Probably temporary loss of foraging habitat used by very small numbers of a few species on an occasional and irregular basis.
- **Other fauna.** Mortality risk during clearing. Some loss of habitat (upland vegetation and riparian vegetation) and loss of connectivity along the drain.

Summary of Potential Impacts	
Mortality during construction	Risk to Western Ringtail Possum. Slight risk to Quenda. Very slight risk to Rakali and nesting black-cockatoos. Note: construction does pose a mortality risk to aquatic and terrestrial fauna that are not listed as of conservation significance. This could include Long-necked Tortoises, frogs, fish and terrestrial reptiles. Nestling birds could also be at risk
Loss of Habitat	Risk to Western Ringtail Possum (about 10-20 individuals displaced); Black-cockatoos could lose a very small number of potential nest trees and a small area of foraging habitat, Quenda would lose a very small area of habitat. Temporary loss of habitat to Rakali. Loss of habitat is also a consideration for non-significant fauna.

Summary of Potential Impacts	
Loss of Connectivity	Risk to Western Ringtail Possum. Possible risk for Quenda. Temporary risk for Rakali, although the importance of the VDD for Rakali movements may be low. Loss of connectivity is also a consideration for non-significant fauna such as terrestrial reptiles.

5. Impact Mitigation

Mitigation of impacts can involve generic management practices that affect levels of impacts to a range of species, as well as targeted practices designed to reduce impacts on particular species.

Species-specific management practices are proposed only for those species where there is considered to be at least a moderate risk, and only for those aspects of the proposed drain widening that constitute a risk. The focus is on the Ringtail Possum and black-cockatoos, while Quenda and Rakali are considered lower risk. Generic management practices are included below, and cover the general fauna assemblage, as well as species of conservation significance where the risk is considered low.

5.1. Management Objectives

As defined in the *CD00116 Vasse Diversion Drain Upgrade, Construction Environmental Management Framework* (Water Corporation 2020), fauna management objectives are to:

- Facilitate compliance with relevant legislation, regulations and approvals
- Minimise or prevent impacts to native fauna resulting from project activities:

Performance indicators:

- No injury or death as a result of project activities
- Number of fauna required to be rescued from open excavations
- No impacts to habitat outside the approved clearing footprint.

Methods and actions for individual species and groups of species are presented in detail below.

5.2. Change Management

This Fauna Management Plan and the materials and methodologies therein are correct as at the time of publishing. The following changes to materials and methods will not invalidate this plan:

- Changes to the materials that do not result in additional or different environmental impacts.
- Minor changes to method that do not result in lessened environmental monitoring and/or additional or different environmental impacts.

Changes to the materials or method that may result in reduced monitoring and/or cause a significant environmental impact will be referred to the relevant advisory agencies prior to implementation of the change.

5.3. Roles and Responsibilities

The Fauna Management Plan will be implemented by a suitably qualified ecologist. The ecologist will ensure adherence to the management actions outlines in the Fauna Management Plan. The ecologist will also be responsible for the application, management and reporting of all permits and licences required by the DBCA.

A suitably qualified ecologist will be responsible for preparation of annual monitoring as per the CPS8191/1 and EPBC 2017/7932. Annual monitoring reports/memoranda will be incorporated in the Annual Compliance Reporting conducted by the Corporation to comply with Condition 19 of CPS8191/1 and EPBC 2017/7932 Condition 16.

5.4. Western Ringtail Possum

During clearing and construction, the underlying aims of management of impacts on the Ringtail Possum are to avoid mortality and ensure the abundance and persistence of the local population along the drain area are maintained. In the medium to long term, the aim is to provide new shelter locations and foraging habitat. Relocation is not considered a viable offset by SEWPaC (2011) and has variable success, but given the narrowness of the clearing, moving animals to trees outside the clearing zone (displacement rather than relocation) may mean they are still within their own home range which should maximise survival.

The common themes to WRP survival are:

- high nutrient foliage availability for food,
- suitable structures for protection/nesting, and
- canopy continuity to avoid/escape predation and other threats (DPaW, 2017; Bamford and Gamblin, 2019).

To assist survival of displaced animals, BCE recommends the installation of shelters and rope bridges as part of the VDD Project's *in situ* mitigation measures in the remaining habitat, as habitat augmentation is preferred to relocation.

5.4.1. Displacement

Displacement will take place in the week prior to clearing, and to some extent will be progressive with clearing (depending on timing and progression of clearing). Key stages in the displacement approach will be:

- Daytime survey of trees marked for removal to determine locations of dreys and Ringtail Possums. Unoccupied dreys to be removed. Dreys in good condition and that can be removed intact will be installed in nearby (as close as practical) trees outside the clearing footprint. Record locations of animals (which will usually be in dreys).
- Evening head-torching to locate Ringtail Possums. Where possible, remove dreys (possums will be active so dreys should be unoccupied). These dreys to be installed outside the clearing zone as they are likely to be the most attractive to the Ringtail Possums. The use of food lures, such as apple/peanut paste, placed in trees outside the clearing zone and near dreys that have been moved, may encourage animals to move out of and stay out of the clearing zone.

- Over several days, the sequence of daytime and evening surveys, with removal and movement of dreys, should result in few possums continuing to use the clearing area for roosting and foraging. This is effectively passive displacement. Possums that forage in the clearing zone but do not roost there will not be at risk; therefore the aim at the end of this passive displacement phase is to identify 'recalcitrant' possums that persist in roosting (during the day) within the clearing zone. Such animals will need to be displaced more actively.
- Active displacement can be approached in two ways. The least invasive is to locate possums at night and to encourage them to leave the tree in the clearing zone through the use of long poles and gently prodding the animal so that it moves into a tree outside the clearing zone. The more invasive technique is to locate 'recalcitrant' animals at night and set cage traps in the tree (wired to more or less horizontal branches and baited with apple/peanut paste). They can then be released either that evening or the next day (possibly the next evening) outside the clearing zone. If possible, they would be released into a drey that is likely to be one of their own that has been moved from the clearing zone.
- The above approaches will continue until the evening before clearing is to commence. On the morning of clearing, trees within the clearing zone will be checked for any possums that may have returned. If a possum is present in a tree that is to be cleared, the options are to try to remove it in daylight (hand-capture with a pole-net or using the pole technique to encourage it to move into a nearby 'safe' tree) or to leave that tree and attempt to trap/remove the animal the next night. The tree could be partly pruned during the day so that the only connectivity to another tree will lead the animal out of the clearing zone.

5.4.2. Rope Bridges

Habitat fragmentation is a threat to the Ringtail Possum as they are reluctant to move over ground and if they do, they are at risk of mortality (predation and road death). Small isolated populations have a higher risk of extinction because of their higher vulnerability to stochastic demographic changes and catastrophic events such as severe weather, fire and diseases (Foley, 1997).

Significant genetic divergence has also been known to occur over small distances in the species (Appendix 1) with barriers to movement, such as waterways, found to exert a greater negative impact on population gene flow than roads (Yokochi *et al.,* 2015).

The VDD presents a substantial barrier to movement, and the upgrade project will result in the loss of some fringing vegetation that will further limit movement along the drain. Rope bridges provide connectivity across barriers. Yokochi and Bencini (2015) found that WRP habituated to rope bridges quickly, and the bridges were used regularly by multiple individuals at a high rate every night, even being used intergenerationally. BCE view rope bridges as offering an effective mitigation measure against habitat fragmentation along the drain where the fringing terrestrial vegetation is fragmented, and where there are roads.

Rope bridges across the drain are more challenging because of the distance involved, but may be considered as part of an adaptive management strategy for the project. At least 6 rope bridges will be installed to facilitate movement of animals parallel to the drain, targeting locations where the existing fringing terrestrial vegetation is already fragmented, or where clearing will increase fragmentation. An example of a rope bridge used in the Busselton area is illustrated in Appendix 2. This is a double rope structure with a lattice between the two ropes and has been proven effective. It is therefore the recommended design.

Rope bridge requirements as specified in Condition 14 of CPS8191/1 are:

- The end of each rope bridge must be connected to at least two mature trees, or two different locations in the canopy of a single mature tree, at a height of at least three metres above the ground.
- The rope bridges are to be placed in areas where facilitation of connectivity in the canopy is required to assist in movement across the local area, i.e. across roadways and other large gaps in the canopy.
- Locations of rope bridges to be selected and rope bridges to be installed before clearing commences.
- Usage of rope bridges will be monitored (see Section 5.3.5).

Figure 4. Map 8191/1c shows the areas in red crosshatch that require rope bridge and shelter installation.

5.4.3. Fauna Shelters

Providing shelters may offset the increase in population density in remaining habitat and provide animals with alternative shelter sites outside the clearing area. Construction of shelters could engage the community and we suggest it be done in conjunction with local schools (some are very close to the drain) and/or local conservation groups or Men's Shed Association, using a supplied design.

At least 15 shelters are to be installed before clearing. Even if shelters ultimately become un-useable by possums (such as due to bees or deterioration), they would provide a 'staging post' for displaced animals at the time of clearing.

A range of shelters with different designs will be deployed adjacent to the cleared areas as suitable nesting and resting habitat. Examples of designs include:

- Hollow logs which replicate large eucalypt tree-hollows often used by this species.
- Rectangular wood ply boxes as have been used with many species including for black-cockatoos.
- Hanging basket frames face to face and stuffed with peppermint tree foliage, paperbark (if available from sustainable sources) or coconut matting fibre.

Examples of some of these designs are presented in Appendix 2.

There are many variables affecting what makes shelters attractive to mammals such as the Ringtail Possum. For example,

- Hollow logs are likely to provide the most stable thermal environment and natural hollows are preferred by possums to their own dreys, but the possums do use dreys that probably have limited thermal stability. Tree hollows are better thermal refuges varying less than artificial boxes with ambient temperature especially during periods of high temperatures (Rowland *et al,* 2017), although a study by NSW Environment and Heritage (2007), found that next box design didn't have significant influence on the temperature regime for nest boxes in full sunlight.
- Shelter volume does not appear to greatly influence use except for mammals larger than 1000 grams which appear to prefer a size greater than 0.03 cubic metres (Beyer & Goldingay 2006).
- Volume and entrance size affect humidity.
- Arboreal marsupials appear to prefer nest boxes with narrow entrances just big enough to enter (Menkhorst 1984a), and
- Height of the nest box can sometimes (but not always) influence the frequency of use by some species (Menkhorst 1984b; Beyer & Goldingay 2006).

A nest box study with Sugar Gliders (*Petaurus breviceps*) by Durant *et al,* (2009), showed that the only nest box characteristic to have a strong relationship with occupancy was date of establishment, with longer established boxes more likely to be occupied.

Shelter requirements, as specified in Condition 15 of CPS8191/1 are:

- Shelters shall be designed and placed in accordance with the specifications detailed in the Vasse Diversion Drain Upgrade Revegetation Plan[1].
- Shelters will be placed at least three metres above ground level in a mature tree on the shadiest side of the tree.
- A range of shelters will be trialled. Relocated natural dreys to be included in the monitoring.
- Shelters will be monitored, with a review at six months and maintained for a period of at least ten years, see Section 5.3.5.

Preferred locations of shelters are to be determined and shelters installed before clearing commences.

5.4.4. Revegetation

A revegetation plan for the VDD has been developed by Tranen (2020). This includes the statement:

The overarching strategy for the revegetation works is to re-create naturally occurring and connected vegetation communities that are appropriate for their geographic location, support long-term ecological function and provide suitable habitat for critical species [such as the Western Ringtail Possum].

It is intended that the revegetation plan, which includes infill planting and enhancement of more than 15 ha in the immediate vicinity of the drain, will offset loss of habitat by clearing and improve connectivity. Once established, the planned revegetation is likely to provide a diversity of native food plants for Western Ringtail Possums.

5.4.5. Monitoring

Both rope bridges and shelters are to be monitored and this will be a measure of success.

Monitoring Rope Bridges

Usage of rope bridges by Ringtail Possums (and other fauna) will be monitored by motion-sensitive cameras installed at either or both ends of the bridge.

Initially, monitoring will be monthly in the first six months, after which time level of usage to be reviewed. Subsequently (for 10 years from end of construction), monitoring to be biannual (ca. March and October each year). A monitoring session should be 7-10 days of cameras set on rope bridges. Cameras are not to be baited as the intention is to determine usage of the rope bridges.

Monitoring Fauna Shelters

Shelters will be monitored monthly in the first six months, after which time level of usage to be reviewed. Initial monitoring will target displaced animals by searching for them at the known last location and checking shelters in that area. Locations of other Ringtail Possums will be recorded so that displaced animals can be identified. Subsequently (for 10 years from end of construction), monitoring to be biannual (ca. March and October each year). Methods for monitoring include[1]:

- Visual inspection of shelters such as through a pole-mounted camera.
- Motion sensitive cameras focussed on the shelter opening.
- Use of thermal dataloggers (these record temperature inside the shelter with high temperatures indicating the presence of a possum or other mammal). iButtons (cost of c. $30 ea) have been used to study shelter usage by *captive* Ringtail Possums, with <5-6% error for two shelter designs (Moore *et al.,* 2009).

5.4.6. Record keeping and Reporting

A consolidated final report on all activities is required within one month of practical completion of construction (ca. May 2021). Brief annual reports will be required for 10 years of monitoring of shelters and rope bridges.

Prior to reporting, and within two months of commencement of clearing (estimated November 2020), the locations of rope bridges and shelters must be provided to the CEO, using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees.

Detailed records of all activities need to be kept, in particular, information related to displacement of animals and location of bridges and shelters. Key information to be recorded (where applicable) includes:

- The date of any action.
- the number of individuals observed
- the location where each individual was identified recorded using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees;
- the number of individuals removed and relocated;
- the method of displacement/relocation.
- the location where each individual was relocated.

[1] Monitoring of both rope bridges and shelters could involve capture and injection of subcutaneous implantable transponders into Ringtail Possums with readers then set up on bridges and shelters. This would provide information on individual usage but is very invasive and is not recommended for the purposes of this project.

- details pertaining to the circumstances of any death of, or injury sustained by, an individual.

5.5. Black-cockatoos

There is a slight risk of impact on occupied nests; loss of potential nesting sites and some loss of foraging habitat. Known nests and trees that have potential for nesting (possibly in the future as hollows develop) have been identified. These include one tree (a Flooded Gum *Eucalyptus rudis*) in the south-eastern area (just outside the clearing footprint) which was considered to be an almost definite Carnaby's Black-Cockatoo nest site (T. Kirkby 2019).

If construction activity is required within 50m of such locations, trees are to be checked for signs of occupancy prior to construction/clearing activity. This can be done through late afternoon observation (to detect movement of birds to and from a nest; low level of disturbance). If uncertainty remains, activity can be checked by 'raking' the tree (scratching the trunk can make sitting birds emerge), and/or by inspecting the hollow with a pole camera. These more invasive techniques all cause some level of disturbance.

If an occupied nest is found within 50m of proposed activity, consult with DBCA. If possible, re-schedule activity to when birds have finished breeding. Loss of foraging habitat is minor but replanting/revegetation should include black-cockatoo foraging plants such as Marri *Corymbia calophylla.*

For details of Black Cockatoo biology and threats see - http://www.birdlife.org.au

5.6. Quenda (Brown Bandicoot)

There is a slight risk of mortality (one or two individuals?) during clearing and a slight reduction in connectivity. Quenda can be checked for and removal-trapped if necessary as outlined below.

5.6.1. Survey for presence

Check for Quenda signs a week before; looking for foraging holes within areas to be cleared and with a buffer of ca. 25m. This is to determine if there are Quenda nearby. Foraging signs are distinctive but on occasion Quenda will forage in an area without digging foraging holes (M. Bamford pers. obs.). Therefore, motion-sensitive cameras (baited) should be deployed in clearing area where habitat appears suitable (typically dense, low cover of vegetation, including weeds). These should be placed <50m apart and run for at least three nights. The number of cameras used will depend on the area of suitable habitat, but is likely to be about 10-15.

5.6.2. Trapping

If there are Quenda signs within or close to areas to be cleared, or Quenda are photographed, cage trapping (using universal bait) to be carried out for up to four nights. Cage traps to be at a tight spacing; roughly 20m grid.

Quenda have a reputation for trying to return to their home range if they are relocated, so an option would be to hold animals in captivity for a few days until clearing at the location where they were caught is complete, and then returning them to adjacent uncleared vegetation. This

approach is possible because the clearing area is narrow and represents only a portion of the home range of individuals. Holding Quenda in captivity will require liaison with local wildlife carers.

5.6.3. Revegetation/Habitat Augmentation

Revegetation proposed for the Western Ringtail Possum will also create habitat and improve connectivity for the Quenda. Loss of connectivity in upland areas can be addressed by using logs and large branches harvested during clearing to create shelters for Quenda, including artificial runnels. These offer protection from feral predators, especially the Fox. Cover will eventually develop along the drain as aquatic and emergent plants become established.

For details of Quenda biology and threats see **http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68050**.

5.7. Rakali

While not believed to be a resident species, the drain should be checked for evidence in case one or more animals are present at the time of clearing and construction. There is a very slight risk of mortality as it appears unlikely that animals are resident, but an individual could be present at the time of clearing and construction. The main threat to the species is temporary loss of connectivity along the drain.

5.7.1. Survey for presence

Rakali leave distinctive foraging signs such as chewed remains of mussels and freshwater crayfish on waterside feeding platforms (such as a level log or rock). Distinctive tracks can also be left in fine mud along the shoreline. Evidence of presence therefore needs to be searched for. In addition, motion sensitive cameras can detect Rakali (McIlduff *et al.,* 2014; Bettink, 2016). Remote cameras have been used successfully in recording Rakali by BCE staff. The greatest success with cameras is achieved where there is already some secondary evidence of the species.

Searches for evidence of the Rakali will be undertaken by two personnel with experience in identifying recent evidence of this species, who will survey the sites searching for tracks, scats and feeding middens. Searches will be done by foot and areas of mud/sand will be checked for the Rakali's distinctive tracks. Searches for Rakali tracks need to be conducted in the morning before diurnal species overlay and confuse the pattern, due to their crepuscular/nocturnal habits.

5.7.2. Trapping

Rakali are wary of traps but they have been known to enter cage traps. In the unlikely event that an animal is thought to be resident, cage-trapping will be carried out where there is evidence. We will deploy Sheffield cage traps in areas where secondary signs have been recorded and where they are hidden from public view. Cages will be placed facing the water and above the high water line, and baited with small oily fish such as pilchards (pilchards have been found to be the preferred bait over other types – T. Gamblin pers obs).

5.7.3. Translocation

Animals trapped will be relocated to suitable habitat nearby. For example, the Broadwater almost certainly has a resident population and any animal on the VDD is probably dispersing from that area.

For details of rakali biology and threats see - **http://www.anbg.gov.au/cpbr/WfHC/Hydromys-chrysogaster/index.html**, Bettink, 2016 and 'Rakali Community Survey 2014-2015' Chapter 2, (Trocini, *et al*, 2015).

5.8. Other Fauna

Mortality of other fauna is inevitable during clearing. This can include lizards, frogs and nestling birds if clearing occurs during the breeding season. Note that the breeding season for birds is typically late winter to mid-spring. Waterbirds such as ducks will mostly have finished breeding by mid to late spring when clearing and construction commence. Lizards and frogs can be collected and relocated opportunistically such as when encountered during other work; release sites adjacent to but just outside the clearing area are suggested as this causes the least disruption to the animals. Revegetation and the use of logs and other material from clearing can create habitat for other fauna.

5.9. Overview and Timeline

- Months/weeks prior to works
  - The FMP plan finalised
  - Shelter locations for Ringtail Possums confirmed
  - Shelters (15) constructed and begin installation
  - Locations for rope bridges (6) for Ringtail Possums confirmed
  - Commencement of works date confirmed and all parties alerted
- One week prior to and up to the day before works commencing
  - BCE to provide the CEO with a copy of the fauna licence
  - BCE to check and remove Ringtail Possum dreys from clearing area.
  - Daily check for Ringtail Possums that persist in returning to trees in clearing area; several options for their relocation are provided in Section 5.2.
  - Shelters for Ringtail Possums not already in-situ to be installed – minimum of 15.
  - Installation of rope bridges.
  - Suitable nesting trees for black-cockatoos to be checked for signs of occupancy (late afternoon observation) and activity can be checked by 'raking' the tree, and/or by inspecting the hollow with either a pole camera or a drone.
  - If an occupied black-cockatoo nest is found within 50m of proposed activity, consult with DBCA.
  - Survey for Quenda and Rakali evidence; if detected, cage trapping to be carried out for up to four nights.
  - If Quenda are caught, hold them for a few days before release (in same location). Rakali to be released immediately upstream.

- Opportunistic capture and relocation of other fauna.
- 24hrs prior to clearing (night before and morning of works commencing)
- BCE to re-inspect the trees and hollows in the areas mapped below in **Figure 3 a-c** (cross-hatched yellow) for Ringtail Possums. This will be progressive as clearing proceeds.
- BCE to re-inspect potential black-cockatoo hollows.

- One-month post clearing
  - Final report documenting the works completed, including details of all fauna recorded and relocated, locations of all shelters, rope bridges, revegetation and results of initial monitoring, as well as planning for ongoing monitoring in the first year and thereafter until 2031.

(A)

(B)

(C)

Figure 3 (a,b,c). Clearing areas (hatched yellow) to be searched by BCE for Ringtail Possums and other fauna.

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Appendix 1

Western Ringtail Possum Biology

The majority of this background information is reproduced from *Translocation Management Plan for Western Ringtail Possums from the Busselton Eastern Link Project to Reserve 44757*, Bamford and Gamblin, 2019b and *Translocation Proposal Western Ringtail Possum (Pseudocheirus occidentalis) translocation proposal for various locations*, Kim Williams, Brad Barton, WA Department of Environment and Conservation, July 2012 and *Department of Parks and Wildlife (2017) Western Ringtail Possum (Pseudocheirus occidentalis) Recovery Plan*. Wildlife Management Program No. 58. Department of Parks and Wildlife, Perth, WA.

Conservation Status

The WRP is a threatened species under State and Commonwealth legislation. In Western Australia the species is listed as Critically Endangered fauna under the *Biodiversity Conservation Act 2016*. Nationally it is also listed as Critically Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999,* and internationally is on the IUCN Red List of Threatened Species as Critically Endangered. A population viability analysis study (Yokochi et al, 2015) found that the studied population of WRP in Busselton has an alarmingly high risk of extinction in the next 20 years. Mitigating fox predation and road deaths were seen as the critical management options.

Distribution in the Busselton Region

The Ludlow-Busselton area has long been known as the last substantial stronghold for WRP on the Swan Coastal Plain. This Swan Coastal Plain population has been contracting since the early 1990s, mostly due to habitat loss and fragmentation from urban development and mining (Woinarski *et al*. 2014). The effect of the Southwest's drying climate on the Peppermint stands and canopy in this area is also considered a contributing factor of the decline (Jones and Francesconi 2007). Most of the populations within the Busselton area that have had sufficient monitoring to detect a decline over the last 5-12 years have shown declines of 20-80 per cent (Woinarski *et al*. 2014). From existing survey data, the population in the Bunbury to Dunsborough region is possibly between 2,000 and 5,000 animals (Wilson 2009; B. Jones and G. Harewood pers. comm. 2013).

The main determinant of suitable habitat for the WRP appears to be the presence of myrtaceous species, particularly Peppermint trees, either as the dominant tree or as an understorey component of eucalypt forest or woodland. Habitat fringing riparian zones is often preferentially exploited, presumably as the vegetation has greater access to reliable soil moisture and the foliage exhibits less drought stress. The WRP exhibits a preference for habitat with long interfire periods and continuous upper or mid strata canopy. Population density appears to be directly related to habitat quality, with the densest occurrences occurring in the highest quality habitat found on the lower swan coastal plain. Reproductive output is apparently related to habitat quality. Areas of habitat with low foliage nitrogen content tend to result in lower numbers of births. For example, Peppermint woodlands have higher foliage nitrogen content relative to jarrah forest habitats (Jones *et al*. 1994b, Wayne et al. 2005c). Habitat quality may also influence sex ratios. A ratio of one-to-one may be indicative of a stable population, while a female bias can occur in an expanding population in high quality habitat, and a male bias in declining or marginal habitat (Jones *et al*. 1994b).

The following habitat parameters may have the potential to limit WRP possum abundance (Williams and Barton 2012):

- forest floristics
- the abundance of foliage/extent of canopy connectivity
- nutritional quality of available foliage
- fire regimes.

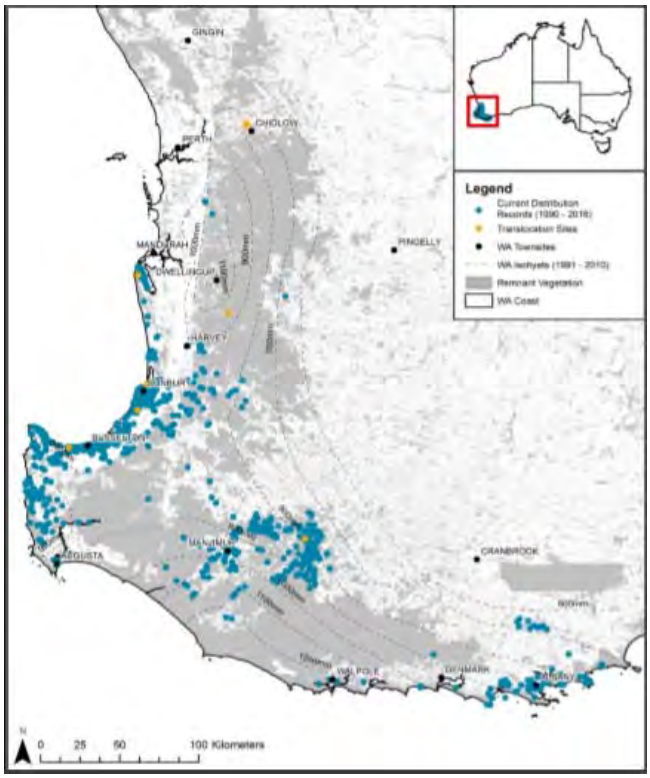

Figure 1: The known current (1990-2015) distribution of the Western Ringtail Possum in Western Australia, based on the Department of Parks and Wildlife's Fauna Database records, and including translocation sites.

Behaviour

WRP tend to shelter during the day and become active at night. Shelter sites include tree hollows, constructed nests in trees (dreys), naturally occurring protected sites on or near ground level (i.e. in dense understorey), under logs and in rabbit burrows. In the coastal Peppermint forests dreys are common, while in the more inland areas tree hollows are more common. They may also use hollows preferentially even in Peppermint woodland where hollows are available (M. Bamford pers. obs.). Although arboreal, the WRP is known to descend to the ground when foraging and if the overstorey is discontinuous. In suburban situations the species may also rest in roof spaces and other dark cavities. WRP generally use between two and seven refuges in their home range, but can use an average of 20 or more refuges over a year (Jones *et al.* 1994b, Ninox 1999a, Wayne *et al*. 2000). Tree hollows are important across the range of the Western Ringtail Possum. Hollow abundance has been positively correlated with

possum abundance in Peppermint/Tuart (*Eucalyptus gomphocephala*) associations (Jones and Hillcox 1995), and hollows generally constitute more than 70 per cent of the refuges used by WRP in the jarrah forest (Wayne *et al*. 2000, Wayne 2005). WRP dreys are also found in large Balga, generally where the Balga supports a fallen tree or is easy to access from the canopy (Driscoll 2000). Deep hollows and Balga skirts may be particularly important for populations in the warmer/drier areas of the Western Ringtail Possum's distribution to help reduce thermal stress (Jones *et al.* 1994a, Driscoll 2000, Wayne *et al.* 2005b).

Home Range

The home range of the WRP is considered small (less than 5 ha) and likely attributed to nutrient limitations. Male home ranges are approximately double that of females. Home ranges in the jarrah forest average 2.7ha (Wayne *et al*. 2000). Home ranges in peppermint dominated habitat are generally less than two hectares and average 0.4ha and 0.3ha for females and males respectively (Jones *et al.* 1994b). Densities as high as 20 possums per hectare have been determined in some remnants of the Busselton Peppermint stands compared with about four adults per hectare in the jarrah forest (Jones 2004). Female home ranges overlap (often in mother-daughter pairs), while male home ranges have little overlap with either females or other males. Dispersal is generally limited with most studies reporting animals remain close to their natal range (Clarke 2001). There is evidence of territoriality within the species (Ellis and Jones 1992).

Key Threatening Processes

A population viability analysis study (Yokochi et al, 2015) found that the studied population of WRP in Busselton has an alarmingly high risk of extinction in the next 20 years. Mitigating fox predation and road deaths were seen as the critical management options.

Clearing and habitat fragmentation

WRP have been significantly affected by the clearing and fragmentation of their habitat throughout their range. Fertile, productive alluvial soils adjacent to waterways typically support the highest local abundance of possums and so when cleared have the greatest impact on numbers. Habitat critical to survival for WRP is not well understood. The common themes to WRP survival are high nutrient foliage availability for food, suitable structures for protection/nesting, and canopy continuity to avoid/escape predation and other threats. Long-term survival of the species requires linkages between suitable habitat and as such habitat critical to survival should not be limited to only the habitat described below but linkages between. Any habitat where WRP occur naturally are considered critical and worthy of protection. Habitat critical to survival in the Busselton region comprises long unburnt mature remnant Peppermint woodlands with high canopy continuity and high nutrient foliage with minimal periods of summer moisture stress, and habitat connecting patches of remnants (Jones *et al*. 1994b, Jones *et al.* 2004, Wayne *et al.* 2006). Habitat critical to survival in the Marri/Jarrah forests are those with limited anthropogenic disturbance (unlogged or lightly logged, and a low intensity and low frequency fire history), that are intensively Fox-baited and have low indices of fragmentation (Wayne *et al.* 2005a, Wayne *et al.* 2006).

Fragmentation has been extensive in both coastal and inland areas. The ongoing requirement for housing and industry on the Swan Coastal Plain (e.g. the greater Busselton – Bunbury area and Albany) will continue to result in habitat loss and displacement of resident populations (de Tores *et al*. 2004).

Many coastal Peppermint habitats in which WRP occur are outside managed reserves. A 2006 assessment of available habitat in the Busselton to Dunsborough area identified that only 0.86% of the remaining habitat was contained in secure conservation reserves.

In the main southern forests, Wayne (2005) reported a decline in populations in the Kingston area following timber harvesting and related regeneration burning. This decline has expanded in area significantly with populations in the Upper Warren area now reduced to undetectable levels (Wayne *et al.* 2012).

Predation

Predation by cats and foxes is one of the main threats to the WRP (de Tores *et al*. 2004; Wayne 2005; Jones *et al*. 1994b), confounded by the predator naivety they display. These predators have been implicated in the disappearance of natural and translocated populations of the WRP and they are likely to be responsible for the poor translocation success with this species (Wayne *et al*. 2000, Grimm and de Tores 2009, Clarke 2011). In hot weather, WRP may come to the ground to find respite from the heat, and this may make the species more susceptible to fox and cat predation (Yin 2006).

During the 1980s there was some evidence to suggest that areas baited for Fox control exhibited stable or increased populations, however this trend has not been maintained (e.g. declines in Perup Nature Reserve). Thus, despite extensive Fox baiting programs, Foxes are still a major cause of mortality, while successful fox baiting programs may result in mesopredator release where the impact of other predators (e.g. Cat, Carpet Python and Chuditch) become more pronounced.

In urban environments predation or injury by domestic dogs and cats is frequent (Williams 2012). High levels of dog ownership within the City of Busselton create dog densities at 4-8 times greater per ha than the average Fox density in the south west forests (Williams 2006).

Harvesting in forests

Timber harvesting and burning operations can result in loss of habitat, habitat fragmentation, loss of nest trees and refuge sites, loss of continuous canopy and population displacement. In the Jarrah/Marri forests in the Manjimup area, abundances of Western Ringtail Possums in timber harvested areas are lower compared with areas unlogged or last logged in the 1960s (when logging practices were less intense) (Wayne *et al.* 2006). Change in forest structure through logging have also resulted in WRP travelling and resting more frequently on the ground which makes them more susceptible to predation. However, many of the known WRP populations are outside of areas currently available for logging.

Altered fire regimes

Fire can negatively impact WRP by reducing the availability of food resources, destroying shelter sites or by directly killing individuals. The slow-moving nature of this species, its flammable diurnal resting sites and habitat preference for dense foliage make it particularly vulnerable to fire. Coastal Peppermint forests in the Bunbury/Busselton region are rarely affected by fire (Jones *et al*. 1994a), however, regrowth after small patch fires may be important for local population recovery in the long-term (Jones *et al.* 2004). The swift growth of the population at Locke Nature Reserve during the late 1980s was apparently linked to the fire regrowth mosaic following a patch burning program. Appropriate patch burning may evolve into an important management tool for offsetting the effects of contemporary habitat destruction events (for example logging, urbanisation) (Jones *et al.* 2004). There are

considerable anecdotal reports of Western Ringtail Possums favouring epicormic eucalypt flushes.

Urban Issues - Road kills, Electrocution, Forced Translocation and Poisoning

High WRP population densities have been recorded in urban settings, particularly where mature Peppermint trees have been retained which have large, dense and overlapping canopies (Harewood 2008). This habitat type appears to provide a variety of nutritious browse items, artificial watering which buffers vegetation against the impacts of a drying climate, alternative habitat connections (fences, powerlines) and alternative shelter/roosts in buildings. It is possible that WRP have benefited from this development and adapted to the urban setting (Shedley and Williams 2013), however there are also risks that are potentially associated with urban environments. In urban settings road traffic may contribute to the decline in abundance of the species near roads. Roadside vegetation pruning regimes and enhanced drainage runoff promote dense fringing foliage which are preferentially utilised by WRP. Populations located in the core of large remnants or reserves would be least affected. Power outages caused by electrocution of WRP and Brushtail Possums have been recognised by power utilities as a significant problem. Possums frequently utilise the power lines as transport corridors. In isolated and highly fragmented habitat bisected by major roads or drains, electrocution of resident animals could lead to localised extinctions.

In high density coastal urban populations, WRP occupancy of buildings and structures, or feeding on domestic gardens often results in public complaints of “nuisance animals” and the complainant taking unauthorised and usually clandestine actions such as poisoning or trapping and relocating animals. The fate of these individuals is unknown but they are considered unlikely to survive. These issues often result in relocation or rehabilitation and eventual release of injured or orphaned possums. Approximately 200 Western Ringtail Possums per year enter rehabilitation in the Busselton area. They are rescued by volunteer wildlife rehabilitators or the general public. Between 50-100 animals per year are thought to successfully survive the rehabilitation process and are released (Williams and Barton 2012).

Effects of drought

Sensitivity to heat and drought-induced stress has been observed in WRP particularly along the lower Swan Coastal Plain and droughts may contribute to the stress and poorer condition of Jarrah forest populations.

Disease

This species has been regarded by some as being particularly poor at mounting immune response to infection, a problem that has heightened with greater risk of disease due to human disturbance and exposure to exotic species and pathogens (de Tores *et al*. 2008).

Cat predation may also expose WRP to toxoplasmosis infection, a disease carried by Cats (de Tores *et al*. 2008), although investigations into the disease load of captive and wild populations has revealed only low rates of contagion (McCutcheon *et al.* 2010, Grimm 2010).

Though not yet confirmed in WA, the possible introduction of Myrtle Rust (*Uredo rangelii*) from the eastern states is of major concern. This rust has the potential to significantly reduce the condition and availability of eucalypt and Peppermint foliage and thus primary habitat for WRP. *Phytophthora* dieback is caused by a microscopic soil-borne organism, *Phytophthora cinnamomi*, which can cause extensive changes in the structure and floristic composition of

susceptible vegetation communities (Department of the Environment 2014, Garkaklis *et al.* 2004). The known canker pathogen *Neofusicoccum australe* has been found to be causing severe dieback symptoms of Peppermint trees. *Neofusicoccum australe* is a common fungal endophyte, which is capable of causing disease in a stressed host plant. The factors causing this stress are not yet known, however, climate change is seen as the driving force in the apparent range expansion of this normally minor disease (Dakin *et al.* 2010). An unknown canker pathogen (possibly *Neofusicoccum australe*) is having a significant impact on *Allocasuarina* spp. at Mount Gardner (S. Comer pers. comm. 2013). WRP dreys are often observed in *Allocasuarina* spp. along the south coast. The swiftness and severity of some of these pathogens could also lead to localised extinctions of WRP, particularly in isolated populations or remnants.

Competition with Brushtail Possums

Interspecies competition has been observed between WRP and Common Brushtail Possums. Brushtail Possums can evict WRP from hollows but there is evidence that habitat partitioning occurs (Grimm 2009). Competition for refuges was less likely in the Jarrah forests. The accumulated impacts of tree removal, patch clearing and burning of remnants has forced a contraction of the distribution of possum species in the south-west and has increased competition with Brushtail Possums for the shrinking resource and stands of good possum habitat (B. Jones pers. comm. 2002, Grimm and de Tores 2009). The European Honeybee (*Apis mellifera*) competes significantly for tree hollows with the Common Brushtail Possum (Wood and Wallis 1997) and hence probably Western Ringtail Possums. Some hollow nesting birds including the introduced Rainbow Lorikeet (*Trichoglossus haematodus*) and the expanding Little Corella (*Cacatua sanguinea*) are also potential competitors with WRP for hollows.

Climate change

WRP are among the species likely to be impacted by climate change predictions in the south west because they have very specific habitat requirements, have a poor ability to migrate, have lost large areas of habitat and have a small genetic base. Over the past 30 years there has been an approximate 20 per cent decline in rainfall in the south-west of WA, with more reductions in rainfall and increased temperatures predicted due to global climate change (Timbal 2004). Changes in these and other associated factors such as fire regimes and the intensity and frequency of severe weather event could result in further contraction of the species to the most fertile and mesic remnants of their extant range (Wayne 2005, Jones and Francesconi 2007). In addition, they are sensitive to drought-induced stress.

Gaps in knowledge

Limited short-term studies and anecdotal accounts have contributed most of the knowledge on the Western Ringtail Possum. An understanding of the ecology and conservation status has also been constrained by the lack of long-term and systematic study (Inions *et al.* 1989, Jones *et al.* 1994b, de Tores 2000). Some of the shortfalls in knowledge include:

- A lack of information on most populations that are small, isolated, and/or at the margins of the extant distribution, including the Waroona, Harvey, Collie, Shannon, Lower Warren and D'Entrecasteaux areas.
- Lack of robust survey methods appropriate for the various habitats of WRP that can provide reliable estimates of population density and/or abundance (as distinct from uncalibrated indices and indirect measures of abundance).

- No strategic or co-ordinated long-term monitoring program across the species' range that can quantify and track population trends over time.
- The causes of decline are not completely understood. The relative importance and extent of threatening processes is generally not known for the species or for individual populations, and the factors influencing population persistence in urban environments are not well understood.
- Lack of understanding of the factors that improve the success of translocations.
- Lack of habitat restoration/creation parameters/prescriptions and effectiveness criteria.

The Western Ringtail Possum (*Pseudocheirus occidentalis*, Thomas 1888) is a folivorous (leaf eating herbivore) marsupial endemic to south-western Australia. Since colonial settlement it has undergone a substantial range contraction, up to 90 per cent of the predicted original range (Jones 2004). As early as 1907 it was "apparently disappearing from many places" (Shortridge 1909) and from surveys in 1985 and 1986 it was considered to have "declined alarmingly" (How *et al*. 1987). Declines in abundance and habitat continue across the range of this species (Jones *et al*. 1994a, Wayne *et al.* 2012).

Description

The WRP is a medium-sized marsupial weighing up to 1.3 kg and 40 cm in body length. The fur is dark brown above with cream to grey fur underneath. The tail grows to 41 cm long and terminates in a white tip. The WRP is readily distinguished from the Common Brushtail Possum (*Trichosurus vulpecula*) by its shorter (usually darker) fur, smaller rounded ears and absence of a brush tail.

Taxonomy

The WRP was described by Thomas in 1888 and was accepted as distinct from a similar species in southeastern Australia. However, later authors placed this species in synonymy with the Common Ringtail Possum (*Pseudocheirus peregrinus*) (Ride 1970). Reinstatement of specific status *Pseudocheirus occidentalis* is widely accepted (on the basis of unpublished morphological evidence and karyotypes (McKay 1984; Murray *et al*. 1980)), despite contradictory evidence from electrophoretic studies and albumin immunology (Baverstock *et al*. 1990). Abbott (2001) collated some names that the local Aboriginal group (the Noongars) used for the species, and recommended five of these: Ngwayir ('n-waar-ear'), Womp, Woder, Ngoor ('n-oor') and Ngoolangit ('n-oolan-it').

Distribution and Habitat

Once widely distributed across southern and south western Western Australia, the WRP now occurs only in south-western Western Australia and its distribution is patchy (Figure 1). The species is most commonly recorded in coastal or near coastal forest that includes Peppermint trees as a major component, and sizeable but low-density populations were known in the Upper Warren sections of the Jarrah Forest 2 Bioregion during the late 1990s.

There have been extensive local declines in the northern and inland parts of the original range of the species. Much of the former habitat of the species was cleared or fragmented during the agricultural development of south-western Western Australia. This original habitat loss, coupled with ongoing loss and degradation of habitat and other threatening processes, has contributed to a restriction of the species' range. Currently, the overall population trend for the species is declining.

Total population size of the species is unknown but has been estimated to be less than 8,000 mature individuals in the wild, with a decreasing trend (Woinarski *et al*. 2014.). The area of occupancy is calculated to be less than 800km2, using 1990-2013 data from Department of Parks and Wildlife fauna databases and 2km by 2km grids. It is however likely that this over-estimates the area of occupancy due to declines since 1990.

There have been translocations of mostly displaced or rehabilitated Western Ringtail Possums to numerous locations since 1991. Translocation sites approved by Department of Parks and Wildlife include Leschenault Peninsula Conservation Park, Yalgorup National Park, Lane Poole Reserve and Keats State Forest Block at Dwellingup, Locke Nature Reserve at Busselton, Karakamia Sanctuary (predator-free wildlife sanctuary privately owned and managed by Australian Wildlife Conservancy), Gelorup bushland south of Bunbury and Perup Sanctuary (predator-free enclosure within Tone Perup Nature Reserve) east of Manjimup. They have persisted at only a few of these sites including Karakamia Sanctuary, Perup Sanctuary and Yalgorup NP.

Knowledge of absolute abundance is limited because of a lack of comparable population estimates and variability in survey methods across the range of the Western Ringtail Possum (Inions 1985, Jones *et al*. 1994b, de Tores 2000, de Tores *et al*. 2004). Techniques used to census Western Ringtail Possums commonly include spotlighting, drey (a nest typically formed from a mass of twigs) searches, distance sampling and scat counts (Wayne *et al*. 2005a; de Torres and Elscot 2010). However, variations in survey methodology compromise comparable estimates of abundance between studies, areas and over time.

The number of WRP in the southern forests is not known but is considered to have been in the tens or low hundreds of thousands (A. Wayne pers. comm. 2013), and thus is thought to have been the largest population prior to 2002. A severe decline in the number of WRP of >95% (probably >99%) between 1998 and 2009 has occurred in this sub-population. Although the spatial extent of the declines is not well understood, it is clear that there has been a decline at all inland forest monitoring sites (Wayne *et al.* 2012). Subsequent surveys (spotlighting, scats and camera trapping) have confirmed that WRP were still present in 2013 at a number of sites, but numbers were extremely low (J. Wayne and A. Wayne pers. comm. 2013).

Reproduction

Female WRP breed once a year, giving birth to 1-3 pouch young (normally one) (Jones 2000). In the southern Jarrah forest, most of the breeding activity occurs March–April with a minor second peak in September–October (Wayne *et al*. 2005). In coastal populations, breeding

peaks in April–June and October–December (Jones *et al.* 1994). As breeding predominantly occurs in autumn, this ensures that the later stages of lactation and weaning, requiring the highest nutritional demands, occur in spring and summer.

Gestation is 2-4 weeks and the young remain in the pouch for 3-4 months (Jones *et al*. 1994). The young are weaned at six to eight months and disperse at 8–12 months (Wayne *et al*. 2005). Breeding has been documented to start at 12 months of age (Ellis & Jones 1992; Wayne *et al*. 2005).

The sex ratio is generally equal in stable populations. A female bias may occur in expanding populations in high quality habitat, and male bias when conditions are marginal (Jones 2004, Wayne *et al*. 2005). The average longevity in the wild is estimated to be three years, rarely exceeding 4-5 years.

Diet

The diet of the WRP consists almost entirely of myrtaceous leaves, the major component (79–100%) being Peppermint tree (*Agonis flexuosa*) foliage, but also Marri and Jarrah (Jones *et al*, 1994b), although a recent dietary study (Mathieson *et al.* 2020) has found that the diet may be somewhat broader with minor components of the overstorey and mid-storey being important food plants. Where Peppermint is not present, the diet consists mostly of Marri and Jarrah leaves. However, in urban settings such as around Busselton and Bunbury, their diet is widely varied and includes items such as rose flowers and buds, citrus fruit, vegetables and herbs. They also feed on leaves and apparently blossom of Coojong *Acacia saligna* and Saltwater Paperbark *Melaleuca cuticularis* (M. Bamford pers. obs).

Genetic Differentiation

A lack of phylogeographic structuring from WRP mitochondrial DNA analysis suggests that historically, populations were interconnected as one large population. This is consistent with the original distribution at the time of colonial settlement (Wilson 2009). Population subdivision and microsatellite genetic differentiation has been a result of more recent patterns of population separation, exacerbated by habitat clearing and fragmentation occurring over the last ~180 years — when colonial settlers started to utilise the forests in south-western Australia (Ward *et al.* 2001). For example, Wilson's (2009) microsatellite DNA analysis revealed three discrete populations existing with some as little as 30km apart. Populations in the southern forests showed slightly higher genetic variation than populations within the Swan Coastal Plain at Busselton and Gelorup (Wilson 2009). A recent study of a 200ha area near Busselton indicated that limited dispersal of Western Ringtail Possums may result in population structuring at even finer-scales, and that genetic structuring was evident in continuous habitat over distances up to 600m (Yokochi 2015), but further work is needed to determine if similar patterns are found in other WRP populations.

Life History Traits

The relatively short life span and annual fecundity rate of one young per mature female make the species vulnerable to changes in recruitment. To maintain population size, a female needs a minimum of two successful reproductive seasons and 100% offspring survival to maturity. Anything that negates this may threaten the viability of the population.

Appendix 2

Infrastructure for WRP

Rope Bridges

The inaugural rope bridge built in Busselton was constructed using:

- an 8.5m wooden pole with concrete foundation
- 2 metal stays per pole
- A 300mmm wide bridge, 26.5m in length
- The bridge was supported by two steel wires and marine grade ropes
- The wire stays provided passage to nearby trees

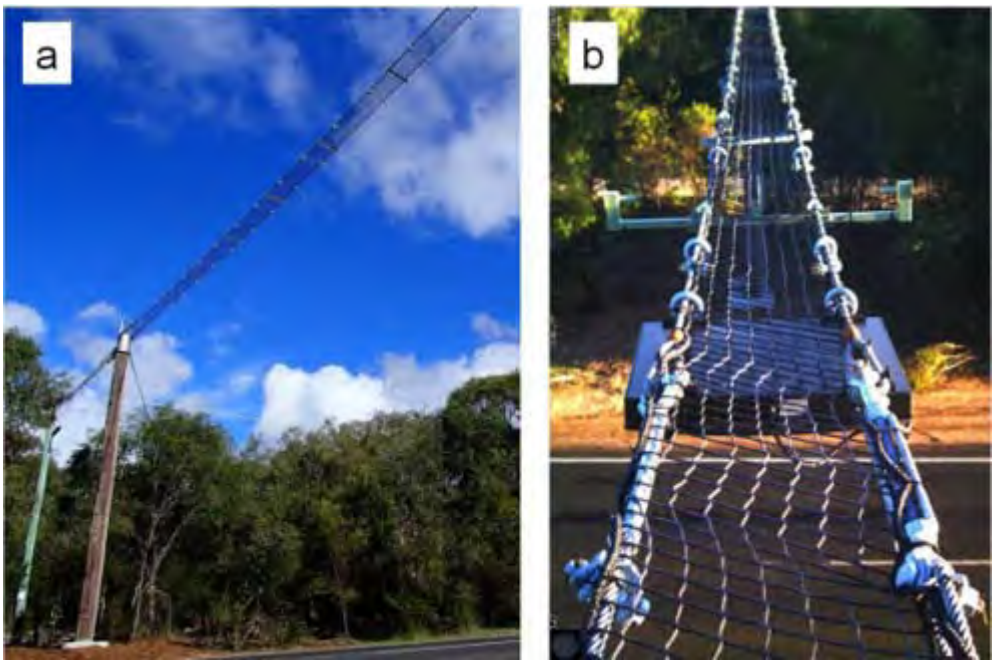

Figure 1. The first rope bridge constructed over Caves Rd, Busselton.

WRP Shelter Designs

The designs below show the variety that can be employed. BCE recommend trialling the hanging basket design as a priority but that a range of boxes should be made available.

Figure 2. Shelter designs.

Habitat Enhancement

Revegetation and addition of logs and rocks.

Figure 3. Habitat Enhancement.

Fauna Management Plan for the Vasse Diversion Drain Upgrade
Bamford Consulting Ecologists
September 2020