Growling Grass Frog Masterplan for Melbourne's Growth Corridors

Melbourne Strategic Assessment

VICTORIA State Government | Environment, Land, Water and Planning

Cover: Growling Grass Frog basking on rock (Merri Creek). Photo by Rob Valentic www.gondwanareptileproductions.com

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High quality instream habitat for Growling Grass Frogs (Merri Creek). Photo by Kathy Preece

Executive summary

The Growling Grass Frog *Litoria raniformis* is listed as a threatened species under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

The *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* (DEPI 2013a) identified measures for protecting, enhancing and connecting important populations of Growling Grass Frogs within conservation areas and mitigating the losses of habitat that will occur as a result of urban development in Melbourne's growth corridors approved under the strategic assessment.

The purpose of the *Growling Grass Frog Masterplan for Melbourne's Growth Corridors* (Masterplan) is to provide guidance on implementing protection measures and investing in habitat creation and enhancement within Growling Grass Frog conservation areas.

The Masterplan consists of a package of linked components:

- two design standards that update the *Sub-regional Species Strategy for the Growling Grass Frog* (DEPI 2013b) guidance on habitat construction and design of infrastructure crossing conservation areas;
- high level priority reaches for habitat creation; and
- Areas of Strategic Importance mapping to inform decision making for the protection of existing and potential breeding habitat.

The *Growling Grass Frog Habitat Design Standards* underpin planning to protect existing habitat and create a network of reliable breeding wetlands to support connected populations of Growling Grass Frog in conservation areas.

Growling Grass Frog (*Litoria raniformis*). Photo by Geoff Heard, University of Melbourne

A strategic prioritisation process that included an innovative Growling Grass Frog population model was used to select scenarios that would maximise the benefits (in terms of numbers of wetlands occupied over the long term) of investment. The aim of the prioritisation is to ensure that funds collected from those developing land are invested to mitigate the loss of habitat caused by urban development in the most effective way.

The prioritisation process showed that the biodiversity outcomes are most effectively delivered by creating clusters of wetlands that will support metapopulations (multiple populations linked by migration) in the most important waterways for Growling Grass Frogs. Ten high priority reaches were selected within five waterways across the four growth areas. Most investment will occur in the two waterways with the lowest risk of extinction and greatest capacity to support multiple metapopulations: Merri Creek and Kororoit Creek. One cluster will be created in each of the conservation areas along the Werribee River, Jacksons Creek and Cardinia Creek where there is good capacity to support a metapopulation and connectivity to other suitable habitat.

The areas outside the high priority reaches will not receive investment in habitat creation. These medium and low priority reaches still contain valuable habitat and populations of Growling Grass Frogs that contribute to the persistence of the species, but the prioritisation process showed that additional wetlands constructed here would be less effective overall than creating clusters in the high priority reaches.

The primary purpose of Areas of Strategic Importance mapping is to protect existing and potential breeding habitat within Growling Grass Frog conservation areas from incompatible uses. The maps will help planners and those developing land to avoid and minimise impacts of infrastructure on the most critical parts of the Growling Grass Frog conservation areas.

Introduction

Growling Grass Frog conservation under the Melbourne Strategic Assessment

The Growling Grass Frog *Litoria raniformis* is listed as a threatened species under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. It was once one of the most common frogs in south-eastern Australia but has suffered a substantial decline in range and abundance in recent decades (Clemann and Gillespie 2012). Numerous threatening processes are thought to contribute to this decline, and several of them may be mutually reinforcing (Box 1).

The Commonwealth Government has approved urban development under the Melbourne Strategic Assessment on condition that, among other things, actions are undertaken in accordance with the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* and *Sub-regional Species Strategy for the Growling Grass Frog*.

The Victorian Government has committed to ensuring the persistence of the Growling Grass Frog within the Melbourne Strategic Assessment program area. The *Program Report: Delivering Melbourne's newest sustainable communities* (DSE 2009), which specifies the program and identifies the processes and mitigation measures for the Melbourne Strategic Assessment program, outlines the activities to:

> Maintain functioning sustainable populations of … Growling Grass Frog within and adjacent to the growth corridors with connectivity between populations. Protect and enhance … important populations of Growling Grass Frog that occur within the growth corridors.

The *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* identified Growling Grass Frog conservation areas that must be protected and enhanced in order to achieve the conservation outcomes for Growling Grass Frog. The *Sub-regional Species Strategy for the Growling Grass Frog* noted that:

> Growling Grass Frog populations and habitats within … the growth corridors need to be protected and managed on a landscape level and also on a patch or population level, where frogs have the capacity to move within and between sites. The greatest opportunity to achieve this outcome is by protecting key waterways with large buffers that allow for protection and creation of additional breeding habitat with sufficient area for foraging and dispersal between sites.

The Growling Grass Frog conservation areas (CA) are based on the following waterways which were identified in the *Sub-regional Species Strategy for the Growling Grass Frog* as containing important populations and habitat required for Growling Grass Frog persistence:

- CA 14 - Lollypop Creek, Werribee River and Davis Creek
- CA 15 - Kororoit Creek and tributaries
- CA 21 - Jacksons Creek and Emu Creek
- CA 34 - Merri and Kalkallo creeks and their tributaries; Darebin Creek
- CA 36 - Clyde Creek, Cardinia Creek, Gum Scrub Creek and Toomuc Creek.

Box 1 Threatening processes affecting the Growling Grass Frog

- Permanent removal of habitat through constructing infrastructure, draining wetlands and filling quarry pits
- Changed hydrological regimes, including timing, frequency, volume and speed of flows
- Aquatic vegetation changes, including frequent scouring of vegetated pools or overgrowth due to increased nutrients
- Poor water quality, including nutrients, pesticides, detergents and heavy metals, particularly affecting tadpole survival
- Fatal disease caused by the chytrid fungus
- Predation by introduced fish
- Loss of connectivity between habitats, including barriers posed by roads, other infrastructure or unsuitable habitat
- Too much dense terrestrial vegetation, and shading of pools
- Grazing damage to wetland margins, including removal of vegetation and shelter, and reduction in water quality

The *Sub-regional Species Strategy for the Growling Grass Frog* established a strategic approach to protecting existing habitat first, then enhancing habitat in the vicinity of wetlands occupied by the Growling Grass Frog, and finally creating new habitat to compensate for losses incurred by urban development. It set out a range of protection and mitigation measures for Growling Grass Frog conservation areas, including:

- protecting and managing conservation areas in perpetuity, with dedicated habitat and corridor function as the priority;
- providing extensive areas of habitat including a network of existing and constructed wetlands connected by dispersal routes;
- achieving a hydrological regime beneficial to both the waterway and to the long-term use of these areas by Growling Grass Frogs;
- sensitively siting compatible infrastructure such as shared trails and viewing areas; and
- developing standards for habitat construction.

Purpose of the Growling Grass Frog Masterplan

The Department of Environment Land, Water and Planning (DELWP) has prepared this Masterplan to provide guidance on:

- the implementation of habitat protection measures outlined in the *Sub-regional Species Strategy for the Growling Grass Frog*; and
- investment in creating and enhancing habitat within Growling Grass Frog conservation areas to mitigate the impacts of urban development.

The *Sub-regional Species Strategy for the Growling Grass Frog* required:

> an overall implementation Masterplan for the network of conservation areas across Melbourne's growth corridors, focused primarily on metapopulation nodes. This will draw on the best available science to prioritise and optimise strategic management actions based on available resources, adaptive management principles and the results of monitoring. These management actions... eventually will form the basis of detailed management plans for individual sites.

The Masterplan provides the implementation framework for Growling Grass Frog conservation areas by updating habitat and crossing design standards, identifying the most important core areas for protection, and selecting high priority reaches for investment in habitat creation. The Masterplan is not a "blueprint" that specifies wetland layouts within high priority reaches. Site-specific planning will be needed when making those decisions in the future.

The Masterplan updates some elements of the *Sub-regional Species Strategy for the Growling Grass Frog*, particularly the habitat design standards that underpin the investment prioritisation. These standards also set out habitat protection and threat abatement measures that are key elements of the Growling Grass Frog conservation program.

The Masterplan will also inform implementation decisions about habitat works, boundary changes and infrastructure in Growling Grass Frog conservation areas under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors*.

The Masterplan consists of a package of linked components (Figure 1):

- this report which provides an overview of the package components;
- design standards for Growling Grass Frog habitat;
- design standards for crossings through conservation areas;
- high level investment priority reaches for habitat creation (Appendix 1 of this report); and
- mapping of the Areas of Strategic Importance within Growling Grass Frog conservation areas (Appendix 2).

Growling Grass Frog on Common Water-ribbons *(Cycnogeton procerum)*. Photo by Geoff Heard, University of Melbourne

Figure 1 Masterplan components and context

Legislation and policy framework

Environment Protection and Biodiversity Conservation Act 1999

The approvals made under s146B of the *Environment Protection and Biodiversity Conservation Act 1999* for urban development in Melbourne's growth corridors, and the conditions of these approvals

Biodiversity Conservation Strategy for Melbourne's Growth Corridors (2013)

Sub-regional Species Strategy for the Growling Grass Frog (2013)

Growling Grass Frog Masterplan for Melbourne's Growth Corridors

Investment prioritisation

High priority reaches

Growling Grass Frog conservation area standards

Crossing design

Habitat design

Growling Grass Frog habitat

Existing waterbodies

Potential wetland locations

Areas of Strategic Importance mapping

Decision making

Works in conservation areas

Boundary changes

Growling Grass Frog habitat creation

Information on Growling Grass Frog ecology, threatening processes and management approaches

Research, monitoring, modelling, expert advice

Good habitat for Growling Grass Frogs. Photo by Geoff Heard, University of Melbourne

Design standards for Growling Grass Frog conservation areas

Habitat and connectivity objectives

The *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* and *Sub-regional Species Strategy for the Growling Grass Frog* addressed some of the threatening processes that are likely to be contributing to the decline of the Growling Grass Frog in the Melbourne growth corridors, but identified the need for further information and standards for some issues.

The two design standards included in this Masterplan package update relevant guidance in the *Sub-regional Species Strategy for the Growling Grass Frog* and its supporting documents, to ensure that the habitat and connectivity objectives can be met in cost effective ways.

Growling Grass Frog habitat design standards

The *Growling Grass Frog Habitat Design Standards* (DELWP 2017a) provide updated information to support both:

- the implementation of habitat protection measures outlined in the *Sub-regional Species Strategy for the Growling Grass Frog*; and
- investment in creating and enhancing habitat to compensate for the impacts of urban development.

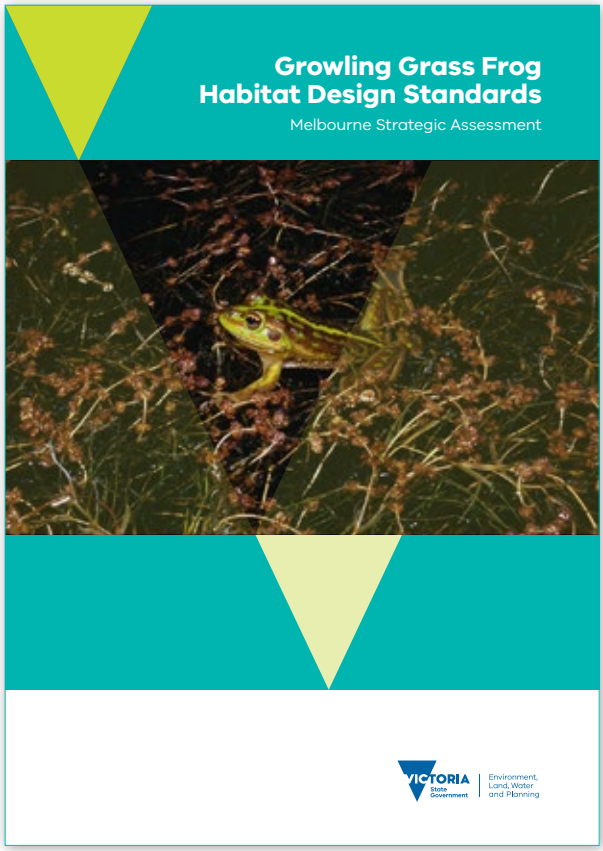
The standards apply to the creation of dedicated Growling Grass Frog wetlands and adjacent terrestrial habitat within conservation areas established under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors*. They do not apply to stormwater wetlands or other types of waterbodies such as lakes built for amenity purposes.

The habitat design standards are informed by contemporary studies of Growling Grass Frog occupancy and breeding in a variety of habitats including creek pools, swamps, quarry pits, farm dams and stormwater assets (sediment ponds and treatment wetlands). They incorporate new research on the factors affecting the species' susceptibility to the chytrid fungus disease. Much has also been learnt from observations of wetlands constructed in the Melbourne area over the past 15 years,

particularly the loss of Growling Grass Frog populations from waterbodies that became dominated by dense emergent reeds and rushes.

The *Growling Grass Frog Habitat Design Standards* are based on the following principles.

- Achieve "metapopulation capacity" by creating clusters of breeding wetlands to support multiple interacting populations;
- Replicate the microclimate, physical and chemical attributes of successful Growling Grass Frog habitat, especially "anti-chytrid" features such as rocky perimeters with warm and moderately saline water, without requiring intensive management;



- Ensure that new wetlands are large enough to provide extensive areas of permanent deep water containing dense submergent vegetation, and avoid overgrowth of emergent reeds and rushes;
- Provide drainage infrastructure to allow water levels in wetlands to be manipulated as required to provide optimal ecological conditions, and also to allow wetlands to be dried out when required for management purposes; and
- Prevent predatory fish entering the wetlands from stormwater systems or floods by providing structures such as gravel filters and embankments, respectively.

The *Growling Grass Frog Habitat Design Standards* provide detail on the following issues.

- Cluster design: each cluster should contain at least 10 breeding wetlands, although smaller clusters may be acceptable in shorter reaches (where there are fewer opportunities for wetland creation) provided that there are other clusters along the waterway. The cluster total includes existing waterbodies to be expanded and/or enhanced, but does not include instream pools or billabongs that are likely to be frequently inundated because of the higher risk that these will become unsuitable for breeding. Wetlands in the cluster should be within easy migration distance, preferably no more than 200-300 metres apart where feasible;
- Water supply: at least three-quarters of the wetlands in a cluster should be permanent, and as many as possible should hold water over the breeding season (September to February). Ideally water levels should draw down over late summer and autumn to support healthy ecological processes in the littoral zone. Groundwater of moderate salinity should be provided wherever feasible.
- Predator control: wetlands should be constructed above at least the 10year and preferably the 20year flood line. A fish exclusion filter (for example, a gravel bed) must be incorporated in the connection between stormwater systems and Growling Grass Frog wetlands to prevent predatory fish from entering. Drainage infrastructure must be provided to enable Growling Grass Frog wetlands to be easily dried out to control predatory fish;
- Wetland size: most of the wetlands in a cluster should be around 0.3 hectares in order to provide at least 0.1 hectares of deep (greater than 1.5 metres) water over the long term. Where possible, at least one wetland in a cluster should be large (or two standard sized wetlands could be combined);
- Anti-chytrid attributes: wherever feasible, rock piles should be placed around the perimeter to warm the shallow waters to assist Growling Grass Frogs to combat chytrid fungus infection. Where appropriate, excavated soil should be used to create embankments to protect wetlands from cold winds;
- Aquatic vegetation: dense submergent vegetation is critical for Growling Grass Frogs. A diversity of vegetation in the littoral zone is preferable; and
- Terrestrial habitat: shading of Growling Grass Frog wetlands should be avoided, especially in the areas designed for warm anti-chytrid properties. Short vegetation with an open structure is preferred; any shrub and tree plantings should be sparse, and mulch should not be used within 50 metres of the wetlands.

The *Growling Grass Frog Habitat Design Standards* will be updated as necessary to incorporate the results of monitoring, scientific research and practical experience gained from implementation.

Growling Grass Frog crossing design standards

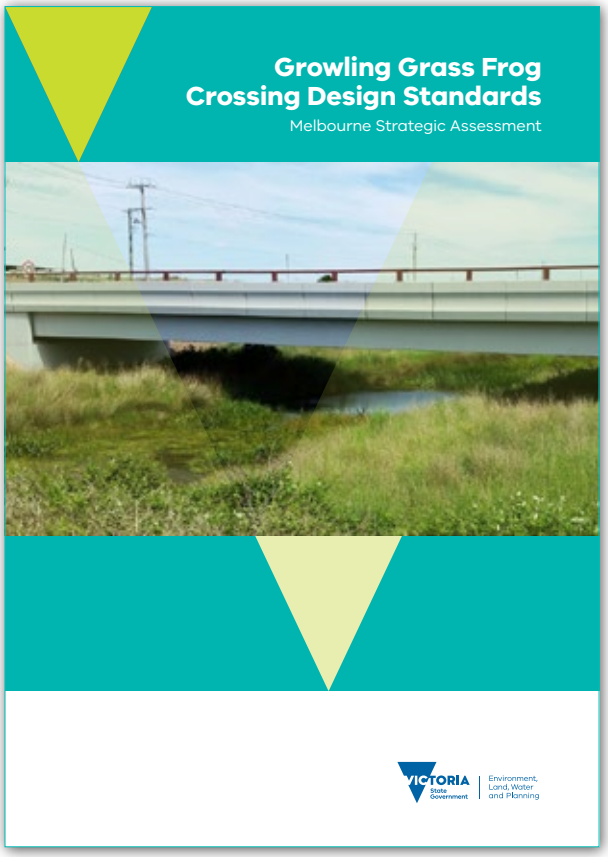
The *Sub-regional Species Strategy for the Growling Grass Frog* referred to the need for transport infrastructure (roads and railway lines) through conservation areas to be appropriately designed to meet conservation objectives. Crossings can have several potentially significant impacts on conservation areas, the most serious of which is creating a barrier between populations and disrupting the metapopulation dynamics that are essential for the long-term viability of the Growling Grass Frog.

Research on Growling Grass Frog population genetics in the Merri Creek catchment showed that urban infrastructure, including roads, created a barrier to movement between the populations.

The purpose of the *Growling Grass Frog Crossing Design Standards* (DELWP 2017b) is to ensure that there is the minimum number of crossings possible over a reach, the impact on existing habitat is reduced, and crossings are designed to enable Growling Grass Frogs to easily pass under, so that metapopulation dynamics can be maintained. The *Growling Grass Frog Crossing Design Standards* apply to all Growling Grass Frog conservation areas and any adjacent sections of waterway that have been identified as Nature Conservation areas under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors*.

The *Growling Grass Frog Crossing Design Standards* incorporate the best available research and expert opinion to provide detailed guidance on the following issues.

- Type of crossing structure: whether a bridge and/or culverts are most appropriate for a site, based on stream order, topography, flood conveyance and river health requirements and importance of the area for Growling Grass Frog. Higher bridges with a wide span pose the least barrier, and are preferred wherever possible. Where a bridge is not feasible, wide arched culverts that preserve the natural stream floor are recommended. Box culverts are the least likely to provide easy movement for Growling Grass Frog because the internal conditions are generally cold and dark, unless they sit within a waterbody through which frogs and tadpoles can swim;
- Dimensions of each crossing: structures over waterways must provide some ability for Growling Grass Frogs to move through dry areas during frequent peak flows – a minimum of two metres on each bank above the three month average recurrence interval level. Structures in terrestrial areas should be wide and high enough to provide suitable conditions for frogs;
- Distance between openings under a crossing: maximum 50 metres. An opening is likely to be required on a dispersal route between breeding wetlands; and
- Total proportion of the barrier that is open for movement under a crossing: varies depending on the ease of movement through the structure, and the importance of the site for Growling Grass Frog. The targets are: 30 per cent of the section of road 50 metres each side of the waterway must be open for passage if the whole opening is provided by a bridge; 40 per cent if constructing arched culverts or permanently inundated box culverts; 50 per cent if using regular box culverts that are normally dry.



The *Growling Grass Frog Crossing Design Standards* will be updated as necessary to incorporate the results of monitoring, scientific research and practical experience gained from implementation.

Figure 2 Growling Grass Frog conservation area overview

Priorities for investment of habitat compensation funds in Growling Grass Frog wetlands

The investment prioritisation process

The *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* sets out the conservation measures required for Victoria to satisfy the commitments made to the Commonwealth Government under the Melbourne Strategic Assessment Program. The conservation measures are funded from contributions from developers that pay for the cost of mitigating the loss of habitat resulting from urban development.

For Growling Grass Frog, funds collected from developers will be used for habitat actions in the Growling Grass Frog conservation areas established under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors*. The precincts that were approved prior to 1 March 2012 are not included in the investment prioritisation because they already have individual contribution arrangements and habitat protection and creation plans in place.

The main habitat actions are to construct new wetlands and enhance existing waterbodies through measures such as revegetation, addition of rocks or supply of water. Management of these wetlands and the adjacent terrestrial habitat will be funded for 10 years through fees collected from developers.

The *Sub-regional Species Strategy for the Growling Grass Frog* identified the need to draw on the best available science to prioritise habitat actions, based on available resources, adaptive management principles and the results of monitoring.

The primary purpose of the investment prioritisation process is to identify the parts of the conservation areas (reaches) that will receive funding through the Melbourne Strategic Assessment for Growling Grass Frog habitat creation and enhancement. These actions will complement the protection actions in the conservation areas. This approach manages program implementation risks by identifying the most cost-effective combinations of actions in suitable geographical locations and allowing for uncertain timing, while minimising development constraints and costs where possible.

The investment prioritisation process involved three main steps:

1. mapping all existing habitat and potential future wetland locations;
2. using population modelling to help identify cost-effective wetland creation scenarios designed to maintain Growling Grass Frog metapopulations; and
3. applying risk-based criteria to determine the relative priority for wetland creation of reaches within all Growling Grass Frog conservation areas.

Mapping existing and potential future wetland locations

Approach

The project team led workshops with small groups of experts covering the fields of Growling Grass Frog ecology, hydrology including stormwater design, wetland restoration and waterway corridor management.

The workshop groups considered a range of information sources including aerial imagery, published literature and more recent research results, survey data, mapping and expert opinion. The DELWP draft habitat design standards informed the size, spacing and water quality aspects of the task.

As the aim was to identify high level investment priorities across the full suite of growth corridors, a broad approach was initially taken to identifying existing and potential wetland locations in all Growling Grass Frog conservation areas.

All waterways within Melbourne's growth corridors were assumed to be of great significance to Traditional Owners, and Aboriginal Cultural Heritage. Traditional Owners will be respectfully consulted in the planning and development stages of each wetland construction project, and appropriate Cultural Heritage Management Plans will be developed and adhered to.

Identifying existing habitat

Existing waterbodies including instream pools were mapped using available data or, where this was not available, by examining aerial imagery, contour data and relevant reports. The availability of aerial imagery taken during different seasons and years allowed a preliminary assessment of wetland permanence (scored on a four-point scale following Heard *et al.* 2013). The presence of dense reeds and rushes around the wetland perimeters could be detected, but the cover of other types of aquatic vegetation could not be determined from imagery.

Most existing off-stream waterbodies within the Growling Grass Frog conservation areas were assumed to persist post-development, unless their location was known to make this unlikely (for example, those under proposed new roads or adjacent to existing roads that will be widened).

Existing off-stream waterbodies outside the Growling Grass Frog conservation areas were identified as likely to be either retained or lost post-urbanisation, mainly on the basis of their location and expected water supply. Most retained waterbodies were farm dams outside the urban

growth corridors, but some were in different types of conservation area, reserve, park, waterway corridor or naturally undevelopable land within the urban growth areas.

Existing retained waterbodies within one kilometre of Growling Grass Frog conservation areas were included in the modelling because Growling Grass Frogs have been recorded travelling such a distance. However only the waterbodies closer to wetland locations within the conservation areas would usually influence the results.

Identifying opportunities for habitat creation

The expert groups aimed to identify potential locations for enhancing, expanding (in area and/or depth) and creating wetlands consistent with the draft standards for Growling Grass Frog habitat design. The preferred layout of medium sized (0.3 hectare) and some larger wetlands, each no more than 200-300 metres apart, could not always be met because of the width or topography of the conservation area; in these cases the next best (smaller or further apart) locations were identified.

The *Growling Grass Frog Habitat Design Standards* recommend a variety of water sources with a preference for groundwater because of its association with lower rates of chytrid fungus infection. Preliminary information from Melbourne Water indicated that groundwater of an appropriate salinity range occurs at reasonable depths in all growth corridors apart from the southeast. In the absence of detailed information about the availability and cost of groundwater or other sources of cleaner water, the expert groups took a cautious approach and ensured that many locations would be likely to have a secure supply of treated stormwater post-urbanisation. Nevertheless, opportunities to create large, warm rocky groundwater-fed wetlands well outside of the flood zone should be given priority in the configuration of wetland clusters.

Uncertainty regarding location and timing of wetland construction was addressed by adopting a precautionary approach: retaining enough suitable options to provide a low risk "safety margin" in the likely event that some locations will be unsuitable when the time comes to construct wetlands. To provide this "safety margin", the Masterplan identifies enough sites for all the proposed new wetlands to be constructed including a 50 per cent contingency that can be used if any sites are discovered to be unsuitable – that is, one contingency for every two sites identified for the construction of new wetlands.

Prior to wetland construction, these potential wetland locations will be included within Areas of Strategic Importance, meaning no other works or infrastructure associated with urban development will be constructed at these locations without the approval of the Commonwealth Minister for the Environment. Potentially suitable locations within Growling Grass Frog conservation areas but outside Areas of Strategic Importance are not precluded from use for new wetlands in the future, except where DELWP has agreed to stormwater assets or other infrastructure at those locations.

Modelling to identify cost-effective locations for new wetlands

Metapopulation model

Existing models for the metapopulation dynamics of Growling Grass Frogs in the Merri Creek corridor (Heard *et al.* 2012, 2013) explained the processes of local extinction and colonisation of wetlands by populations of the Growling Grass Frog, based on a comprehensive dataset tracking the occupancy of a large number of wetlands in the Merri Creek corridor.

The probability that an occupied wetland becomes vacant (because the population of Growling Grass Frogs goes extinct) during a given 12 month period is related to its area, hydroperiod, cover of aquatic vegetation and connectivity to neighbouring wetlands. Conversely, the probability that a vacant wetland is colonised (becomes occupied) by Growling Grass Frogs during a given 12 month period is related to its connectivity to neighbouring wetlands.

This metapopulation model underpins the numerical modelling method that was developed to select preferred sets of habitat creation locations with maximised conservation benefits.

Modelling method

A process was devised for making decisions about where to direct investment in habitat creation in order to maximise the conservation benefits to populations of the Growling Grass Frog within the Melbourne Strategic Assessment area. Benefits were defined as improvements in the modelled probability of extinction; these relative changes in modelled risk were deemed sufficiently robust for the purpose of the analysis.

The modelling method simulates the extinction and colonisation dynamics of the wetlands included in the input dataset, given the location and habitat attributes of each wetland and the barriers between them. The objective is to find the most cost-effective (greatest improvement in extinction risk) combinations of wetland locations. The relative risks of scenarios are expressed as the mean minimum number of occupied wetlands across the replicate runs, following Heard *et al.* (2013).

For the purposes of this initial overall prioritisation, the input dataset consisted of the following types of wetlands in all four growth corridors:

- existing retained waterbodies inside and adjacent to Growling Grass Frog conservation areas; and
- potential locations for new wetlands (designed in accordance with the standards) within Growling Grass Frog conservation areas.

The habitat attributes included in the input wetland dataset were:

- hydroperiod: ephemeral or permanent; and
- aquatic vegetation cover: low (30 per cent) or high (70 per cent).

The analysis also takes into account the potential effect of any roads or railway lines on dispersal between wetlands, as it is highly likely that such infrastructure provides an impediment to the colonisation of vacant wetlands. The barrier effect is simply expressed as a distance penalty on dispersal that involve crossing a road or railway between wetlands. In order to explore the influence of different barrier effects, a distance penalty of 250 metres was applied to represent a moderate strength barrier, and 1,000 metres to represent a near-complete barrier to dispersal.

The aim of applying the habitat and crossing standards is to achieve the following preferred combination of attributes for most Growling Grass Frog wetlands:

- permanent hydroperiod: most constructed Growling Grass Frog wetlands will have reliable sources of stormwater or groundwater. However some existing retained waterbodies have been identified as ephemeral based on their expected water supply post-urbanisation;
- moderate to high cover of aquatic vegetation, although this is likely to naturally fluctuate over time; and
- moderate barrier effect: upgrades of existing roads and new roads to be built as part of urban development in the growth areas should provide connectivity.

Given the uncertainty about the likely quality of created habitat and ease of movement under crossings, a prudent approach was taken in modelling different combinations of the above values. This provided an understanding of the potential effect of, for example, drought (assuming most wetlands are ephemeral and vegetation quality is low), lack of movement under crossings (assuming the barrier effect is high) or lack of aquatic vegetation. The results consistently showed that hydroperiod and the barrier effect of crossings influenced selections more strongly than did the cover of aquatic vegetation.

The modelling method was applied to each Growling Grass Frog conservation area under hypothetical construction "budgets" of 50, 100 and 150 wetlands in order to detect patterns in wetland selections under the different combinations of attributes.

The outputs of the modelling were:

- a map for each combination of habitat attributes under each "budget" showing the most cost-effective wetland locations found during 250 modelling runs iterated over a 50 year period; and
- estimated extinction risks based on the modelled parameters, expressed in a variety of ways. The most useful for Masterplan purposes is the probability of the minimum number of occupied wetlands persisting in the conservation area falling below 20.

Method for determining investment priority reaches

The following process was applied to determine priority reaches for investment in Growling Grass Frog wetland creation and enhancement.

1. Determine the importance of each reach for Growling Grass Frog populations, considering the following information (in descending order of influence):
    a. whether the reach is known or likely to support a metapopulation, based on the metapopulations identified by Biosis Research (2012) along with more recent distribution and habitat information;
    b. whether the reach provides connectivity between known or likely metapopulations; and
    c. the availability of other habitat adjacent to the reach and accessible to Growling Grass Frogs.
2. Consider the number of wetland locations selected in the 100-wetland modelling, taking into account any existing waterbodies suitable for enhancement. Focus on the preferred combination of attributes (permanent wetlands with moderate barriers created by roads and railway lines) but also consider the results for all the different combinations of attributes, to ensure that decisions take into account more challenging conditions such as drought and inability to pass under roads.

3. Identify reaches that have the capacity to support a metapopulation by providing a cluster of eight to 10 wetlands, taking into account existing retained waterbodies and especially those that would be suitable for enhancement. The *Growling Grass Frog Habitat Design Standards* defined 10 as the preferred minimum number of wetlands to support a metapopulation over the long term. However in some cases, such as short reaches with other habitat available along the waterway, a smaller cluster may be acceptable. This step consisted of manually reallocating some outlier wetland locations (where metapopulation capacity clearly could not be achieved) into reaches where the model favoured the formation of a cluster.

4. Check the modelled risk of extinction for the combined set of retained waterbodies plus the new and enhanced wetlands selected at item 2. These relative extinction risks were modelled for the initial selection of new wetland locations plus the retained waterbodies within and outside the conservation area, but not the subsequently refined metapopulation cluster approach.

Note on risk modelling: It is important to note that the extinction risk modelling is based on only the attributes included in the model (a subset of all the threatening processes operating on Growling Grass Frogs). In some areas, risks were underestimated due to the influence of a large number of farm dams on adjacent land outside the urban growth boundary; this was particularly pronounced in the topmost reach of Merri Creek where there are numerous farm dams of poor quality largely due to their location in sedimentary (rather than volcanic) soils. Appropriate adjustments were made to the results to reflect this.

The criteria for determining the priority of each reach were:

High priority reaches

1. Existing or potential metapopulation **or** connection between two existing or likely metapopulations;

2. At least four locations for wetland creation or enhancement selected in at least half of the modelled attribute combinations;

3. Metapopulation capacity – the opportunity to create a viable cluster of eight to 10 wetlands; and

4. Modelled extinction risks relatively low under at least the preferred combination of attributes (noting that the preliminary risk estimates apply to the initial modelling results and are likely to be lower for the completed clusters).

Medium priority reaches generally did not contain or connect existing or potential metapopulations, had limited capacity to create a cluster of eight to ten wetlands and were at moderate risk of metapopulation extinction because of their isolation.

Low priority reaches did not contain or connect existing or potential metapopulations, had very few (if any) locations selected by the modelling, and presented little opportunity to create a viable cluster of wetlands.

Constructed wetland with fringing Salt Club-rush (*Bolboschoenus caldwellii*) and submergent pondweed. Photo by Daniel Gilmore, Biosis Pty Ltd

Investment prioritisation within Growling Grass Frog conservation areas

The modelling favoured creating clusters of wetlands, particularly in the vicinity of existing waterbodies, rather than improving connectivity between (inadequate) clusters. This reflects the need for robust metapopulations that will be viable over the long term, even if migration between metapopulations could be limited to wetter years.

Ten high priority reaches were identified (Appendix 1) under the expected allocation of funds, based on cost estimates for the preferred Growling Grass Frog wetland concepts described in the habitat standards. Some portions of these reaches are not suitable for the creation of Growling Grass Frog wetlands (because they contain native vegetation or other important biodiversity values) and will not receive funds for habitat creation. The high priority reaches were selected to provide enough opportunities to create clusters of Growling Grass Frog wetlands outside these unsuitable portions of the waterways.

The prioritisation process concluded that there should be:

- a high level of investment in the two waterways with the lowest risk of extinction and greatest capacity to support multiple metapopulations (four reaches in Merri Creek and three in Kororoit Creek), thereby spreading risk within and between these two most important catchments; and
- one cluster in each of the next best waterways where there is good capacity to support a metapopulation and connectivity to other suitable habitat in the conservation area (Werribee River, Jacksons Creek and Cardinia Creek), thereby spreading risk across the whole system of conservation areas in the urban growth corridors.

The 10 high priority reaches are described in Table 1. Based on estimates of the costs of constructing the various wetland designs and enhancing retained waterbodies, the results indicate that up to 93 wetlands could be provided in these 10 high priority reaches: 11 are existing waterbodies that are suitable for enhancement, two are existing wetlands that may need to be expanded or deepened, with the balance of up to 80 new Growling Grass Frog wetlands to be constructed. Final wetland numbers and designs will depend upon local site conditions, availability of suitable quality and quantities of water, and budget variables.

Table 1 High priority reaches for investment in Growling Grass Frog wetlands

Werribee River	**Conservation area 14, western growth corridor**
Description	Single reach based on Biosis Research's (2012) potential metapopulation, now known to be an existing metapopulation. Breeding habitat is provided by the turkey nest dams that are periodically filled and drawn down for irrigation purposes. The high priority reach extends far enough upstream to provide enough options to create a cluster and spread risk.
Modelling results	The existing large dams on the floodplain had a very strong influence on the results. The combination of a suite of new wetlands and the existing waterbodies produced low modelled risks of extinction, regardless of the combination of attributes.
Associated habitat outside the conservation area	Large open space and retarding basins/wetlands on this floodplain; proposed Regional Park; existing Presidents Park immediately downstream of the high priority reach.
Investment approach subject to land availability	Create a cluster of 10 wetlands by enhancing three existing farm dams and constructing up to seven new wetlands.
Kororoit Creek	**Conservation area 15, western growth corridor**
Description	Three high priority reaches based on Biosis Research's existing and potential metapopulations.
Modelling results	Kororoit Creek received the second largest number of wetland locations in the modelling, and very low extinction risks. Many locations were selected in the reach based around the Deanside Wetland area, and another cluster around the large wetland on Beattys Road towards the western end of the conservation area. Lower numbers were selected in reach 3, mainly because fewer opportunities for habitat creation were initially identified due to the low-lying flood-prone topography.
Associated habitat outside the conservation area	Extensive open space and drainage reserves on the floodplain adjacent to reach 3.
Investment approach subject to land availability	Reach 2: Create a cluster of up to 10 wetlands by enhancing three existing wetlands (the two Deanside Wetlands and associated lignum swamp) and constructing up to seven wetlands. Reach 3: Opportunities limited by the extensive low-lying area. Create a connecting corridor of up to six wetlands on the higher land above the frequently inundated area by expanding one wetland and constructing up to five wetlands. Reach 4: A short reach based around a large swamp that is high quality breeding habitat when wet. Create a cluster of up to eight wetlands by enhancing the existing large wetland and constructing up to seven wetlands.
Jacksons Creek	**Conservation area 21, north-western growth corridor**
Description	Single reach includes Biosis Research's potential metapopulation based around an old quarry. There are three existing waterbodies suitable for enhancement, one of which is a large turkey nest dam on the higher ground above the quarry pit. The high priority reach extends far enough upstream to provide enough options to create a cluster and spread risk.
Modelling results	The modelling selected the third highest number of wetlands in Jacksons Creek but they were relatively scattered, partly because of the limited opportunities in narrow reaches. Consolidation of wetlands into reach 1 allowed for a cluster incorporating the existing waterbodies. The modelled risks of the initial selections depend on wetland attributes, but are relatively good under the expected permanent water supply scenarios.
Associated habitat outside the Growling Grass Frog conservation area	Holden Flora and Fauna Reserve and areas retained for landscape values adjacent to the conservation area.
Investment approach subject to land availability	Create a cluster of up to 10 wetlands by enhancing the three existing waterbodies and constructing up to seven wetlands.

Merri Creek	Conservation area 34, northern growth corridor
Description	Four high priority reaches based on Biosis Research's existing metapopulations. A portion of Merri Creek Reach 4 is a Nature Conservation area because of its very high biodiversity values, and is therefore unsuitable for wetland construction.
Modelling results	The modelling selected the greatest number of locations in Merri Creek, regardless of wetland and road barrier attributes, and determined it to be the lowest risk waterway.
Associated habitat outside the conservation area	Very large grassland reserve to the south. Large conservation area adjacent to reach 4.
Investment approach subject to land availability	Reach 2: Create a cluster of up to 10 new wetlands. Reach 3: A very long reach with existing Growling Grass Frog populations around the confluence with Kalkallo Creek and the mineral springs and large dam upstream. Create a cluster of up to 13 wetlands by enhancing/expanding two wetlands and constructing up to 11 new wetlands. Reach 4: Fewer opportunities because the Nature Conservation area is usuitable for wetland creation; however it contains high quality breeding habitat. Create a cluster of up to eight new wetlands outside the Nature Conservation area portion of the reach. Reach 5: A small reach with fewer opportunities. Create a cluster of up to eight new wetlands.
Cardinia Creek	**Conservation area 36, south-eastern growth corridor**
Description	Single reach based on Biosis Research's potential metapopulation in the southern half of the conservation area.
Modelling results	Southern half of the conservation area is clearly favoured despite the space constraints.
Associated habitat outside the conservation area	Growling Grass Frog wetlands required under earlier development approvals adjacent to the central portion of the conservation area. Grazing land adjacent to the conservation area outside the Urban Growth Boundary.
Investment approach subject to land availability	Create a cluster of up to 10 new wetlands.

Policy implications for high, medium and low investment priorities

The Growling Grass Frog conservation areas were established under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors* for protection and enhancement in order to achieve the conservation outcomes for this threatened species.

All conservation areas are protected for this purpose under the conditions of the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act* approvals, zoning and overlay restrictions in the relevant planning schemes, and in some cases, land management co-operative agreements

In addition, investment of Melbourne Strategic Assessment funds to increase the amount and quality of habitat will be strategically directed to high priority reaches identified in this Masterplan.

In high priority reaches, potential wetland sites will be protected from incompatible infrastructure to ensure that they are available when required in the future. To achieve this, DELWP has included these sites, along with existing habitat such as instream pools and off-stream waterbodies, within Areas of Strategic Importance.

Although medium priority and low priority reaches will not receive investment in new habitat creation, they contain valuable habitat and populations of Growling Grass Frogs that contribute to the persistence of the species under the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors*. For this reason, existing habitat in medium and low priority reaches are also included as Areas of Strategic Importance, primarily to inform decisions about proposed works in the conservation areas.

Areas of Strategic Importance for Growling Grass Frog habitat within conservation areas

Purpose of Areas of Strategic Importance

The *Biodiversity Conservation Strategy* states:

> Development that occurs as a direct result of urban development, such as transport infrastructure (e.g. roads, bridges), utility infrastructure and public facilities, will only be permitted within conservation areas with the agreement of [DELWP] and only after appropriate design and construction impact mitigation processes have been put in place.

The primary purpose of Areas of Strategic Importance mapping is to protect existing and potential breeding habitat within Growling Grass Frog conservation areas from incompatible uses. The Areas of Strategic Importance maps are intended to help planners and developers avoid and minimise potential impacts of proposed infrastructure on the critically important parts of the Growling Grass Frog conservation areas.

Regulatory requirement

Under condition 2 of the Commonwealth Government's approvals for urban development in Melbourne's growth corridors, actions resulting in a net loss of "habitat" for matters of national environmental significance require the agreement of the Commonwealth Minister for the Environment.

Growling Grass Frogs are highly mobile, and move freely over a wide variety of landscape and vegetation types, which could all broadly be classed as "habitat". For condition 2 to be practically applied in Growling Grass Frog conservation areas, a more specific definition of "habitat" is required.

The Commonwealth Government and DELWP have agreed that, for the purposes of condition 2, Growling Grass Frog "habitat" should be defined as the areas identified and mapped as Areas of Strategic Importance.

Areas of Strategic Importance are areas that:

- contain existing high quality habitat (currently or highly likely to contain key habitat attributes required for breeding as well as foraging and dispersal);
- contain existing medium quality habitat (currently supports one or more - but not all - key habitat attributes); or
- may be required for habitat creation or enhancement and associated (50 metre) buffers.

Areas of Strategic Importance mapping

Areas of Strategic Importance mapping (Appendix 2) aims to represent the most important components of the above definition: existing and potential breeding waterbodies and the surrounding terrestrial buffers that provide the closest foraging and refuge habitats.

- Areas of Strategic Importance (shaded blue) were mapped by measuring:
  - 50 metres from the Normal Water Level of existing wetland locations;
  - within high priority reaches, 50 metres from the Normal Water Level of the selected potential Growling Grass Frog wetland locations; and
  - instream habitat such as permanent pools.
- Terrestrial habitat buffers (shaded green) were mapped by measuring:
  - 50 metres from the boundary of Areas of Strategic Importance around existing and selected potential wetland locations; and
  - 100 metres from the centreline of streams.
- Other terrestrial habitat beyond the first 100 metres from streams is shaded yellow.

Dispersal routes between breeding waterbodies have not been specifically identified, although they will be critical to the ability of Growling Grass Frog populations to interact and therefore the long term viability of the species. Growling Grass Frogs generally take the most direct route between waterbodies, so suitable dispersal habitat should be provided along these routes. They are generally included in the terrestrial habitat buffer (shaded green) but will need to be considered carefully in infrastructure approval processes.

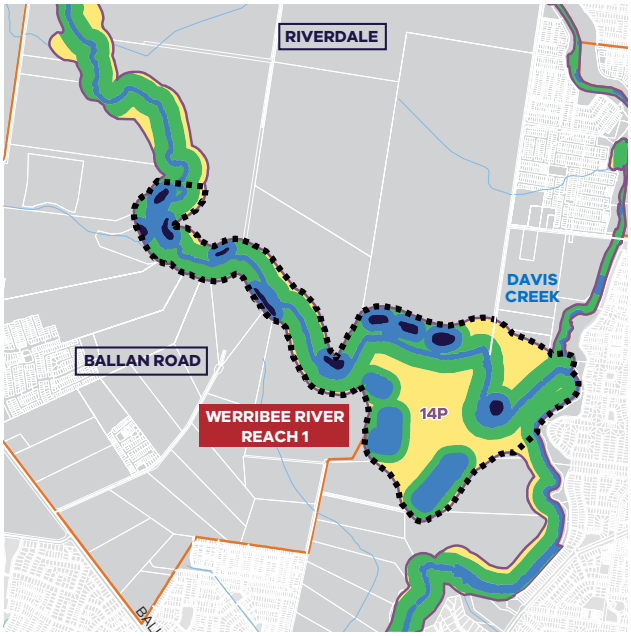
Decisions in Areas of Strategic Importance and terrestrial habitat buffers

Area of Strategic Importance mapping informs decisions about the location and design of infrastructure within Growling Grass Frog conservation areas. DELWP assesses the likely impacts of proposed infrastructure or boundary changes on Growling Grass Frog outcomes, and particularly on the existing or potential new habitat identified in Areas of Strategic Importance. DELWP is able to approve or reject a proposal if it will not impact on an Area of Strategic Importance. If DELWP determines that a proposal is likely to impact on an Area of Strategic Importance, the proposal is forwarded to the Commonwealth Minister for the Environment for approval or rejection.

The Areas of Strategic Importance (shaded blue) are the least suitable for infrastructure. Stormwater assets may be acceptable in some cases where it is shown that they will not have a negative impact on the construction of the Growling Grass Frog wetland in the Area of Strategic Importance. Functional design of stormwater management assets demonstrating integration with Growling Grass Frog objectives is usually required in these cases.

Terrestrial habitat buffers (shaded green) around the core Areas of Strategic Importance and along waterways may be suitable locations for compatible infrastructure provided that sufficient terrestrial habitat remains in the vicinity of the adjacent Area of Strategic Importance and instream waterbodies.

Other terrestrial habitat (shaded yellow) is generally the most suitable for compatible infrastructure as it is the furthest from the breeding wetlands and existing aquatic habitat at the core of the Areas of Strategic Importance. Growling Grass Frogs are still likely to use these other terrestrial habitat areas for foraging, over-wintering and dispersal, and conservation area objectives still apply.



Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location

Growling Grass Frog (*Litoria raniformis*). Photo by Geoff Heard, University of Melbourne

Implementation and review

Adaptive design

The *Sub-regional Species Strategy for the Growling Grass Frog* emphasised the importance of an adaptive management approach to Growling Grass Frog conservation area planning and management.

An adaptive approach will be taken to habitat creation to ensure that designs are rapidly improved and made more cost-efficient. For example, a cluster of wetlands may include a variety of wetland types with different water sources and wetting-drying cycles. Research and monitoring will enable scientists and land managers to identify the optimal designs and management regimes for Growling Grass Frog breeding success and long term persistence. Any changes to the delivery of the program due to findings from the experimental wetland designs, or from adaptive management processes, will still be delivered within the existing funding arrangements.

The metapopulation model underpinning the prioritisation process can also be used to compare different wetland layout scenarios, and estimate relative changes in extinction risk that would occur as a result of modelled habitat actions. This will be a valuable tool for conservation area managers seeking the most effective design for Growling Grass Frog habitat in high priority reaches in the light of new information about land availability, Aboriginal Cultural Heritage and Growling Grass Frog habitat and population changes.

Monitoring and review

Regular monitoring of Growling Grass Frog wetlands in conservation areas will be undertaken in accordance with the Melbourne Strategic Assessment's *Monitoring and Reporting Framework* (DELWP 2015).

The Masterplan will be reviewed at the same time as the first review of the *Sub-regional Species Strategy for the Growling Grass Frog*.

Glossary

chytrid fungus	*Bactrachochytrium dendrobatidis*, a widespread parasitic fungus that causes a fatal disease in amphibians, implicated in many species' declines in Australia and other parts of the world. It spreads within water and moist environments.
colonisation	The process by which a species establishes a new population in an unoccupied environment.
connectivity	The degree to which a corridor, network or matrix of wetlands is connected for Growling Grass Frogs. In practice, this usually refers to the capacity for physical movement, or gene flow for the species, through the landscape.
dispersal	The movement of Growling Grass Frogs through the landscape. Especially relates to movements between habitat patches, such as between waterbodies, or between aquatic and terrestrial micro-environments.
ephemeral	A non-permanent waterbody that generally fills and dries out annually with average rainfall.
floodplain	An area of low-lying ground adjacent to a river or stream, formed mainly of river sediments and subject to periodic flooding.
hydroperiod	The length of time in which a wetland holds standing water. Definitions of hydroperiod (from Heard *et al.* 2010): • Ephemeral - fills and dries out annually with average rainfall. • Semi-permanent - dries out only during years of below average rainfall. • Permanent – never dries out, regardless of rainfall.
littoral zone	The area of a wetland that is subject to regular wetting and drying as water levels change, usually seasonally.
metapopulation	A discrete cluster of Growling Grass Frog populations (each population within the cluster occupying a separate waterbody) which interact through dispersal.
Normal Water Level	The top of a permanent waterbody.
reach	A section of a waterway.
submergent vegetation	Aquatic plants rooted and with foliage below the water's surface.
terrestrial habitat	Land outside the wetland or stream margin. This may include native or non-native vegetation in which Growling Grass Frogs forage for food or move between waterbodies, and rocks or logs under which they seek refuge (including over the winter).

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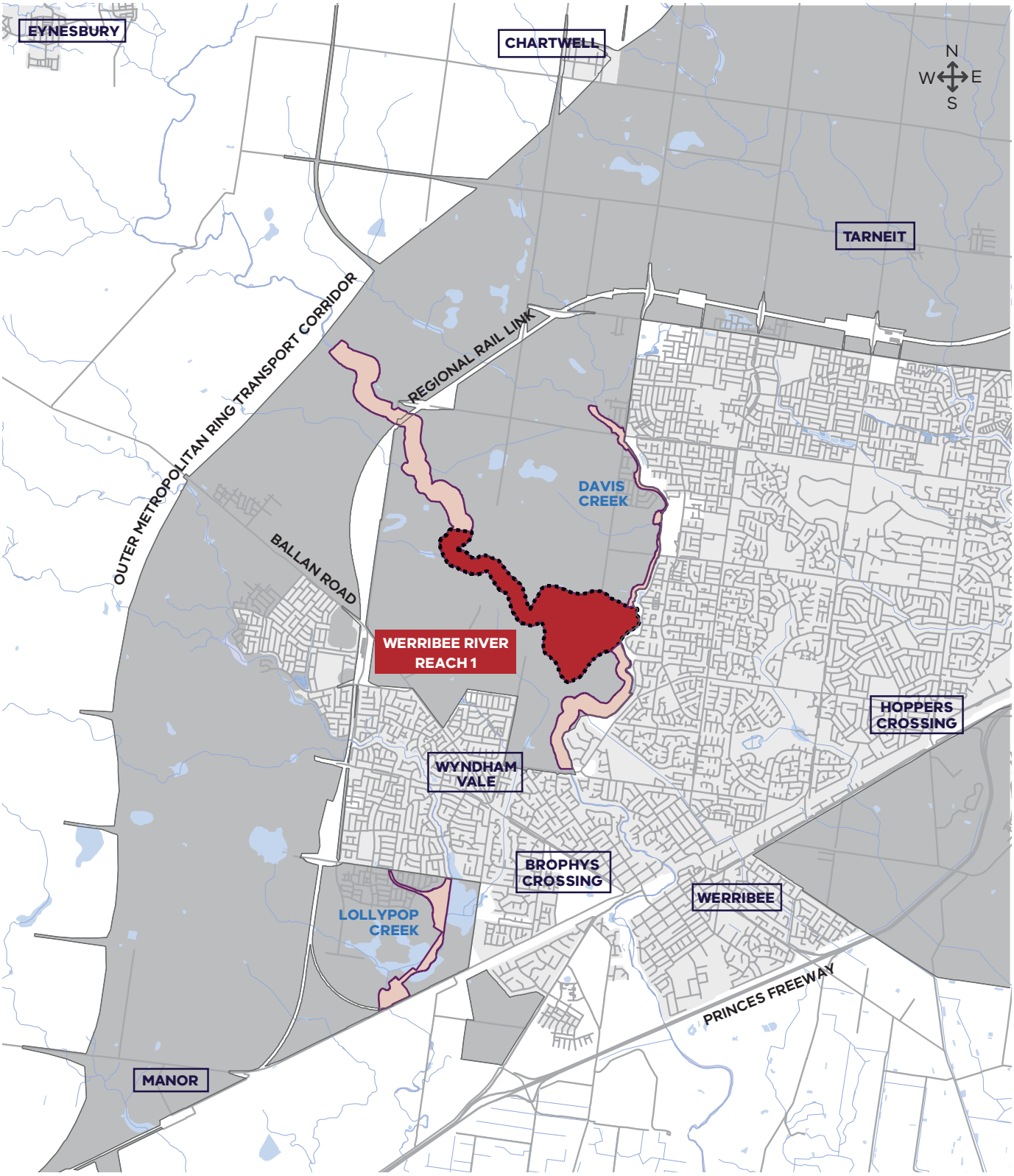
Appendix 1: Maps – Priorities for investment in Growling Grass Frog habitat

Large off-stream wetlands with dense aquatic vegetation provide breeding habitat for Growling Grass Frogs.
Photo by Damien Cook, Rakali Ecological Consulting

Investment priorities in conservation area 14



Legend

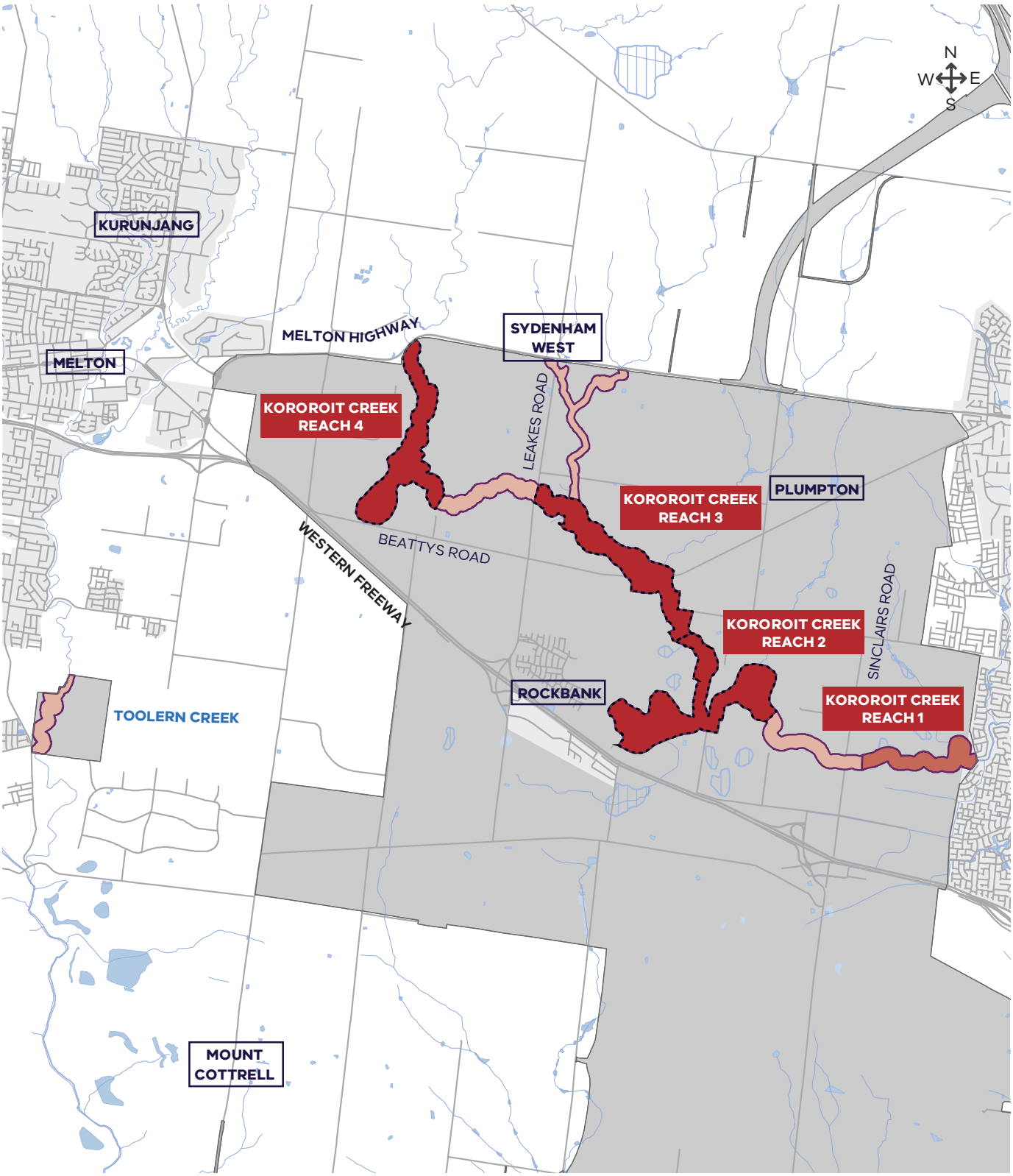
Investment priority

- High priority reach
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

Investment priorities in conservation area 15



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Investment priority

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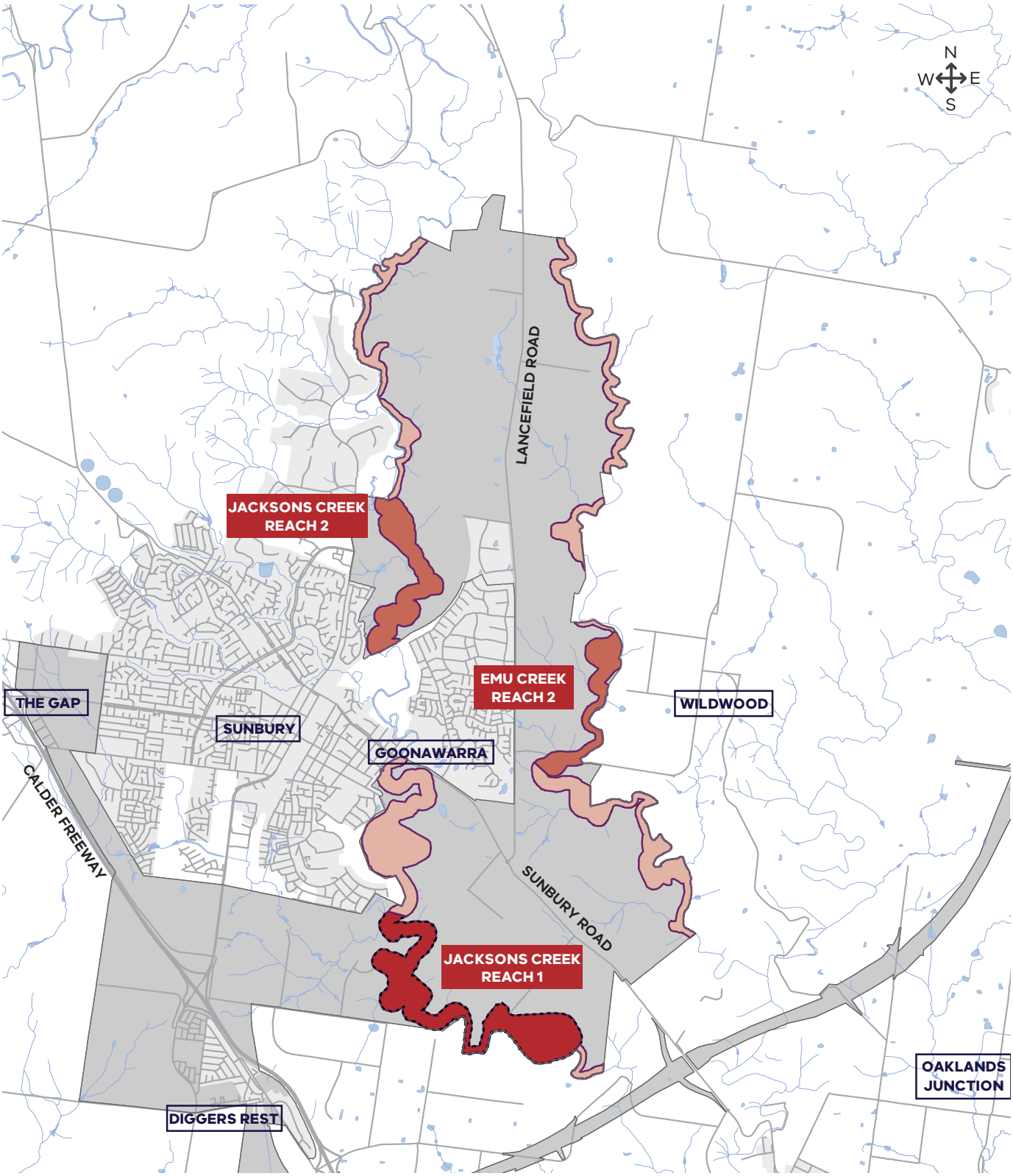
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

Investment priorities in conservation area 21



Legend

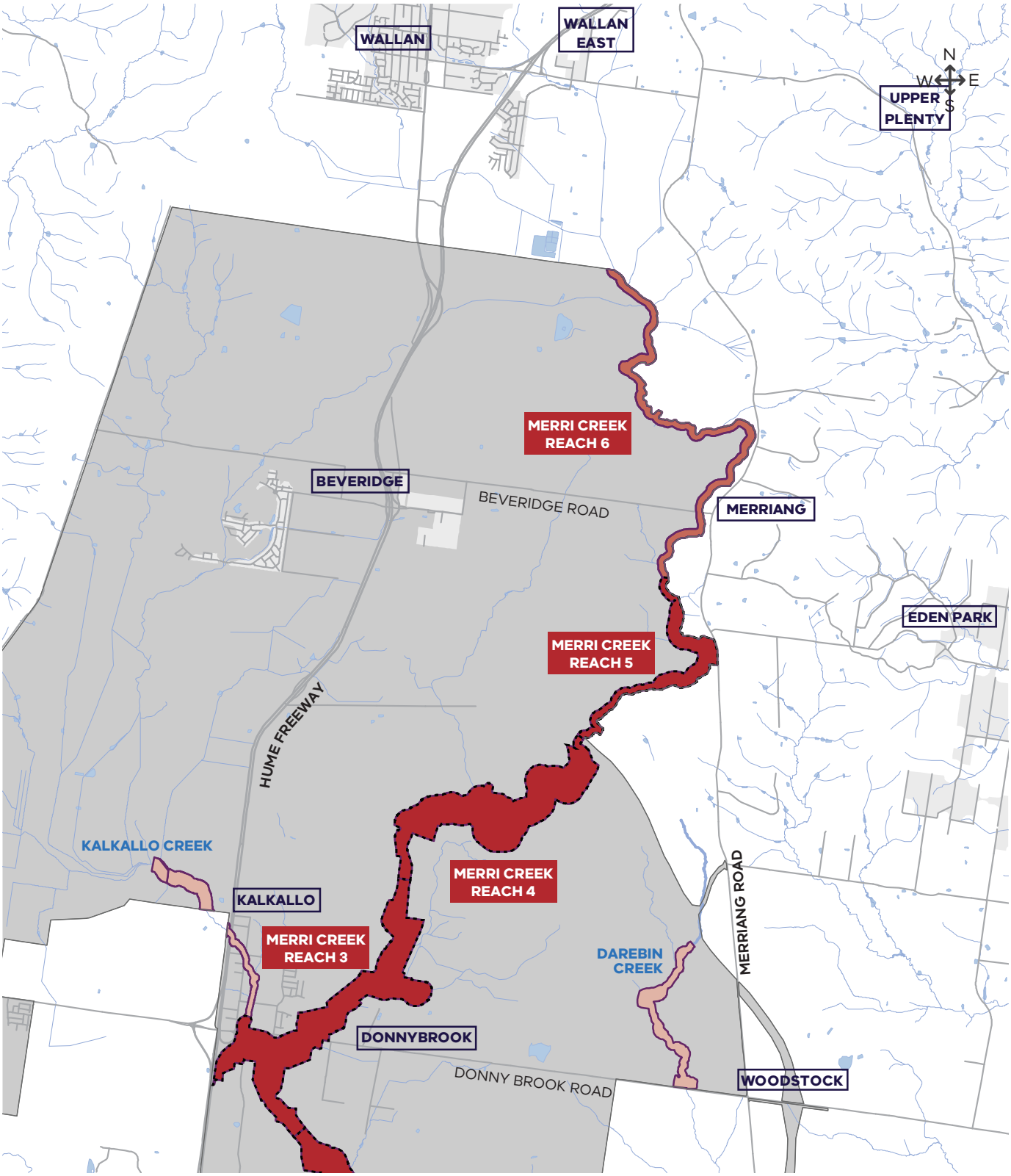
Investment priority

- High priority reach
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

Investment priorities in conservation area 34 - NORTH



Legend

Investment priority

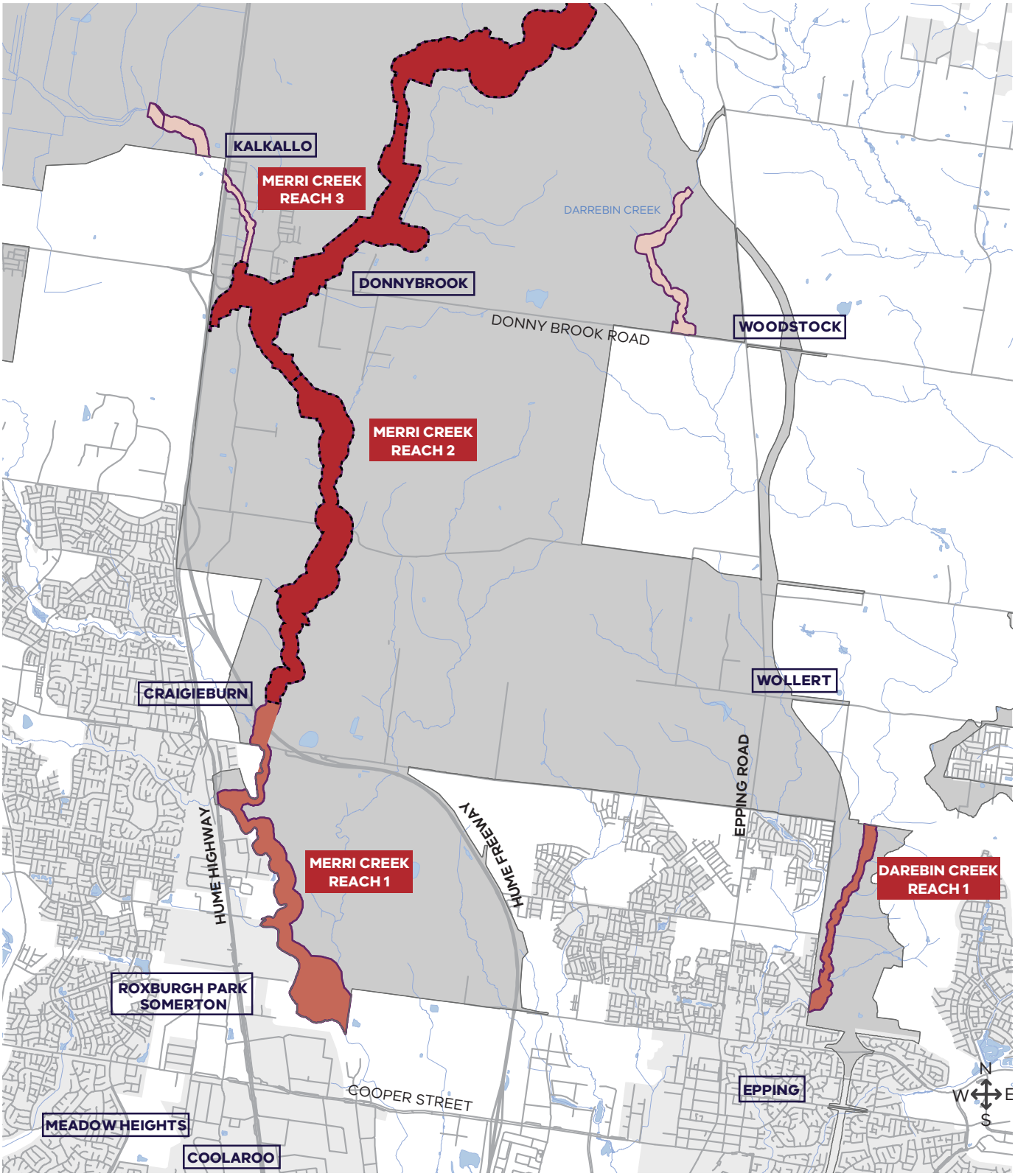
- High priority reach
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

25

Investment priorities in conservation area 34 - SOUTH



Legend

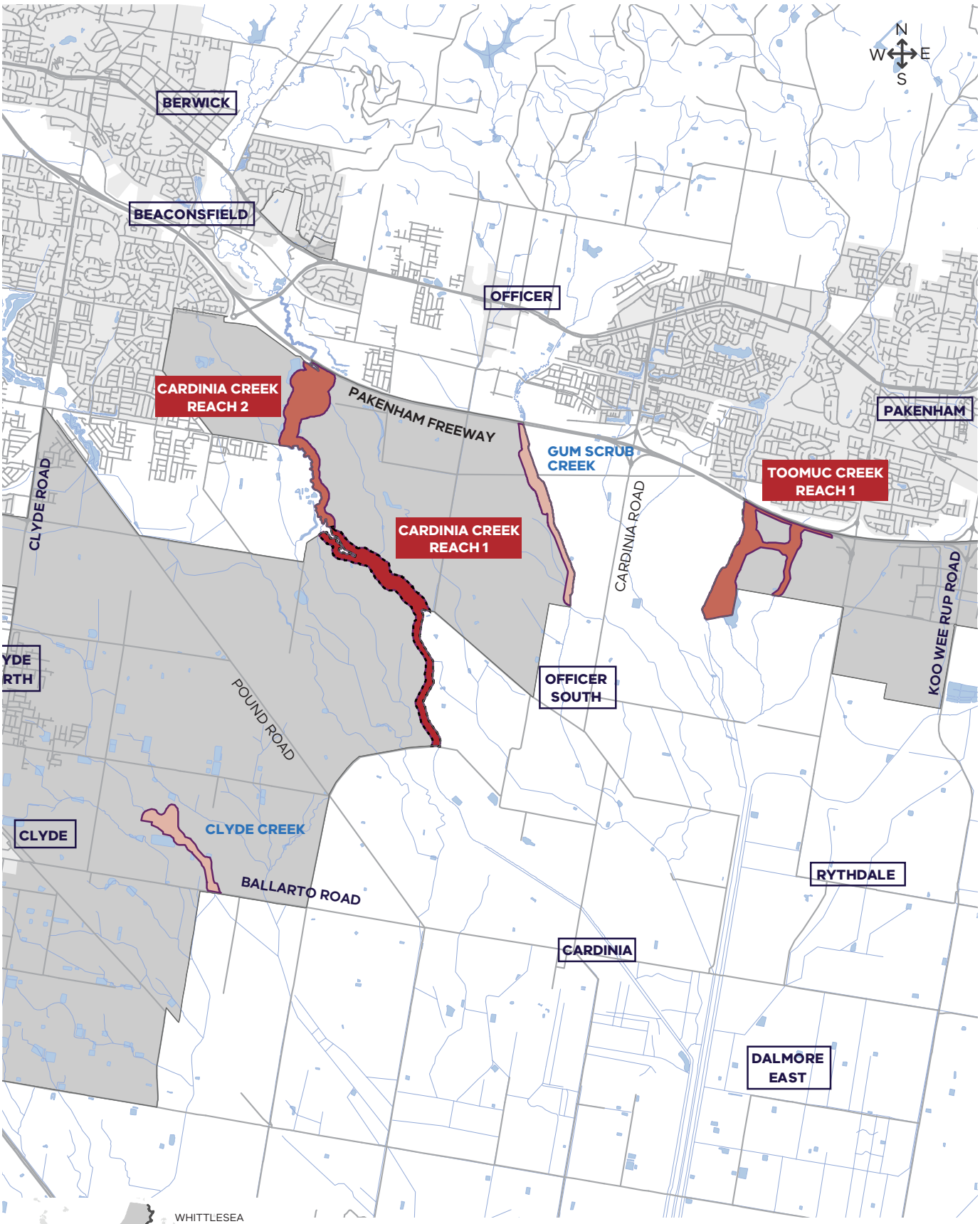
Investment priority

- High priority reach
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

Investment priorities in conservation area 36



Legend

Investment priority

- High priority reach
- Medium priority reach
- Low priority reach
- X Precinct Name

0 800 1,600 2,400

METRES

Appendix 2: Maps – Areas of Strategic Importance

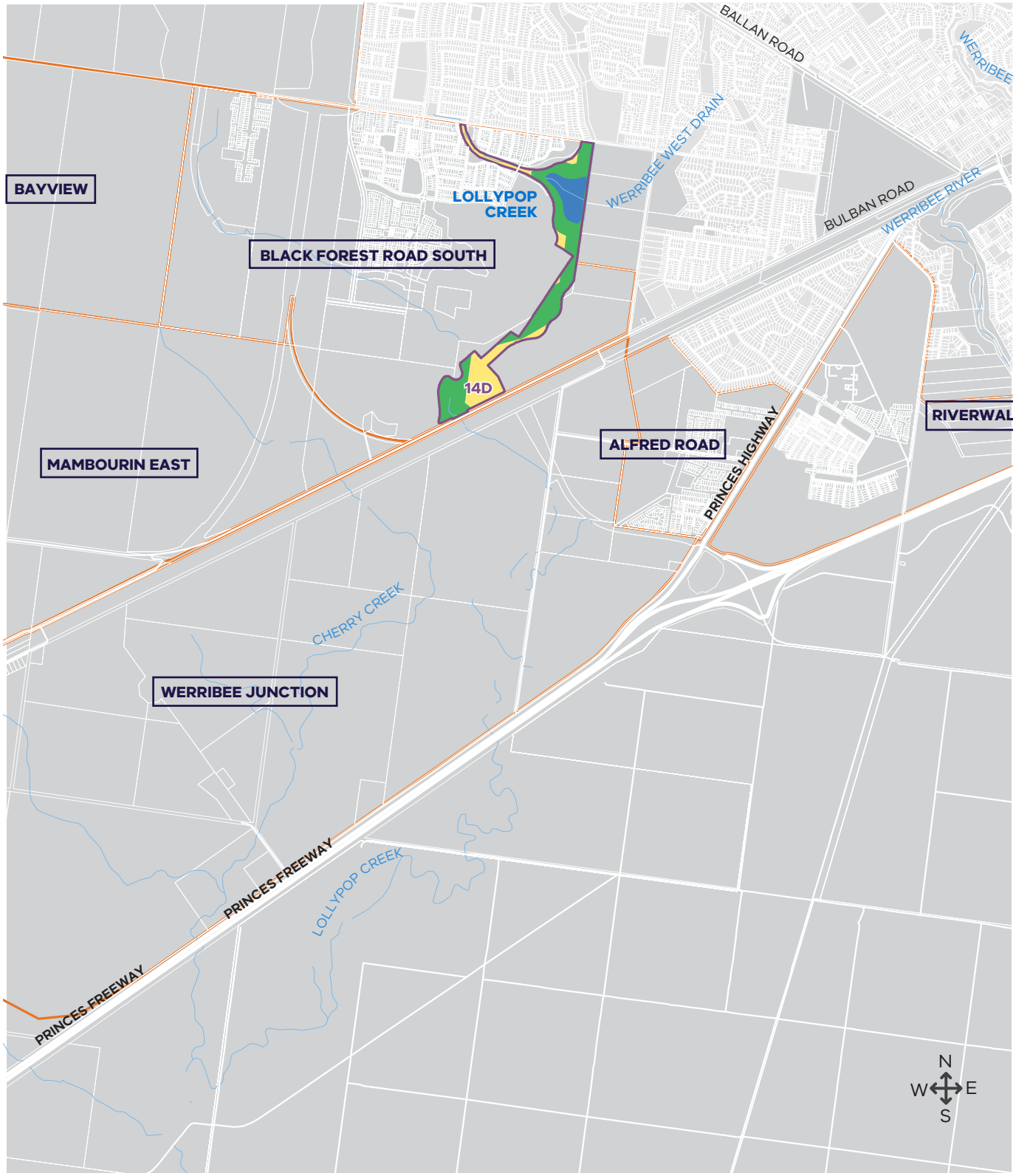
Diverse vegetation planted in the shallows of a constructed wetland supports a variety of habitats and food species for Growling Grass Frogs. Photo by Damien Cook, Rakali Ecological Consulting

The Areas of Strategic Importance mapping can be viewed online in DELWP's Native Vegetation Information Management system (NVIM) via **nvim.delwp.vic.gov.au** - Biodiversity Conservation Strategy link.

The spatial data can be obtained through the Victorian government's directory **www.data.vic.gov.au.**

The online maps may be amended occasionally to reflect approved conservation area boundary changes.

Areas of Strategic Importance in conservation area 14 - SOUTH



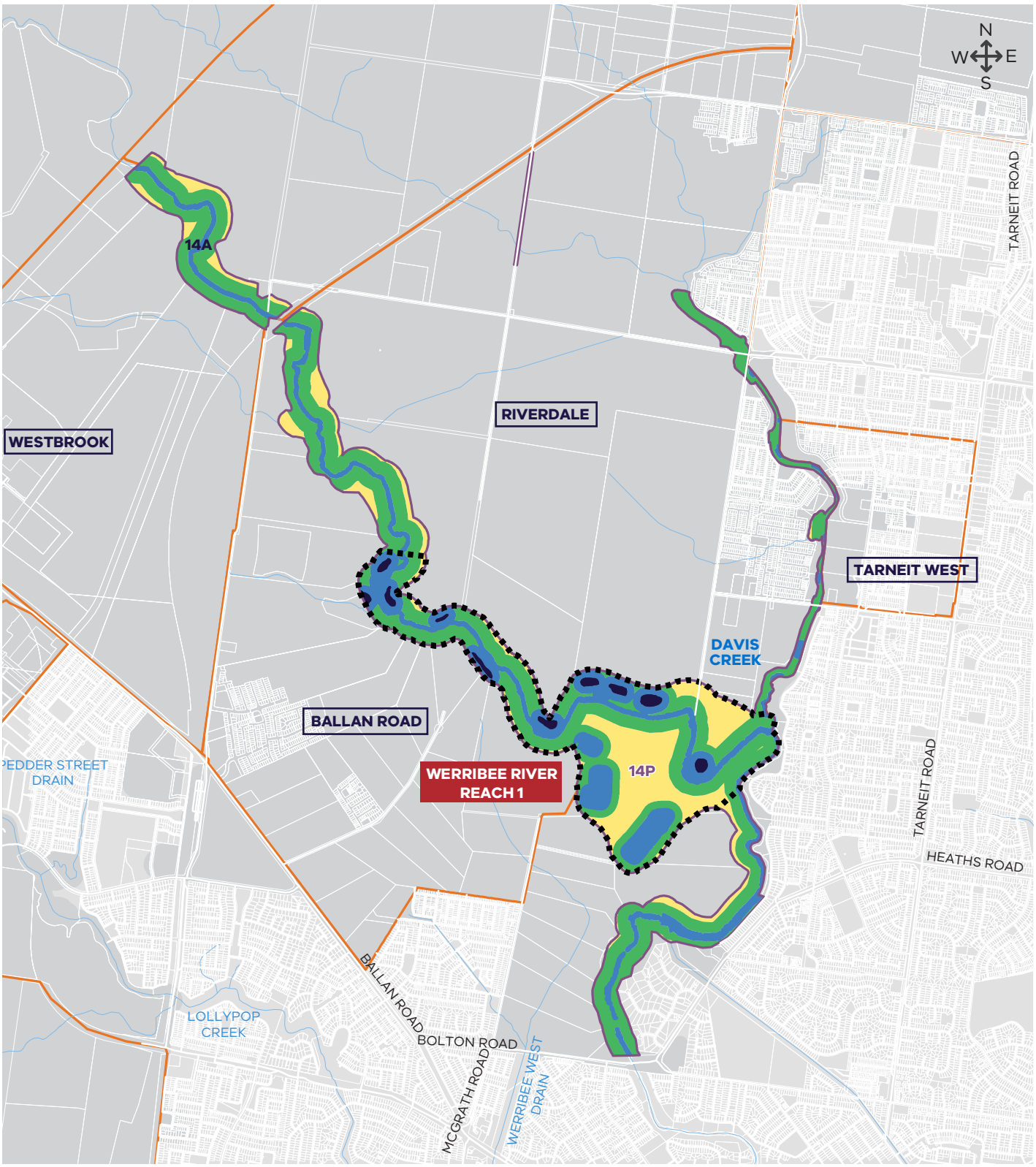
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 14 - NORTH



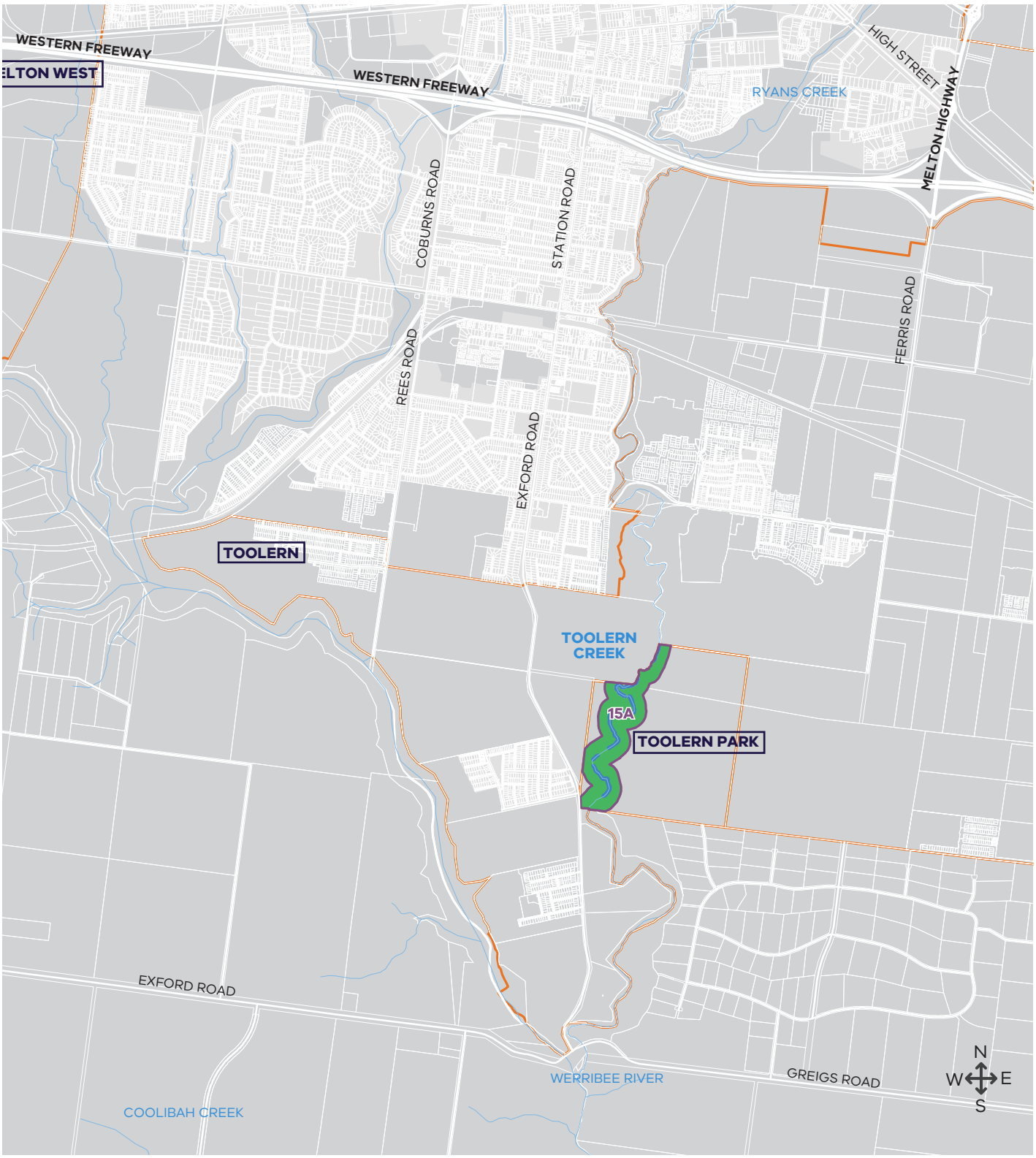
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 15 - SOUTHWEST



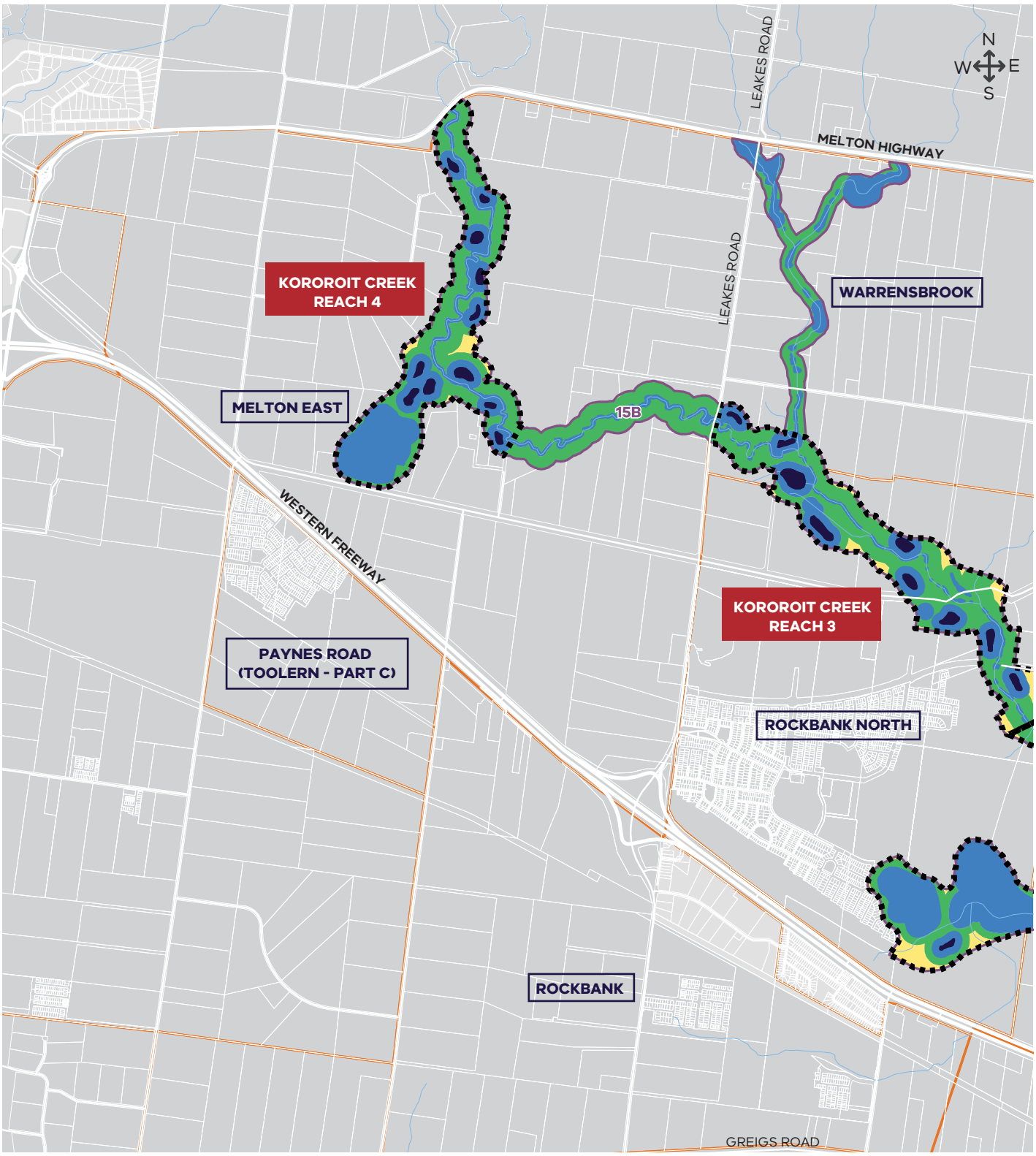
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 15 - WEST



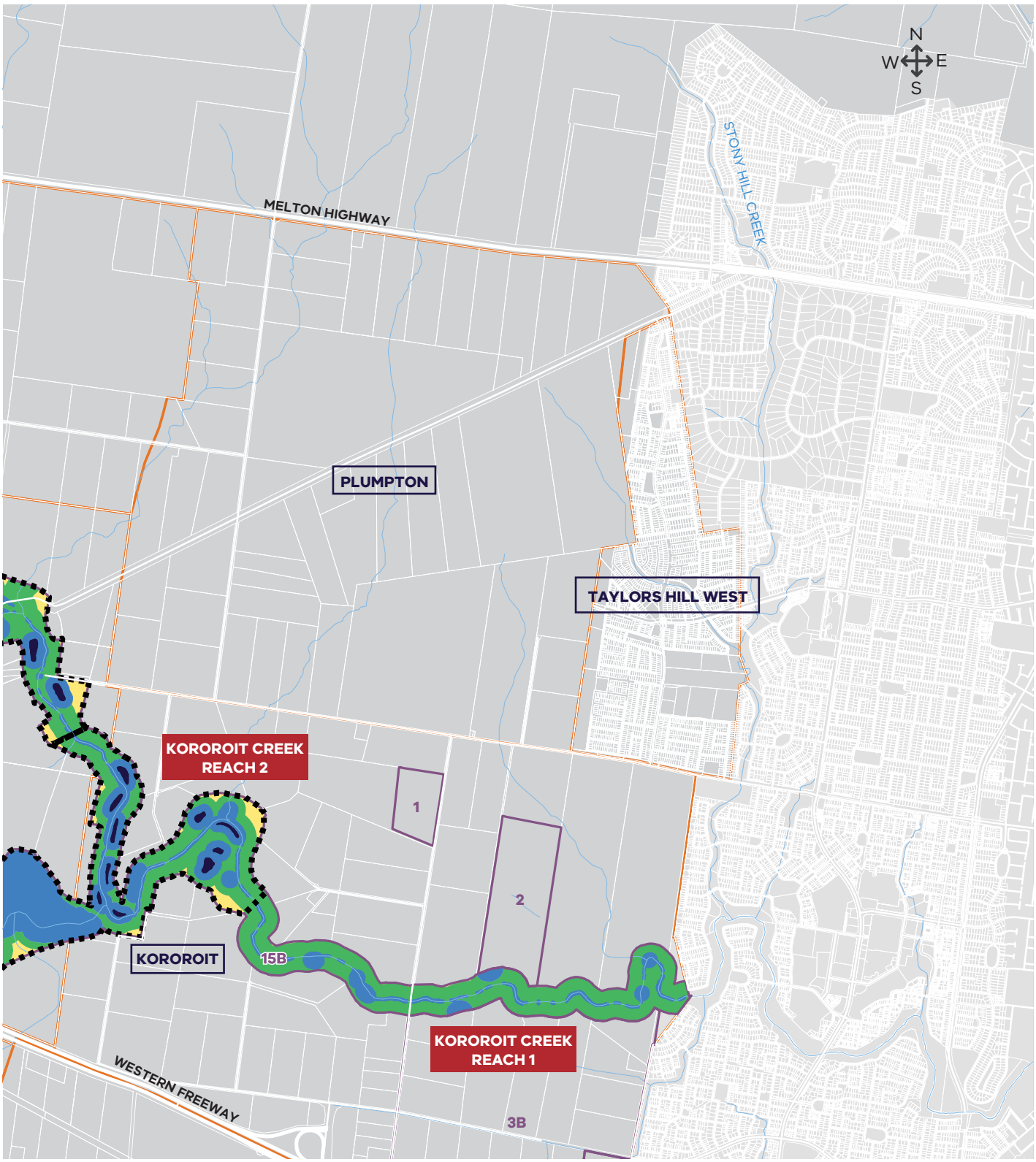
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 15 - EAST



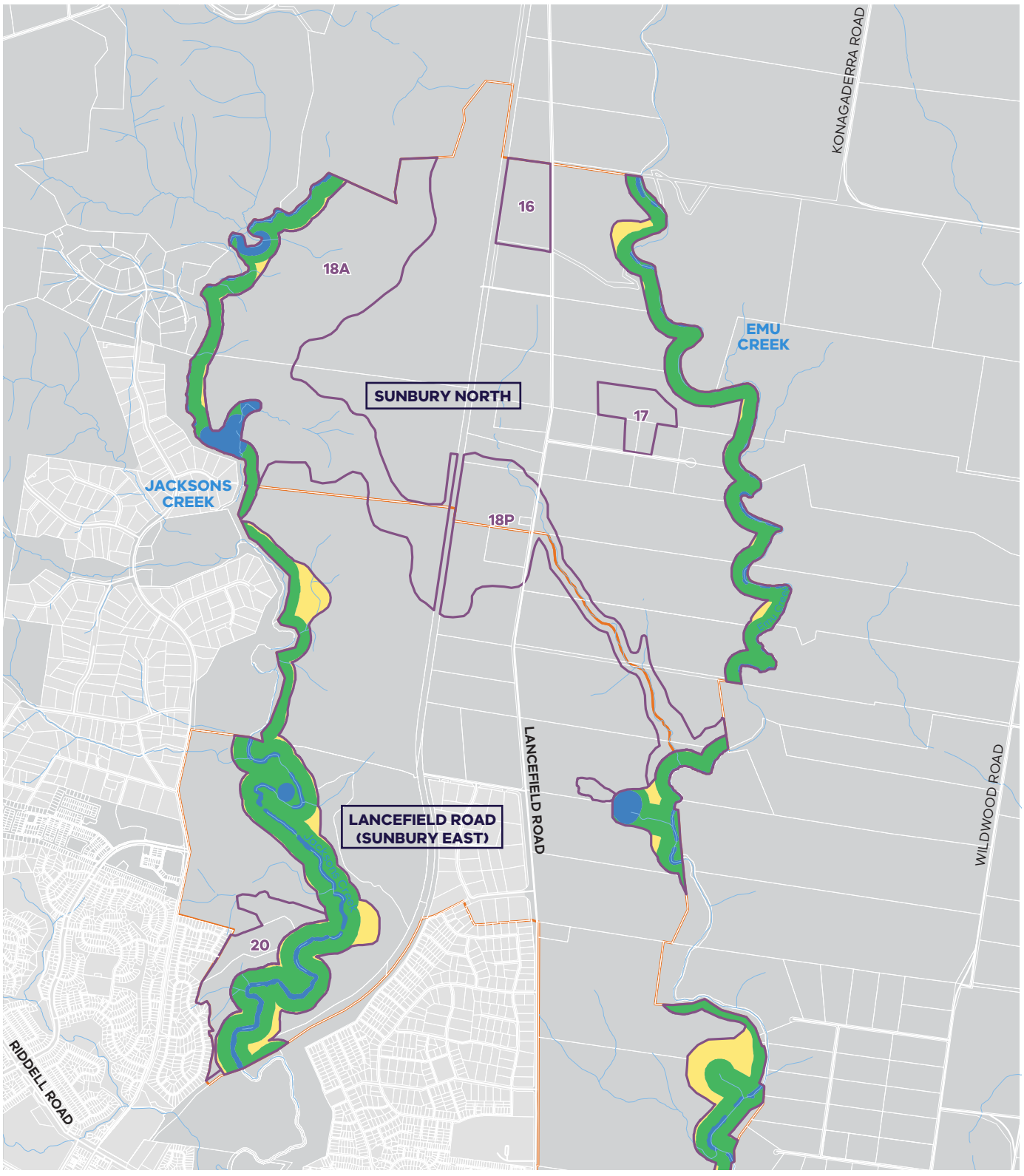
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 21 - NORTH



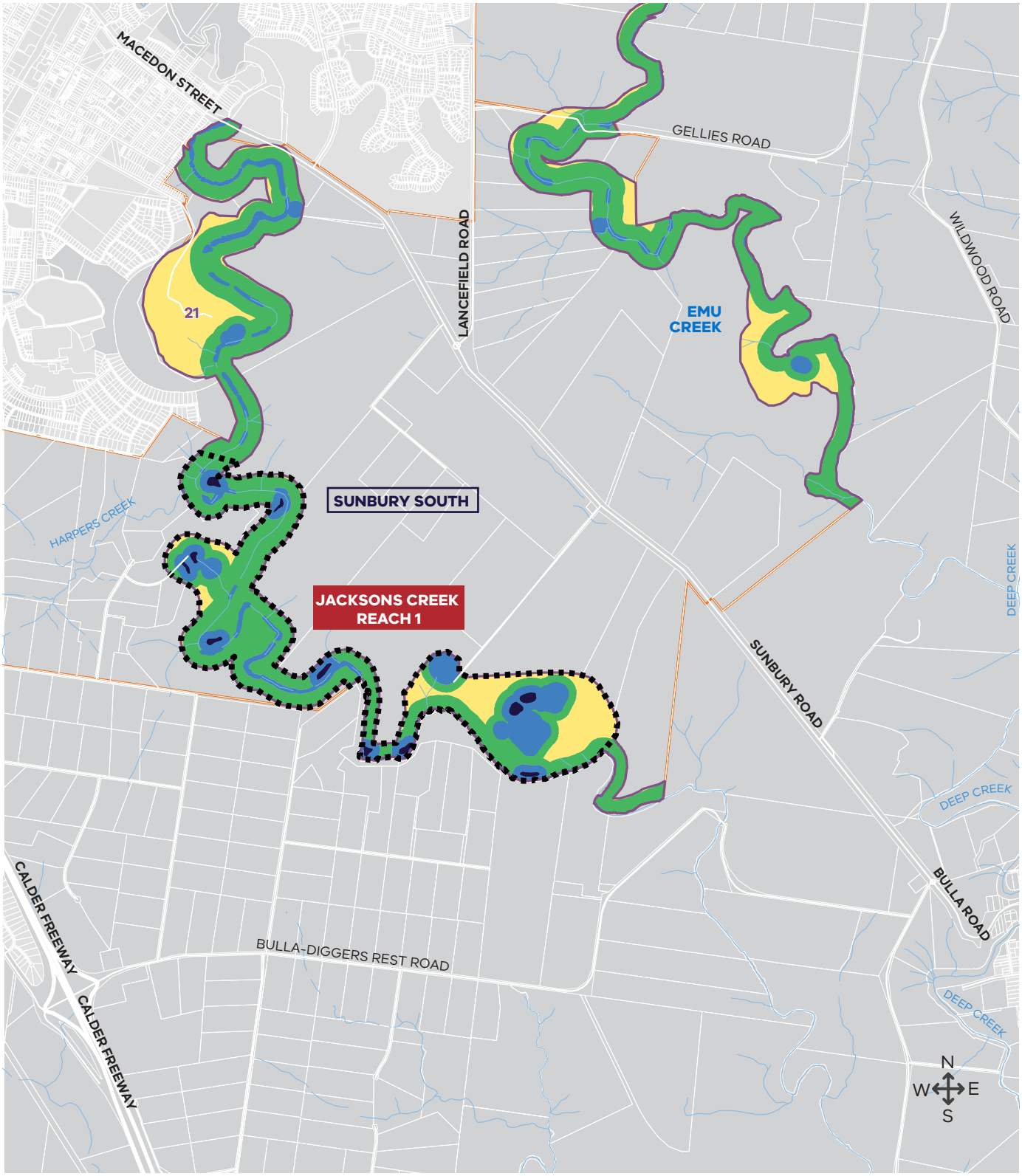
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 21 - SOUTH



Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 34 - NORTH

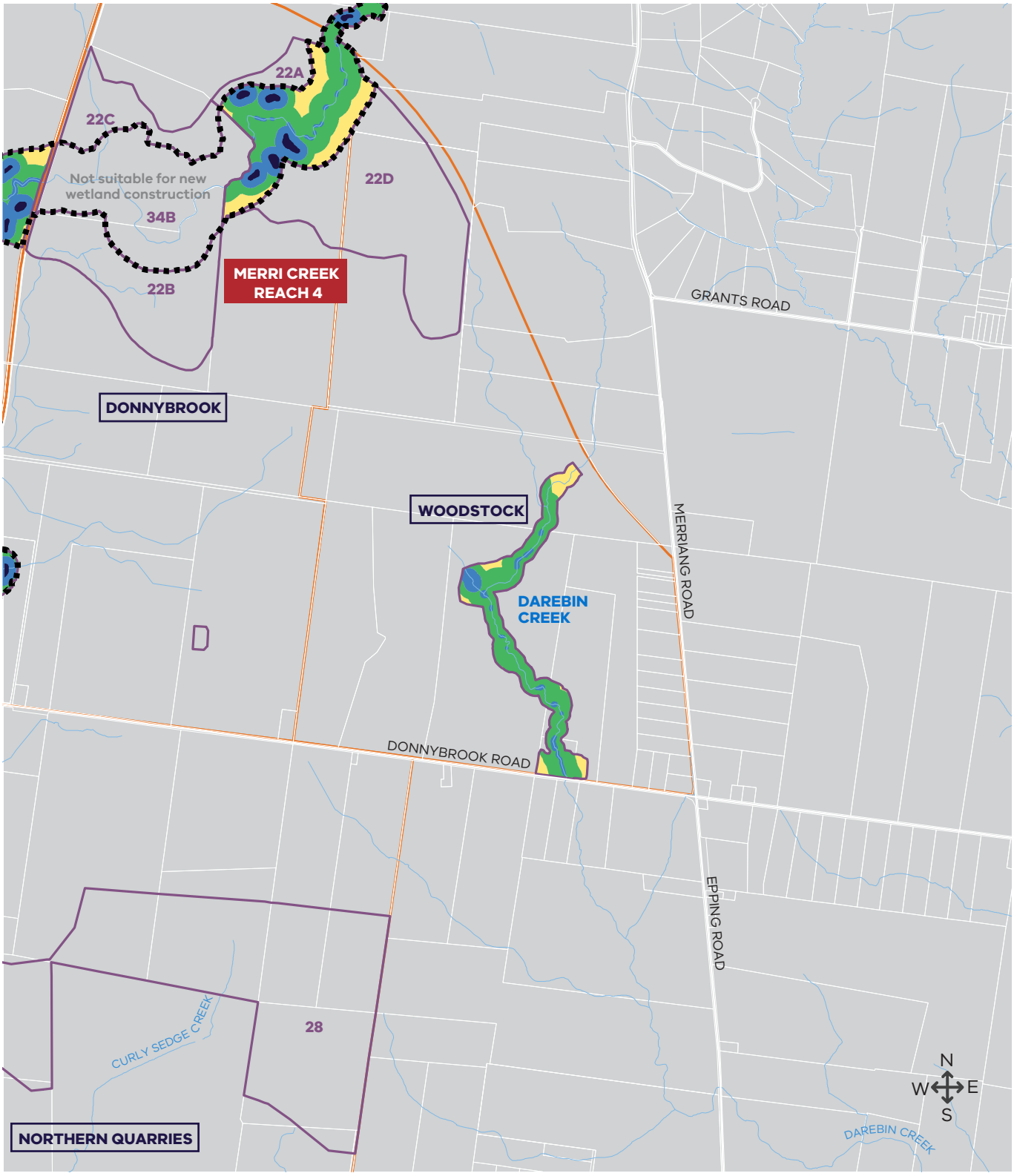
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 34 - CENTRAL EAST

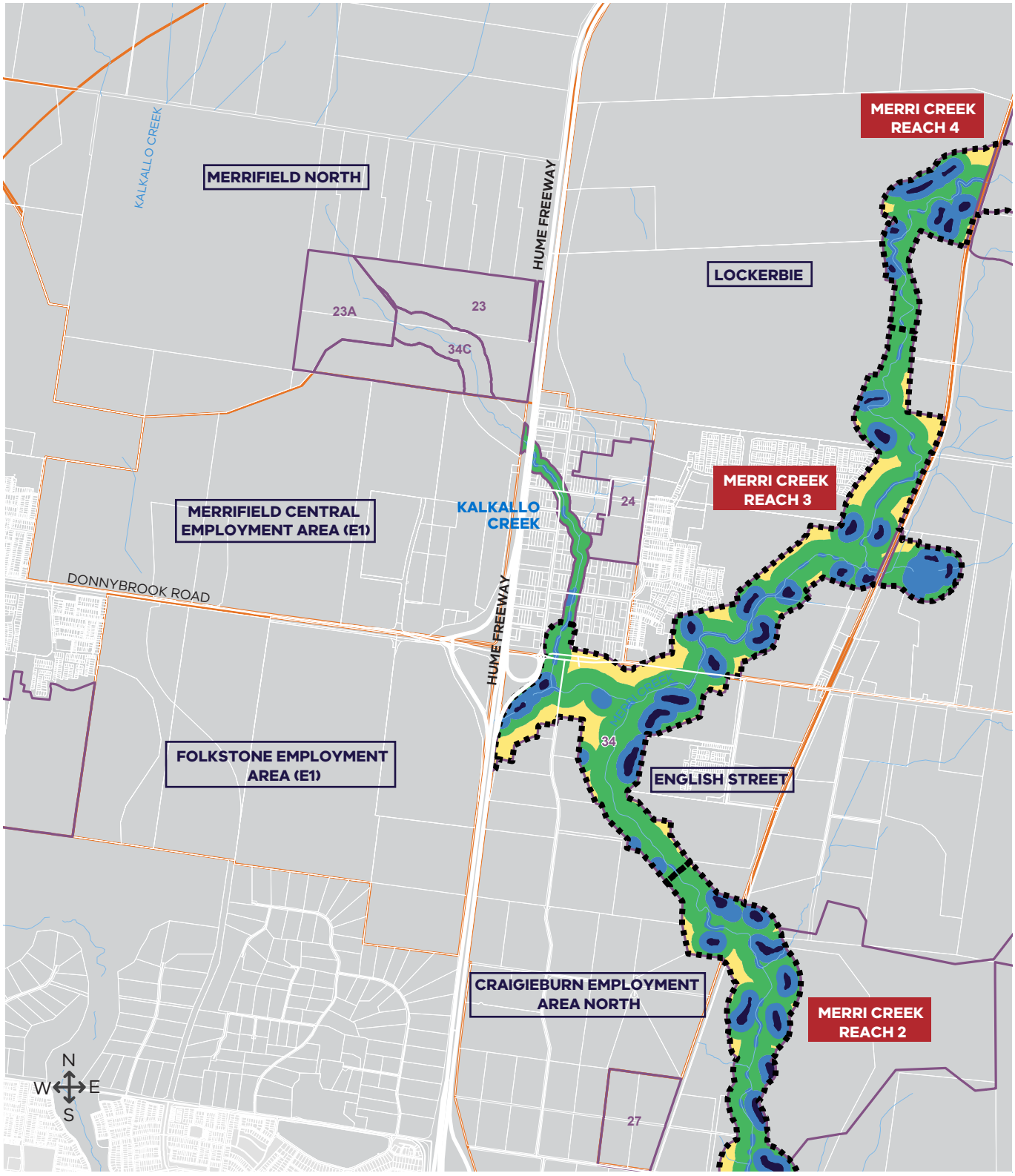


Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000
Metres

Areas of Strategic Importance in conservation area 34 - CENTRAL WEST



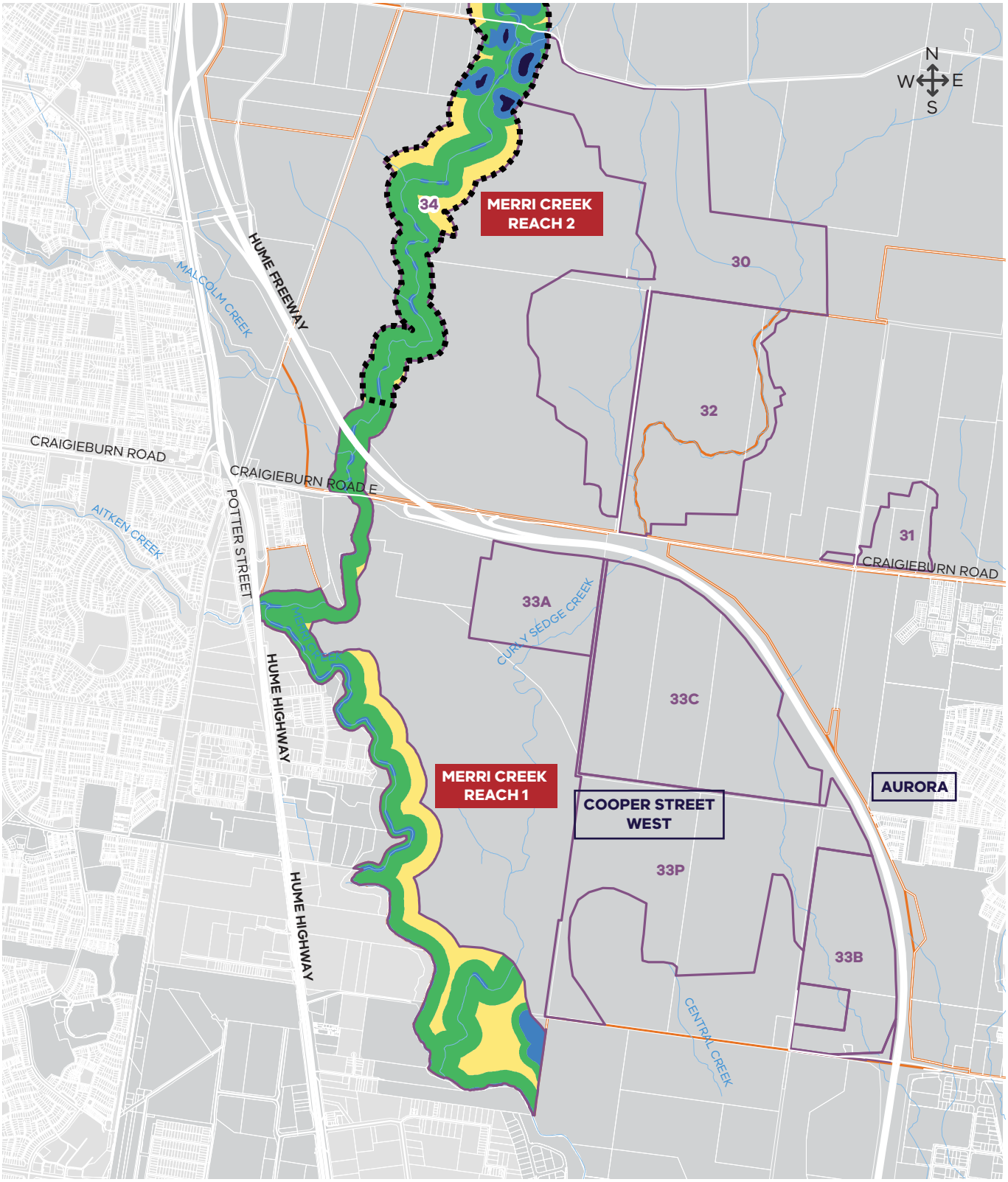
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 34 - SOUTH



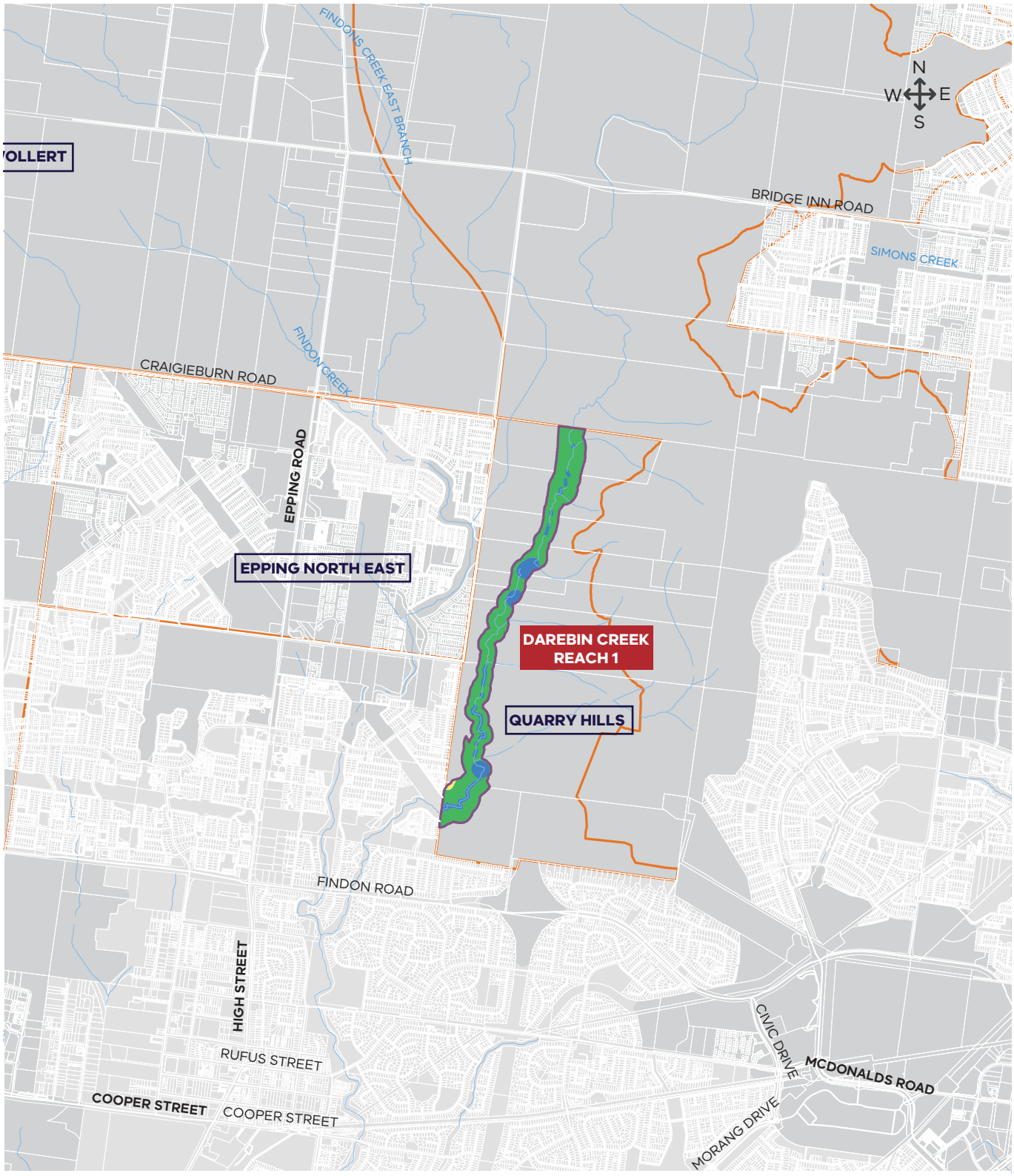
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 34 - SOUTHEAST



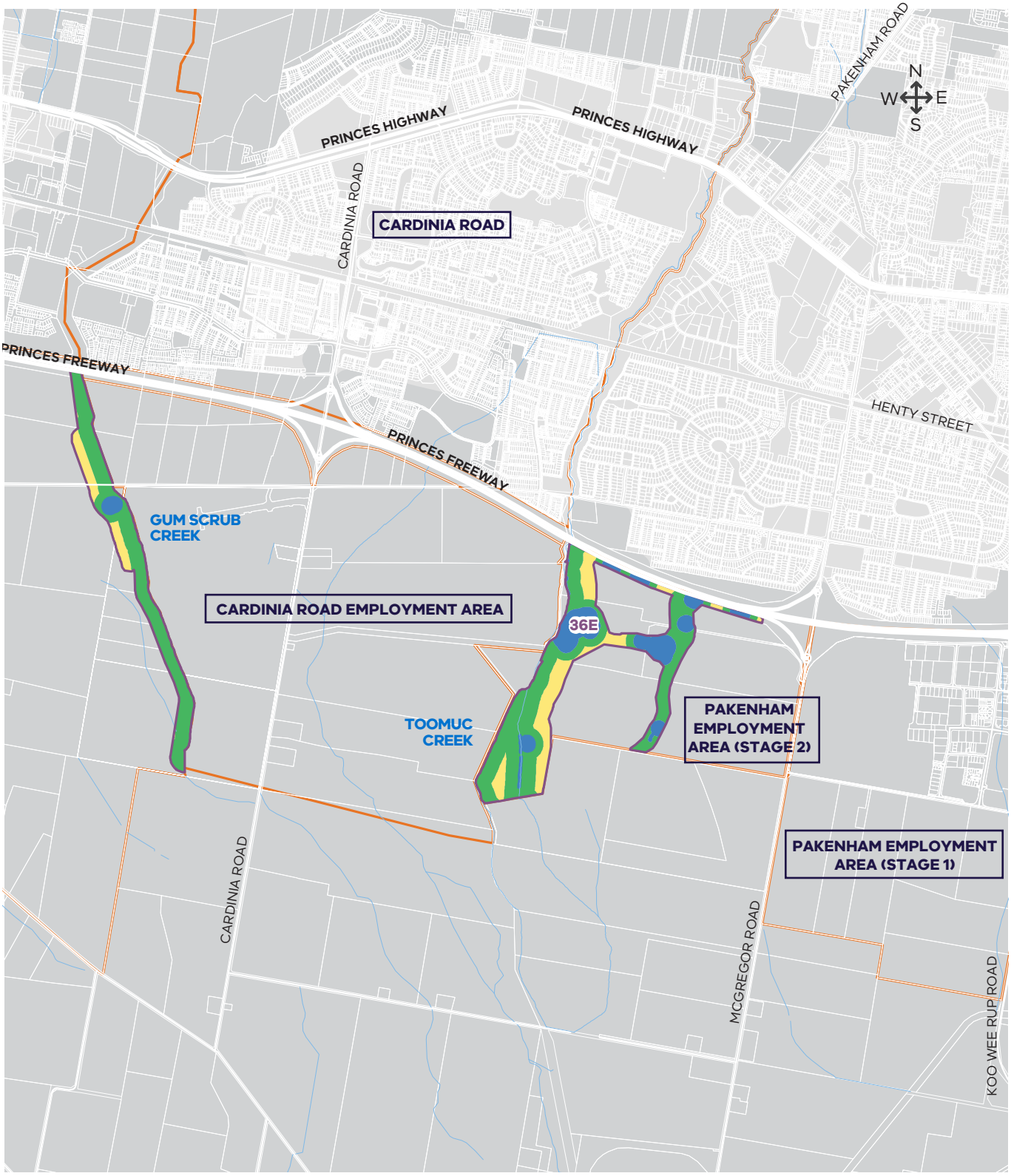
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 36 - EAST



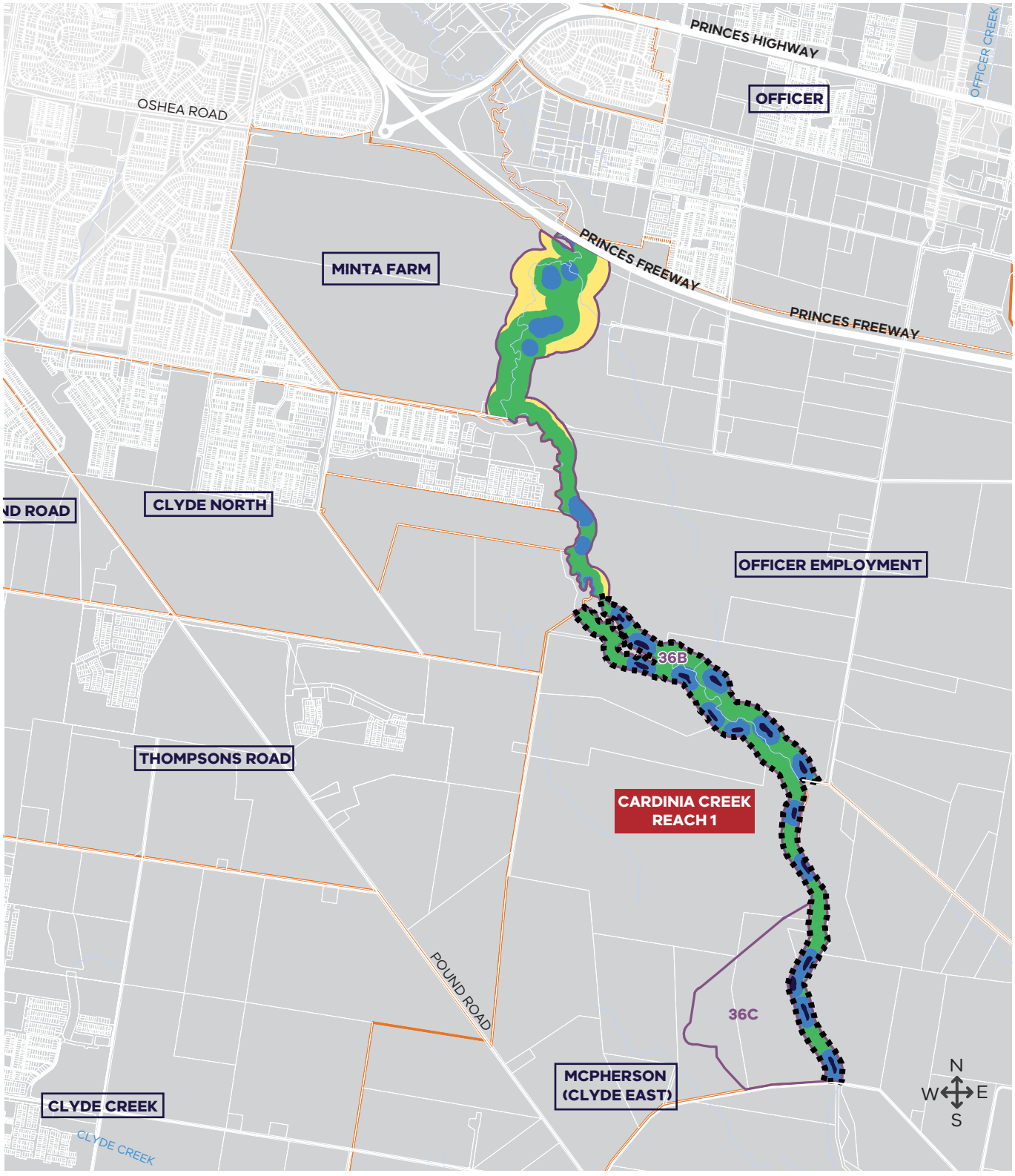
Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 36 - WEST



Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

Areas of Strategic Importance in conservation area 36 - SOUTHWEST

Legend

- Area of Strategic Importance
- Terrestrial habitat buffer to ASI and waterway
- Other terrestrial habitat
- Indicative new wetland location
- Conservation area
- High priority reach
- Precinct boundary
- X Precinct name

0 250 500 750 1,000

Metres

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