

4. Environmental Principles and Factors

4.1 Principles

The five core principles of environmental protection under the EP Act have been considered throughout the development of the Proposal and will continue to be considered through the detailed design and construction phases. Each of the environmental protection principles considered are summarised in **Table 4-1**.

Table 4-1: Principles of Environmental Protection

Principle	Consideration
<p>1. The precautionary principle</p> <p><i>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.</i></p> <p><i>In application of this precautionary principle, decisions should be guided by:</i></p> <p><i>a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and</i></p> <p><i>b) an assessment of the risk-weighted consequences of various options.</i></p>	<p>A range of studies have been undertaken to inform the EIA presented in this ERD. These studies are:</p> <ul style="list-style-type: none"> • flora and vegetation • terrestrial and aquatic fauna • wetlands • groundwater and surface water hydrology and quality • heritage (aboriginal and non- indigenous) • amenity (noise, light, visual impact). <p>This information has reduced the uncertainty surrounding the impact assessment and prediction of impacts and their significance.</p> <p>During the design process the findings from the technical studies have been fed back into the design and modifications made where feasible to reduce or mitigate potential environmental impacts. This has resulted in a design which avoids serious or irreversible damage to the environment. This feedback process will continue through the detailed design phase, where further reductions in environmental impact may be realised.</p> <p>Where desktop analysis identified high value environmental assets, such as CC wetlands or known occurrences of TECs or PECs, which could be impacted by alternative alignment options, a multi-criteria analysis process was undertaken to objectively select the most appropriate route.</p>
<p>2. The principle of intergenerational equity</p> <p><i>The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.</i></p>	<p>The Proposal will ensure the health, diversity and productivity of the environment is maintained through the creation of an offset area(s) to mitigate the impacts.</p> <p>Implementation of the Infrastructure Sustainability Council of Australia (ISCA) framework will also drive sustainable practices and support the principle of intergenerational equity.</p>
<p>3. The principle of the conservation of biological diversity and ecological integrity</p>	<p>The Proposal design has given consideration to avoiding areas of high biological diversity or maintaining biological diversity by minimising the</p>

Principle	Consideration
<p><i>Conservation of biological diversity and ecological integrity should be a fundamental consideration.</i></p>	<p>impact on flora, vegetation, wetlands and fauna habitats as far as practicable.</p> <p>Impacts on flora, vegetation and terrestrial fauna have been assessed and mitigation and management measures proposed.</p>
<p>4. Principles relating to improved valuation, pricing and incentive mechanisms</p> <p><i>(1) Environmental factors should be included in the valuation of assets and services.</i></p> <p><i>(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.</i></p> <p><i>(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.</i></p> <p><i>Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.</i></p>	<p>Main Roads acknowledges that the cost of constructing and operating the Bindoon Bypass must include proposed management and mitigation measures, offset requirements, monitoring, maintenance activities and waste avoidance or disposal requirements. These costs will be included in the budget for the proposal, which will be updated as certainty around these environmental requirements increases.</p> <p>Environmental objectives and goals for the Bindoon Bypass were established at the beginning of the project. These were:</p> <ul style="list-style-type: none"> • undertake practices to help retain and enhance the environmental values of roadsides • no overall loss of the quality and quantity of vegetation communities or habitats • offset significant losses through acquisition of suitable land or other measures in line with State and EPBC environmental offset policies. <p>The Proposal will implement the ISCA framework which encourages design and construction teams to develop innovative solutions to environmental and other sustainability problems.</p>
<p>5. The principle of waste minimisation</p> <p><i>All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.</i></p>	<p>Through the ISCA framework the Proposal has developed concepts and practices for the minimisation of waste and diversion of waste from landfill. This includes the use of recycled materials in the road formation.</p> <p>During the design phases, the amount of cut verses fill across the alignment is calculated to determine if there is an excess or shortfall of fill material, with the objective being that the majority of material excavated from areas of cut is reused in areas where fill is required.</p>

4.2 Key Environmental Factor – Flora and Vegetation

4.2.1 EPA Objective

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

4.2.2 Policy and Guidance

The following EPA policy and guidance have been considered during the preparation of this ERD and the supporting technical studies:

- Statement of environmental principles, factors and objectives (EPA 2016a)
- Guidance for terrestrial flora and vegetation surveys for environmental impact assessment in WA¹ (EPA 2004a)
- Technical guide for flora and vegetation surveys for environmental impact assessment² (EPA & DPaW 2015)
- Environmental factor guideline - flora and vegetation (EPA 2016b)
- Technical guidance: flora and vegetation surveys for environmental impact assessment (EPA 2016c).

Other policy and guidance considered during the preparation of this ERD and the supporting technical studies includes:

- Banksia woodlands of the Swan Coastal Plain: draft guidance for Part 7 referrals (DoEE 2016a)
- Banksia woodlands of the Swan Coastal Plain: a nationally protected ecological community (DoEE 2016b)
- Survey guidelines for Australia's threatened orchids: guidelines for detecting orchids listed as 'Threatened' under the EPBC Act (Department of the Environment 2013)
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (Department of the Environment 2014)
- Approved conservation advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community (Threatened Species Scientific Community 2016)
- Geomorphic wetlands of the Swan Coastal Plain dataset (DBCA 2016)
- WA environmental offsets policy (Government of WA 2011)
- WA environmental offsets guidelines (Government of WA 2014a)
- WA environmental offsets template (Government of WA 2014b).

4.2.3 Receiving Environment

4.2.3.1 Surveys Undertaken

During spring 2016, Focused Vision Consulting Pty Ltd (FVC) were engaged to conduct flora and vegetation assessments of three proposed corridor options for the Bindoon Bypass—collectively referred to as the study area (FVC 2018a). In 2017, the Western Bypass A was chosen to be the preferred corridor (**Chapter 2.4**) and is referred to in this report as the Development Envelope.

¹ This was superseded by EPA (2016b) after the 2016 Spring Survey, which was conducted in accordance with this guidance

² This was superseded by EPA (2016c) after the 2016 Spring Survey, which was conducted in accordance with this guidance

The 2016 spring surveys commenced with desktop reviews, to determine flora and vegetation likely to be found within the study area, and to inform field survey methodology. Desktop reviews were based on the following:

- DAWE's MNES search tool
- DBCA's NatureMap
- WA Herbarium database
- Threatened and Priority taxa listed under the BC Act and by DBCA
- TECs and PECs listed by DBCA
- Declared Pests under WA's Biosecurity and Agriculture Management Act 2007 (BAM Act).

The desktop surveys identified flora species that may be present in the study area, including Commonwealth-listed Threatened flora, State-listed Threatened flora and State-listed Priority flora. The identified flora species were then assessed to determine whether they are known to occur, likely to occur, may occur or unlikely to occur in the study area. This assessment was based on habitat preference, current distribution data and previous survey records. Desktop reviews also identified EPBC Act-listed TECs, TECs endorsed by the WA Minister for the Environment, and DBCA-listed PECs.

Detailed flora and vegetation field assessments (previously referred to as Level 2 flora and vegetation assessments) commenced once desktop assessments were completed. Field assessments took place in October 2016 within the same study area as the desktop assessments, with targeted assessments for *Thelymitra stellata* (Star Sun-orchid) in November 2016 to coincide with the flowering period for this species (FVC 2018a).

All survey and reporting was undertaken in accordance with the following:

- Guidance for terrestrial flora and vegetation surveys for environmental impact assessment in WA³ (EPA 2004a)
- Technical guide for flora and vegetation surveys for environmental impact assessment⁴ (EPA & DPaW 2015)
- Environmental factor guideline - flora and vegetation (EPA 2016b)
- Technical guidance: flora and vegetation surveys for environmental impact assessment (EPA 2016c)
- Survey guidelines for Australia's threatened orchids: guidelines for detecting orchids listed as 'Threatened' under the EPBC Act (Department of the Environment 2013).

These detailed flora and vegetation field assessments collected data from quadrats and opportunistic observations (FVC 2018a). Floristic data for each quadrat was analysed, classified and rationalised into vegetation communities, and described as national vegetation information system (NVIS) Level III and VI. Each local-scale vegetation community was then rationalised with regional vegetation associations as per Shepherd, Beeston and Hopkins (2002—FVC 2018a).

Targeted surveys focusing on *T. stellata* were conducted in November 2016 in locations with habitats that were deemed suitable for the species (FVC 2018a). Sampling methods were designed in accordance with Commonwealth guidelines (Department of the Environment 2013) and included chance finds, meandering searches, area searches and systematic targeted searches, aiming to target at least 50% of the intact vegetation remnants considered to provide suitable habitat for *T. stellata* within the study area (FVC 2018a).

FVC were re-engaged to undertake autumn, winter and further spring surveys of the study area in 2017, following endorsement of the Development Envelope, and in 2018. The results from these surveys provided

³ This was superseded by EPA (2016b) after the 2016 Spring Survey, which was conducted in accordance with this guidance

⁴ This was superseded by EPA (2016c) after the 2016 Spring Survey, which was conducted in accordance with this guidance

new information on autumn and winter conditions, updated information on spring conditions to supplement 2016 data and provided full survey coverage for new areas that were added to the Development Envelope as a result of changes to the proposed alignment following consultation with landowners and other stakeholders. The 2017 and 2018 surveys followed the same desktop assessment approach previously described for the 2016 surveys, with the same databases having been used. Detailed flora and vegetation field assessments followed, including targeted assessments focusing on *T. stellata* and *Drakaea elastica* (Glossy-leafed Hammer Orchid). These surveys were conducted in accordance with:

- Survey guidelines for Australia's threatened orchids: guidelines for detecting orchids listed as 'Threatened' under the EPBC Act (Department of the Environment 2013)
- Technical guidance: flora and vegetation surveys for environmental impact assessment (EPA 2016c)
- Approved conservation advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community (Threatened Species Scientific Community 2016).

A collective total of 139 quadrats (inclusive of two relevés) were sampled over the 2016, 2017 and 2018 surveys, 40 of which are located in the wider region (i.e. outside the Development Envelope) and contribute to the definition of the regional context (FVC 2018a). Quadrats were established and sampled in areas of native vegetation classified as 'Good' or better condition. In accordance with the requirements of the EPA (2016c), observations and opportunistic data were also collected continuously throughout the survey. The targeted surveys for *T. stellata* were conducted in November 2017 and 2018, and for *D. elastica* in July 2017 and mid-July to mid-August 2018. These targeted surveys coincided with the respective species lifecycle phase in which they are most easily identifiable; for *T. stellata* this coincides with flowering, while for *D. elastica* the species is most readily identifiable by the leaf during winter, with follow-up confirmation of identification with the flower in spring (FVC 2018a).

Rainfall observations from the Bureau of Meteorology weather stations at Bindoon (Station ID 9112) and Wannamal (Station ID 9040) show that early winter rainfall in 2017 was below the long-term average, as recorded at Gingin Aero (Station ID 9178) (**Table 4-2, Figure 4-1 and Figure 4-2**). Rainfall in May and June was well below average with both stations reporting rainfall totals more than 40% lower than the long-term average. Rainfall in July and August was well above average with September rainfall close to average. This late start to the season in 2017 may have had an impact on flowering of target species, particularly *T. stellata*, and leaf emergence and flowering of *D. elastica*. Additional targeted surveys were undertaken in 2018. Rainfall in May and June was closer to the long-term average with June exceeding the average at Bindoon. July and August were both at or above the long-term average rainfall for the month. The 2108 season was therefore more favourable for flowering and leaf emergence of the target species and therefore addresses the possible limitations of the 2017 survey due to the late start of the winter (wet) season. Targeted searches for *T. stellata* were also undertaken in November 2016. Rainfall during the preceding Winter months was generally close to the long-term average.

Table 4-2: Winter Rainfall Observations from Bindoon and Wannamal and Gingin Aero Long-term Average

Station	Year	Rainfall (mm)				
		May	Jun	Jul	Aug	Sep
Bindoon	2016	87.4	102.6	129.4	141.4	62.6
	2017	45.2	44.4	194.3	151.2	88.4
	2018	62.6	121.6	157.6	201.2	24.0
Wannamal	2016	73.8	77.1	126.1	107.2	42.7
	2017	25.8	39.9	131.3	112.7	76.2
	2018	53.8	92.1	123.5	158.0	19.3
Gingin Aero	Long-term Average	75.2	109.8	125.3	109.8	80.3

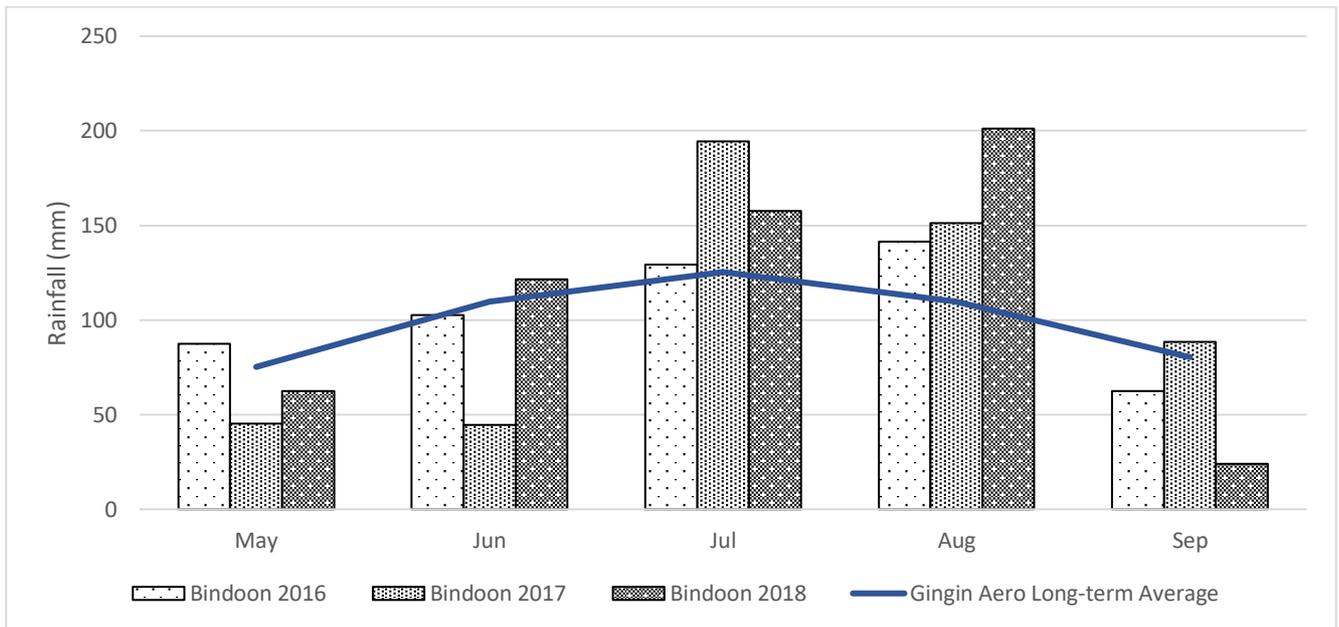


Figure 4-1: Comparison of 2016 and 2018 Winter Rainfall at Bindoon Against the Long-term Average

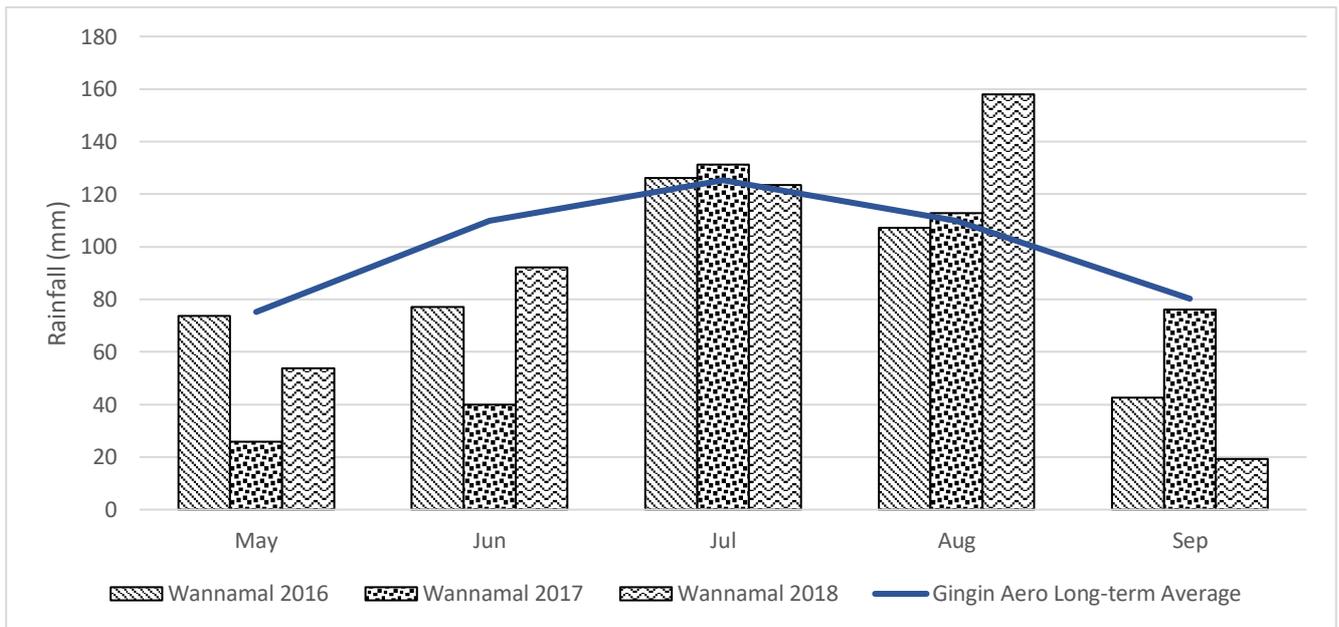


Figure 4-2: Comparison of 2016 to 2018 Winter Rainfall at Wannamal Against the Long-term Average

FVC also undertook a detailed assessment of the wetlands associated with the Brockman River at the proposed crossing location (FVC 2018b). This survey was conducted in accordance with the *Protocol for proposing modifications to the geomorphic wetlands of the Swan Coastal Plain* (DEC 2007), and included:

- detailed desktop assessment, which gathered a range of information about the wetlands adjacent to the Brockman River crossing, including vegetation
- field assessments, which confirmed information from the desktop study and made further observations of the existing environment, including vegetation.

Appendix D contains full copies of the FVC reports, which include detailed descriptions of the surveys that have been undertaken to support this ERD.

4.2.3.2 Flora

A total of 572 flora taxa from 218 genera and 63 families were recorded during the 2016, 2017 and 2018 surveys (FVC 2019). Of these, 30 taxa (7%) were identified as weed species. Over 30% of the taxa recorded were from three families: Fabaceae (12.2%), Proteaceae (10.3%) and Myrtaceae (9.9%) (FVC 2018a). The number of flora taxa recorded is considered relatively high in terms of species diversity, and reflects the diversity of landform types, soils and the location of the Proposal on the boundary of two IBRA regions (FVC 2018a).

Conservation Significant Flora

The desktop studies identified a total of 103 flora species of conservation significance that may occur in the study area. Of these, 55 are considered unlikely to occur in the Development Envelope, for the following reasons:

- proximity of previous records to the Development Envelope
- currency of data
- lack of suitable habitat within the study area.

Of the remaining 48 species, ten are listed under the BC Act—eight of these are also listed under the EPBC Act—and 38 are on the DBCA Priority Flora List (five P1, four P2, nineteen P3 and ten P4). The complete list of 48 conservation significant flora species that may occur in the Bindoon area is provided in Appendix A of FVC’s report (2018a), which is provided in **Appendix D** of this ERD.

The 2016 and 2017 field surveys recorded 11 Priority flora within the study area (FVC 2018a) (**Table 4-3**). No flora species listed under the BC Act or EPBC Act were recorded within the study. **Figure 4-3** shows the locations of all conservation significant flora records for the Bindoon area, including those recorded by FVC (2018a) and from the DBCA and WA Herbarium databases.

Table 4-3 : Conservation Significant Flora Species Recorded by FVC (2018a)

Species	Status	Description	Number of Individuals	
			FVC (2018a, 2019)	Development Envelope
<i>Gastrolobium ?crispatum</i>	P1	Tall shrub, to 2.5 m high. Flowers are yellow and orange and red and flowering occurs September to October.	2	0
<i>Synaphea panhesya</i> (incl. <i>Synaphea ?panhesya</i>)	P1	Erect shrub, 0.3-0.6 m high. Flowers are yellow and flowering occurs August to September.	14	0
<i>Drosera sewelliae</i> (incl. <i>Drosera ?sewelliae</i>)	P2	Fibrous-rooted, rosetted perennial, herb, to 0.06 m high, to 0.025 m wide. Flowers are orange and flowering occurs in October.	303	34
<i>Hibbertia glomerata</i> subsp. <i>ginginensis</i>	P2	Erect shrub, to 0.5 m high. Flowers are yellow and flowering occurs July to September.	383	0
<i>Leucopogon squarrosus</i> subsp. <i>trigynus</i>	P2	Shrub to 1.5 m high and 1.2 m wide. Flowers are white. The flowering period is uncertain but there are records of flowering in July and September. Grows on white sands in association with Banksia woodlands	5	5

Species	Status	Description	Number of Individuals	
			FVC (2018a, 2019)	Development Envelope
<i>Acacia drummondii</i> subsp. <i>affinis</i> (incl. <i>Acacia drummondii</i> subsp. <i>?affinis</i>)	P3	Erect shrub, 0.3-1.0 m high. Flowers are yellow and flowering occurs July to August.	342	23
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	P3	Prostrate, mat-forming, non-lignotuberous shrub, to 0.3 m high. Flowers are white, cream, pink or green and flowering occurs in any month from July to January.	1,068	1
<i>Halgania corymbosa</i>	P3	Erect shrub up to 1 m high. Flowers are blue-purple and flowering occurs in August to November. Grows in gravelly soils and soils over granite.	2	2
<i>Styphelia filifolia</i>	P3	Erect shrub to 0.9 m high and 0.7 m wide. Flowers are white with flowering occurring between March and May. Grows on sandy soils of the coastal plain.	1	0
<i>Verticordia rutilastra</i>	P3	Shrub up to 0.9 m high. Flowers are yellow and flowering occurs between September and November. Grows on hills in sands and lateritic gravels.	2	2
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>	P4	Rhizomatous perennial herb, 0.2-0.4 (-0.8) m high. Flowers are yellow and flowering occurs July to October.	11	3
<i>Hibbertia miniata</i>	P4	Decumbent or erect shrub, 0.1-1.0 m high. Flowers are orange or orange-red and flowering occurs August to November.	1,494	851
<i>Hypolaena robusta</i>	P4	Dioecious rhizomatous perennial herb, about 0.5 m high. Flowers September to October.	4	1
<i>Jacksonia ?sericea</i>	P4	Low spreading shrub, to 0.6 m high. Flowers are orange with flowering usually occurring in December or January to February. Grows in calcareous and sandy soils.	1	0
<i>Verticordia paludosa</i> (incl. <i>Verticordia ?paludosa</i>)	P4	Erect shrub, 0.3-0.9 m high. Flowers are pink or white with flowering occurring January to May.	281	125

Identifications for *Gastrolobium ?crispatum*, *Synaphea ?panhesya*, *Drosera ?sewelliae*, *Acacia drummondii* subsp. *?affinis*, *Jacksonia ?sericea* and *Verticordia ?paludosa* could not be confirmed due to a lack of identifiable material. Where sufficient identifiable material was available, identifications for Priority flora species were verified by Dr Udani Sirisena of the WA Herbarium, with difficult identifications also reviewed by WA Herbarium plant group specialists (FVC 2018a).

The recorded location of the P1 species *Gastrolobium ?crispatum* is approximately 900 m from the Development Envelope, in private land opposite Burroloo Well Nature Reserve. All recorded locations of the P1 species *Synaphea panhesya* are outside of the Development Envelope, though three of these are adjacent to the Development Envelope. The recorded location for the P2 species *Hibbertia glomerata* subsp. *ginginensis* is approximately 420 m from the Development Envelope. The recorded location of the P3 species *Styphelia filifolia*, is just outside of the Development Envelope near the Cook Road rail crossing. The possible *Jacksonia ?sericea* (P4) record is approximately 155 m from the Development Envelope (**Figure 4-3**).

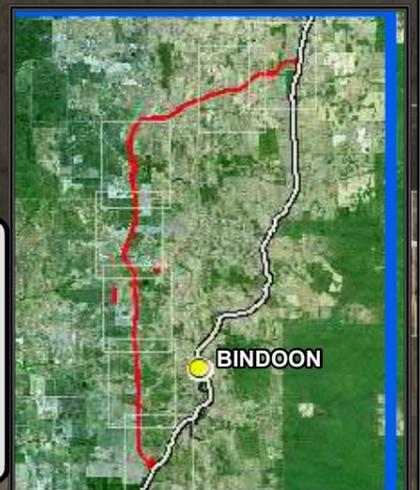
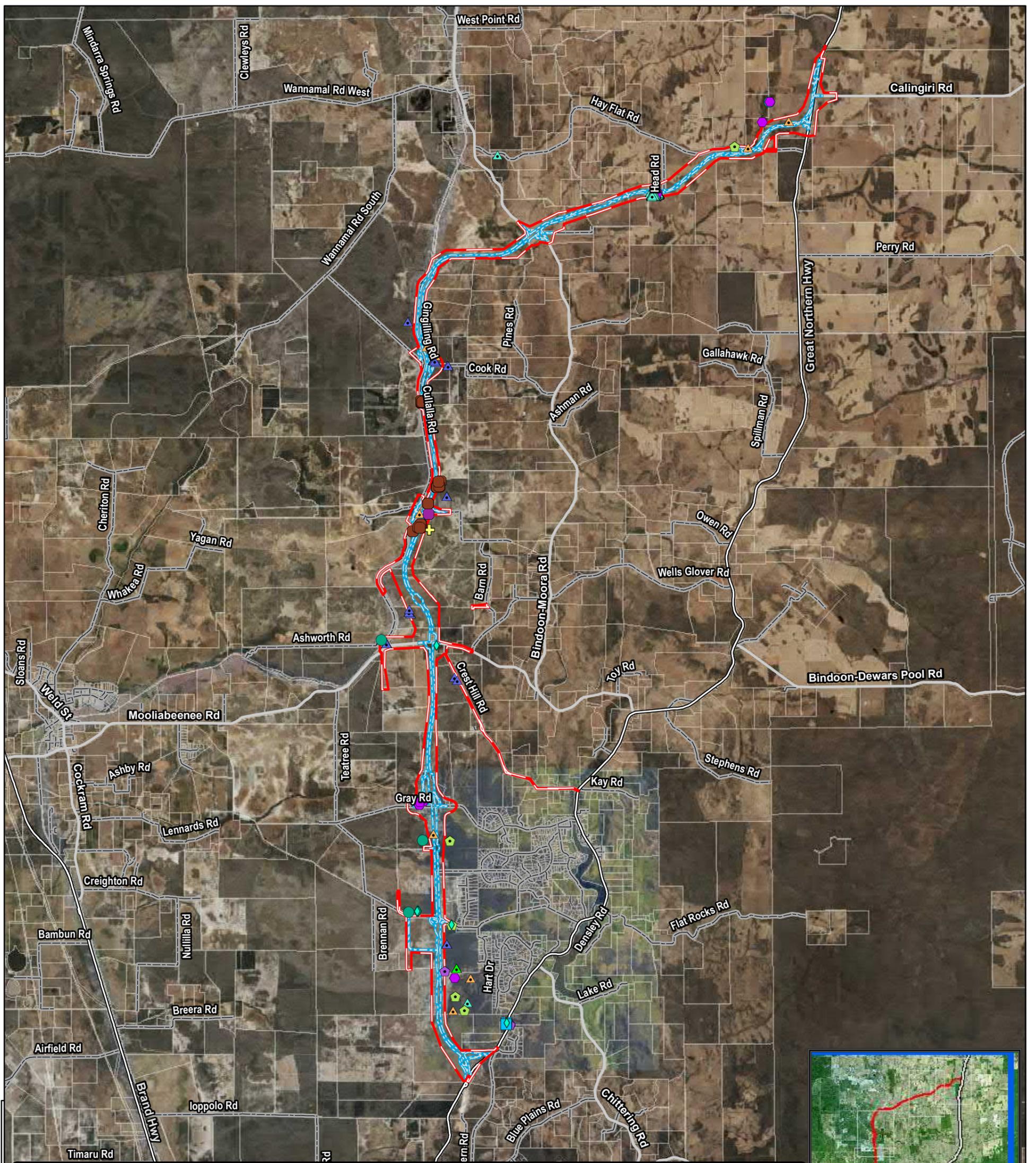
The targeted surveys undertaken for *Thelymitra stellata*, and *Drakaea elastica* focused on areas with suitable habitats for these species. For *D. elastica*, survey included a historic DBCA population record. No evidence of either species was found within the study area. Furthermore, the area where the historic *D. elastica* population was located was found to be significantly degraded. As there were no potential *D. elastica* leaves identified during the July 2017 (winter) survey, follow-up confirmation during spring was not required (FVC 2018a).

Targeted searches were conducted for all Threatened or Priority flora identified as “likely to occur” or “may occur” within the study area, including *Asterolasia nivea* (Bindoon Starbush), *Darwinia acerosa* (Fine-leaved Darwinia), *Darwinia foetida* (Muechea Bell), *Chamelaucium* sp. Gingin—NG Marchant 6 (Gingin Wax), *Grevillea corrugata* and *Spirogardnera rubescens* (Spiral Bush). None of these species were recorded, despite extensive searches of suitable habitat and locations of previous/known records. *Darwinia acerosa* is considered unlikely to occur in the Development Envelope as its preferred habitat includes granite rocks, outcrops and orange-brown gravelly soils, none of which are present in the Development Envelope.

Groundwater-Dependent Flora

A number of Banksia and Eucalypt species are considered to be (at least partially) groundwater-dependent. Facultative species do not depend entirely on groundwater and can draw water from elsewhere, such as surface water or water contained within soil pores above the water table. Obligate species have a higher dependency on groundwater and are therefore more at risk of impacts from changes to groundwater levels. For example, *Banksia ilicifolia* generally occurs in areas where the water table is no more than 5 m from the ground surface (Threatened Species Scientific Committee 2016). Species recorded within the Development Envelope include:

- *Banksia attenuata* – facultative
- *B. ilicifolia* – obligate
- *B. littoralis* – obligate
- *B. menziesii* – facultative
- *Corymbia calophylla* – facultative
- *Eucalyptus rudis* – obligate
- *E. todtiana* – facultative.



Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

● Acacia drummondii subsp. ?affinis (P3)	✱ Gastrolobium crispatum (P1)	◆ Synaphea ?panhesya (P1)
◆ Adenanthos cygnorum subsp. chamaephyton (P3)	▲ Hibbertia glomerata subsp. ginginensis (P2)	◆ Synaphea panhesya (P1)
■ Anigozanthos humilis subsp. chrysanthus (P4)	▲ Hibbertia miniata (P4)	● Verticordia ?paludosa (P4)
▲ Drosera ?sewelliae (P2)	● Hypolaena robusta (P4)	● Verticordia paludosa (P4)
▲ Drosera sewelliae (P2)	⊕ Jacksonia ?sericea (P4)	

Legend Development Envelope Development Footprint Cadastral Boundary Highway Major Road Minor Road		Joint Venture Partners: Anup Pty Ltd Level 14 Exchange Tower 2 The Esplanade Perth WA 6000 Tel +61 8 9327 8300 Fax +61 8 9481 1334 www.anup.com Jacobs Group (Australia) Pty Ltd Durack Centre, 263 Adelaide Terrace, Perth WA 6000 Tel +61 8 9469 4400 Fax +61 8 9469 4488 www.jacobs.com © Main Roads Western Australia	 Main Roads Western Australia Client Project Great Northern Highway Bindoon Bypass Environmental Review Document	Locations of Conservation Significant Flora Figure: 4-3 Page 1 of 8 Drawing No: GNH-CN12-EA-PER-0001-F4-3 Issue 1 <table border="1"> <tr> <td>Task No: ERD</td> <td>Drawing Status / Other: Draft</td> </tr> <tr> <td>Date: 13/08/2019</td> <td>By: BG, Chkd: LB, Appd: TJ</td> </tr> </table>	Task No: ERD	Drawing Status / Other: Draft	Date: 13/08/2019	By: BG, Chkd: LB, Appd: TJ
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Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

- | | | |
|--|-------------------------------|---|
| ● Acacia drummondii subsp. ?affinis (P3) | ▲ Drosera ?sewelliae (P2) | ▲ Hibbertia glomerata subsp. ginginensis (P2) |
| ◆ Adenanthos cygnorum subsp. chamaephyton (P3) | ▲ Drosera sewelliae (P2) | ▲ Hibbertia miniata (P4) |
| ■ Anigozanthos humilis subsp. chrysanthus (P4) | * Gastrolobium crispatum (P1) | ● Synaphea ?panhesya (P1) |
| | | ● Synaphea panhesya (P1) |

Legend

- | | |
|-----------------------|--------------------|
| Development Envelope | Cadastral Boundary |
| Development Footprint | Highway |
| | Major Road |
| | Minor Road |



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1:20,000
Coordinate System: GDA 1994 MGA Zone 50



Main Roads Western Australia

Great Northern Highway
Bindoon Bypass
Environmental Review Document

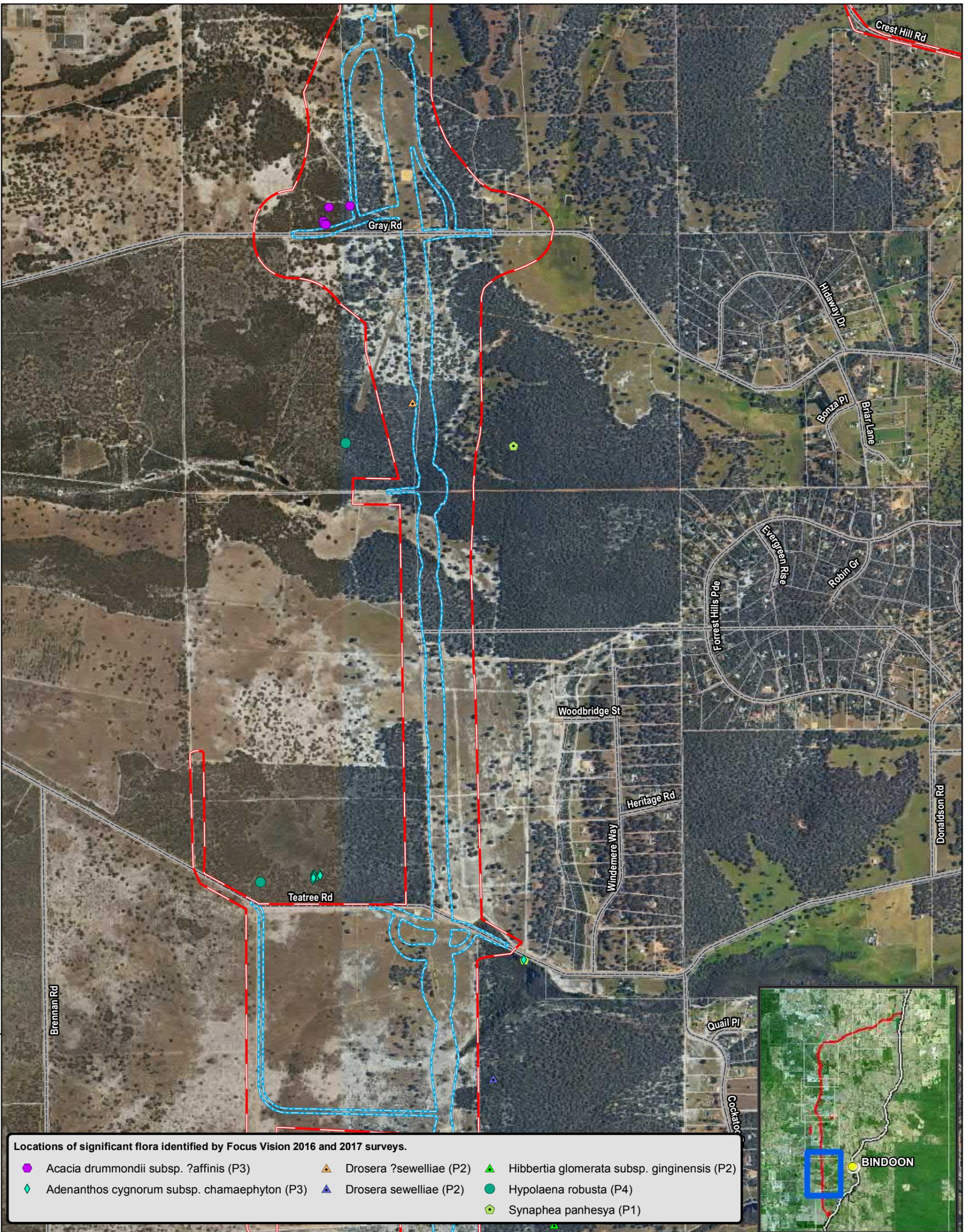
Locations of Conservation Significant Flora

Figure: 4-3 Page 2 of 8

Drawing No: GNH-CN12-EA-PER-0001-F4-3 Issue: 1

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Date	By	Chkd	Appd
13/08/2019	BG	LB	TJ

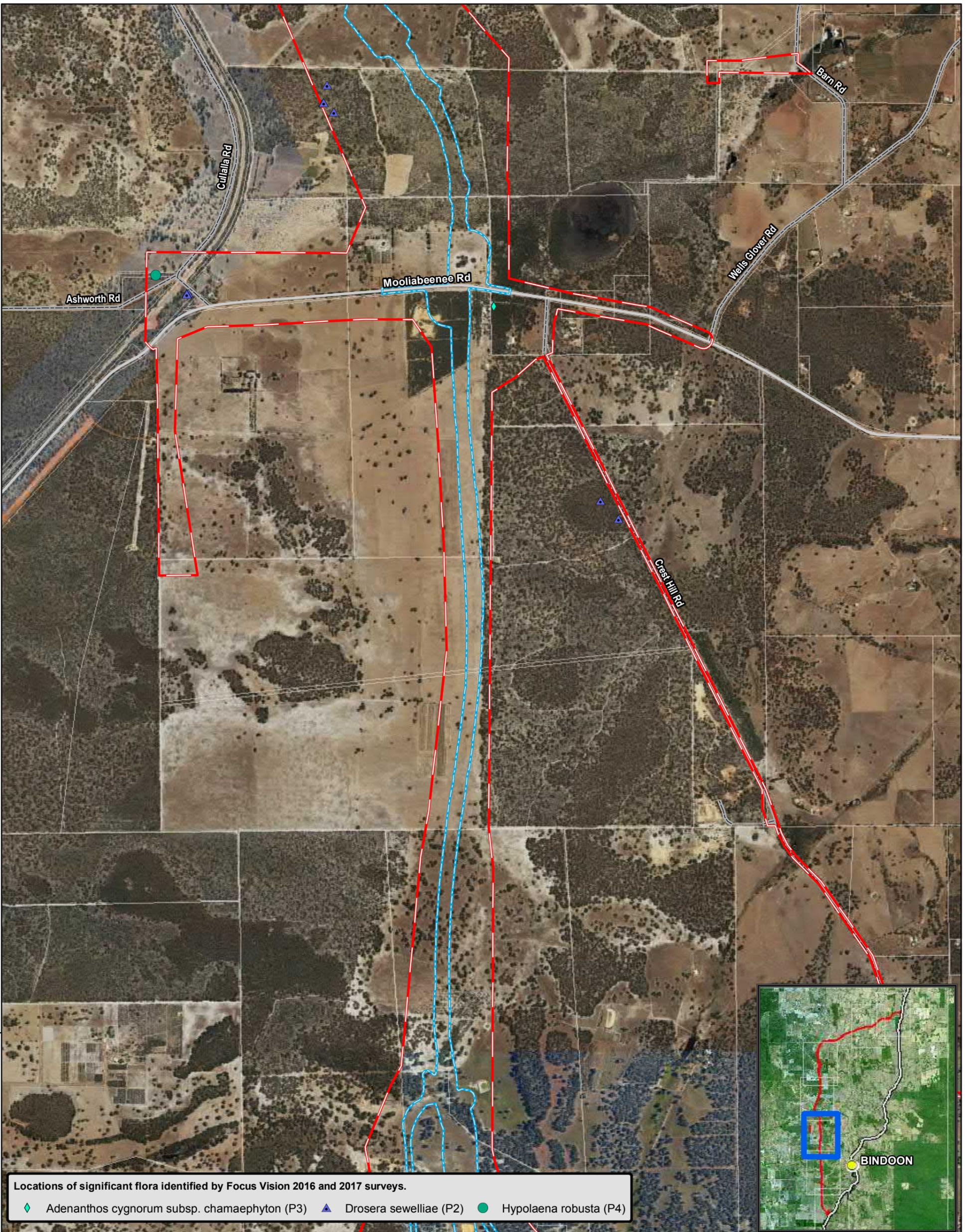


Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

- *Acacia drummondii* subsp. ?affinis (P3)
 ▲ *Drosera ?sewelliae* (P2)
▲ *Hibbertia glomerata* subsp. *ginginensis* (P2)
- ◆ *Adenanthos cygnorum* subsp. *chamaephyton* (P3)
 ▲ *Drosera sewelliae* (P2)
● *Hypolaena robusta* (P4)
- *Synaphea panhesya* (P1)



<p>Legend</p> <ul style="list-style-type: none"> Development Envelope Development Footprint Cadastral Boundary Minor Road 	<p>Joint Venture Partners:</p> <p>Anup Pty Ltd Level 14 Exchange Tower 2 The Esplanade Perth WA 6000 Tel +61 8 9327 8300 Fax +61 8 9481 1334 www.anup.com</p> <p>Jacobs Group (Australia) Pty Ltd Durack Centre, 263 Adelaide Terrace, Perth WA 6000 Tel +61 8 9469 4400 Fax +61 8 9469 4488 www.jacobs.com</p> <p>© Main Roads Western Australia</p> <p>Scale at A3 1:20,000</p> <p>0 240 480 Metres</p> <p>Coordinate System: GDA 1994 MGA Zone 50</p>	<p>Main Roads Western Australia</p> <p>Client Project</p> <p>Great Northern Highway Bindoon Bypass Environmental Review Document</p>	<p>Locations of Conservation Significant Flora</p> <p>Figure: 4-3 Page 3 of 8</p> <p>Drawing No: GNH-CN12-EA-PER-0001-F4-3 Issue: 1</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Task No ERD</td> <td>Drawing Status / Other Draft</td> </tr> <tr> <td>Date 13/08/2019</td> <td>By BG</td> </tr> <tr> <td>Chkd LB</td> <td>Appd TJ</td> </tr> </table>	Task No ERD	Drawing Status / Other Draft	Date 13/08/2019	By BG	Chkd LB	Appd TJ
Task No ERD	Drawing Status / Other Draft								
Date 13/08/2019	By BG								
Chkd LB	Appd TJ								



Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

- ◆ Adenanthos cygnorum subsp. chamaephyton (P3)
- ▲ Drosera sewelliae (P2)
- Hypolaena robusta (P4)

- Legend**
- Development Envelope
 - Development Footprint
 - Cadastral Boundary
 - Major Road
 - Minor Road

North Arrow

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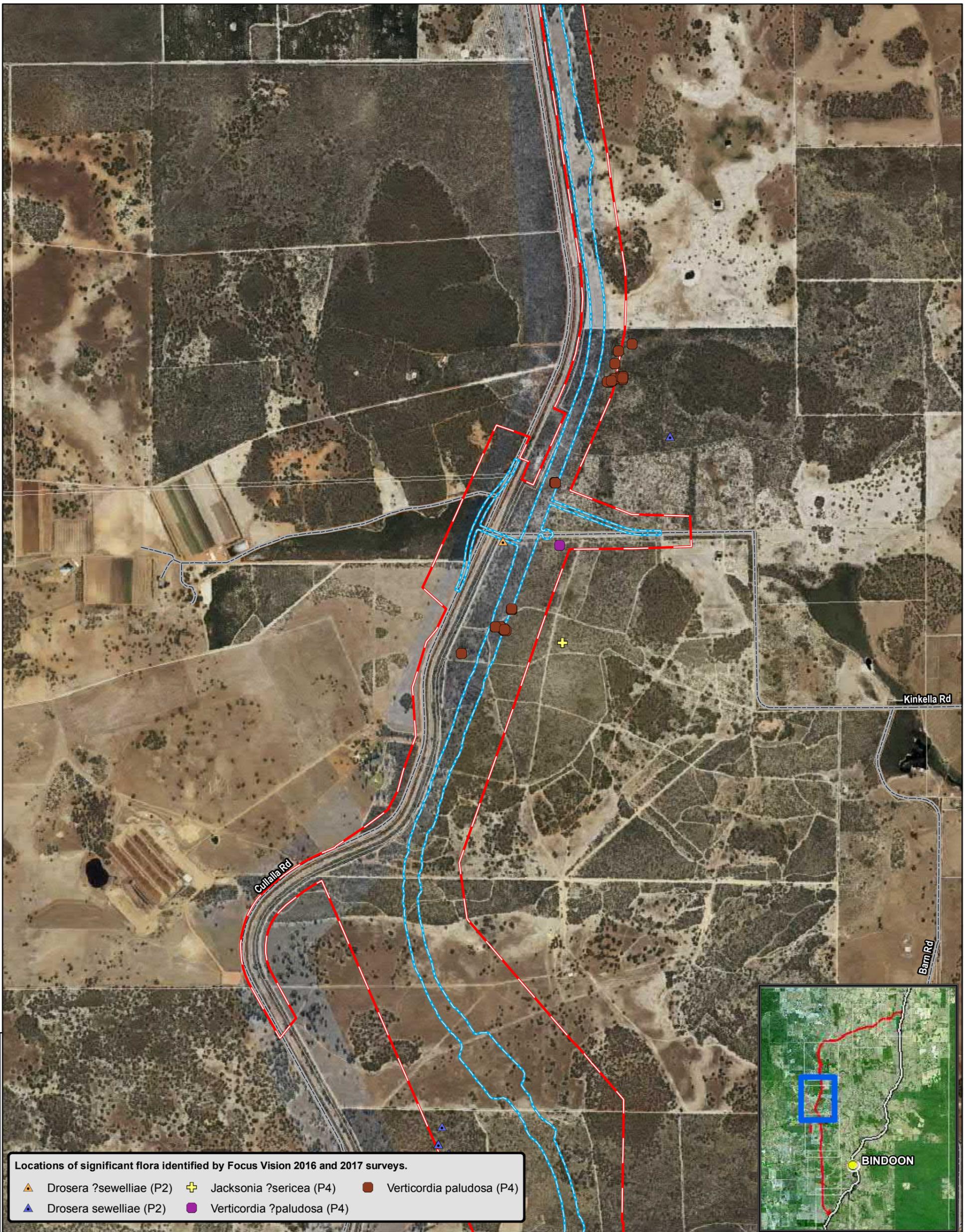
Locations of Conservation Significant Flora

Figure: 4-3 Page 4 of 8

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Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

Drosera ?sewellaie (P2)	Jacksonia ?sericea (P4)	Verticordia paludosa (P4)
Drosera sewellaie (P2)	Verticordia ?paludosa (P4)	

Legend

Development Envelope	Cadastral Boundary
Development Footprint	Minor Road

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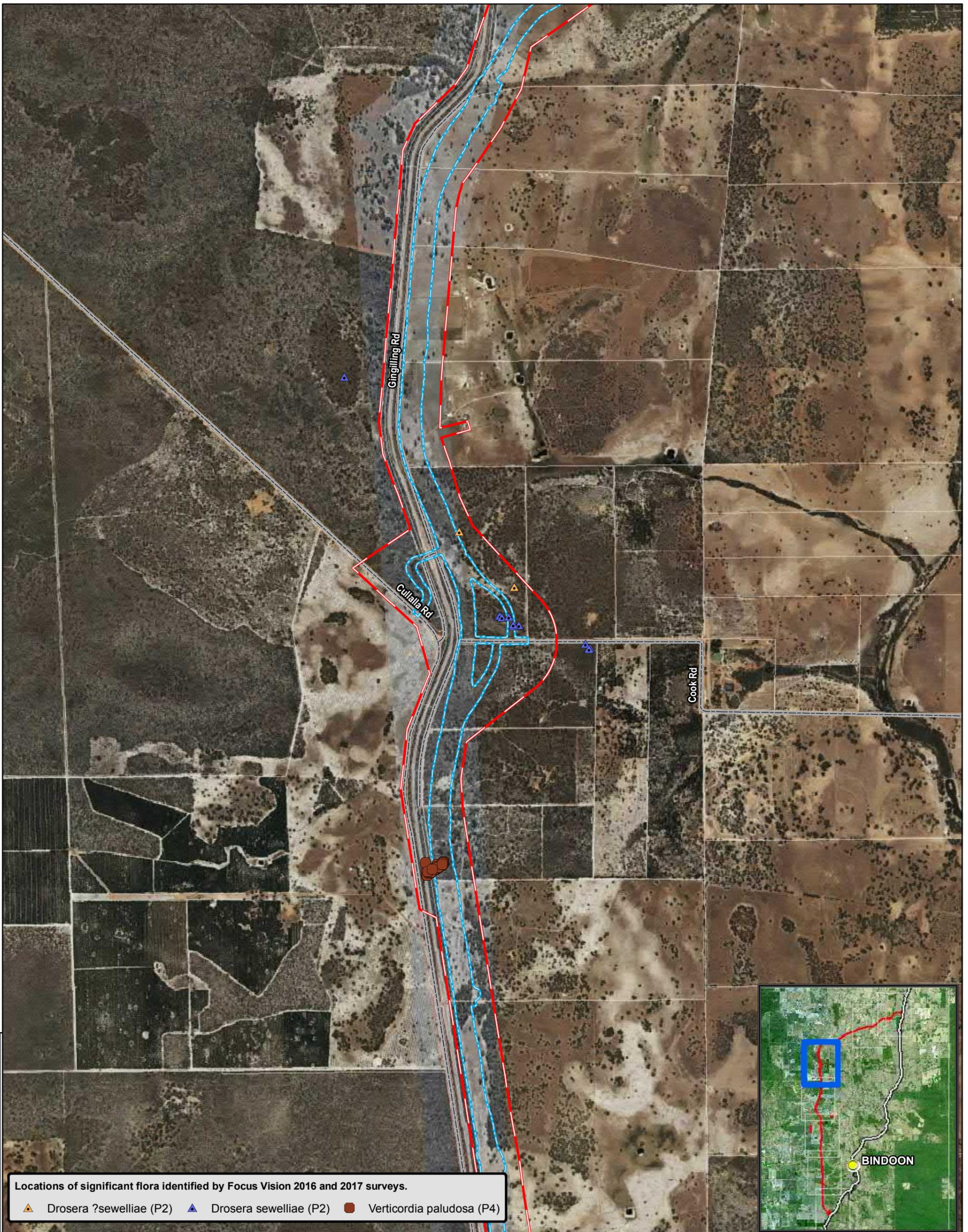
Locations of Conservation Significant Flora

Figure: 4-3 Page 5 of 8

Drawing No: **GNH-CN12-EA-PER-0001-F4-3** Issue: **1**

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Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

▲ Drosera ?sewelliae (P2)
 ▲ Drosera sewelliae (P2)
 ● Verticordia paludosa (P4)

Legend

Development Envelope
 Cadastral Boundary
 Development Footprint
 Minor Road

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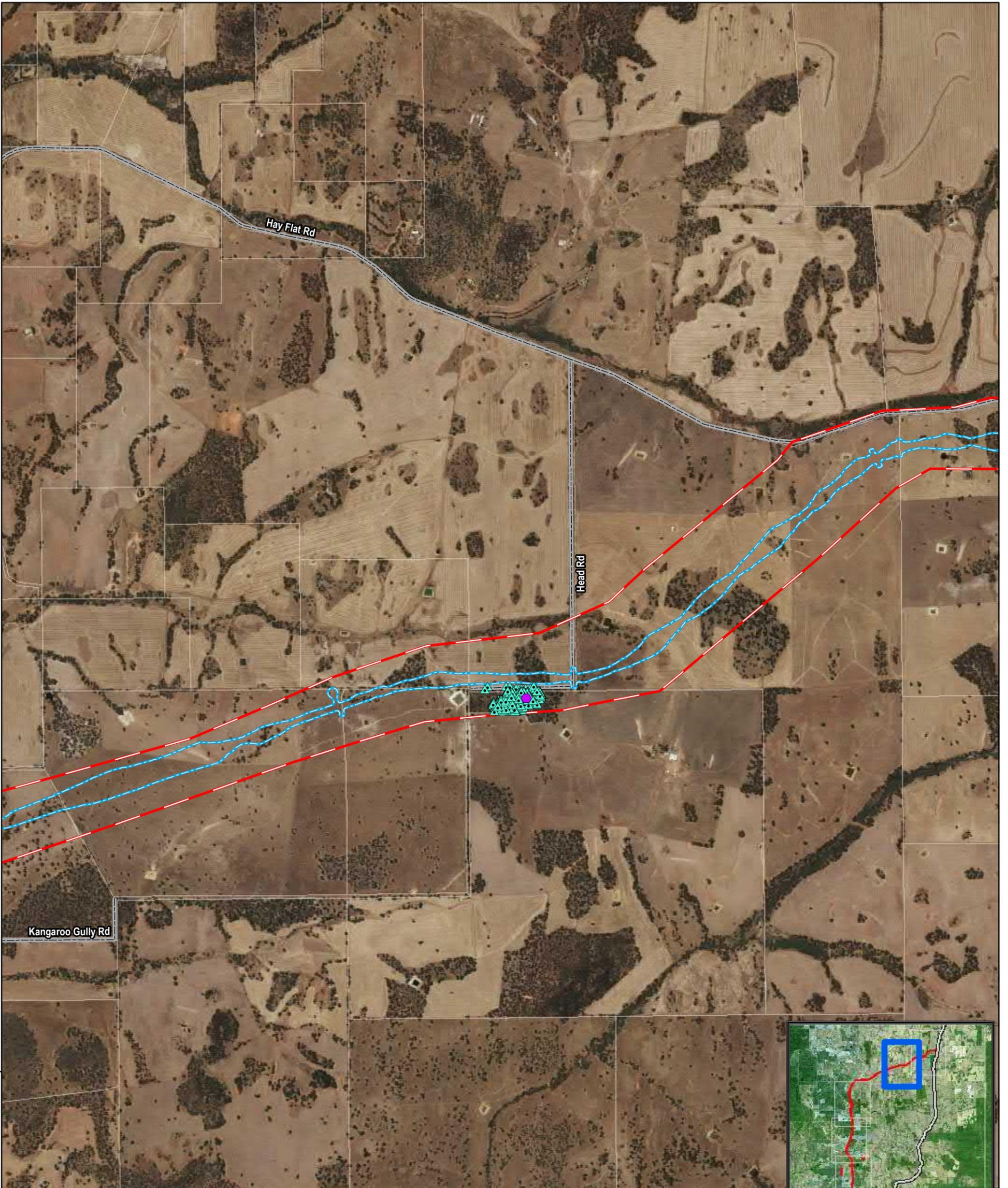
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Locations of Conservation Significant Flora

Figure: 4-3 Page 6 of 8

Drawing No: **GNH-CN12-EA-PER-0001-F4-3** Issue: **1**
 Task No: **ERD** Drawing Status / Other: **Draft**
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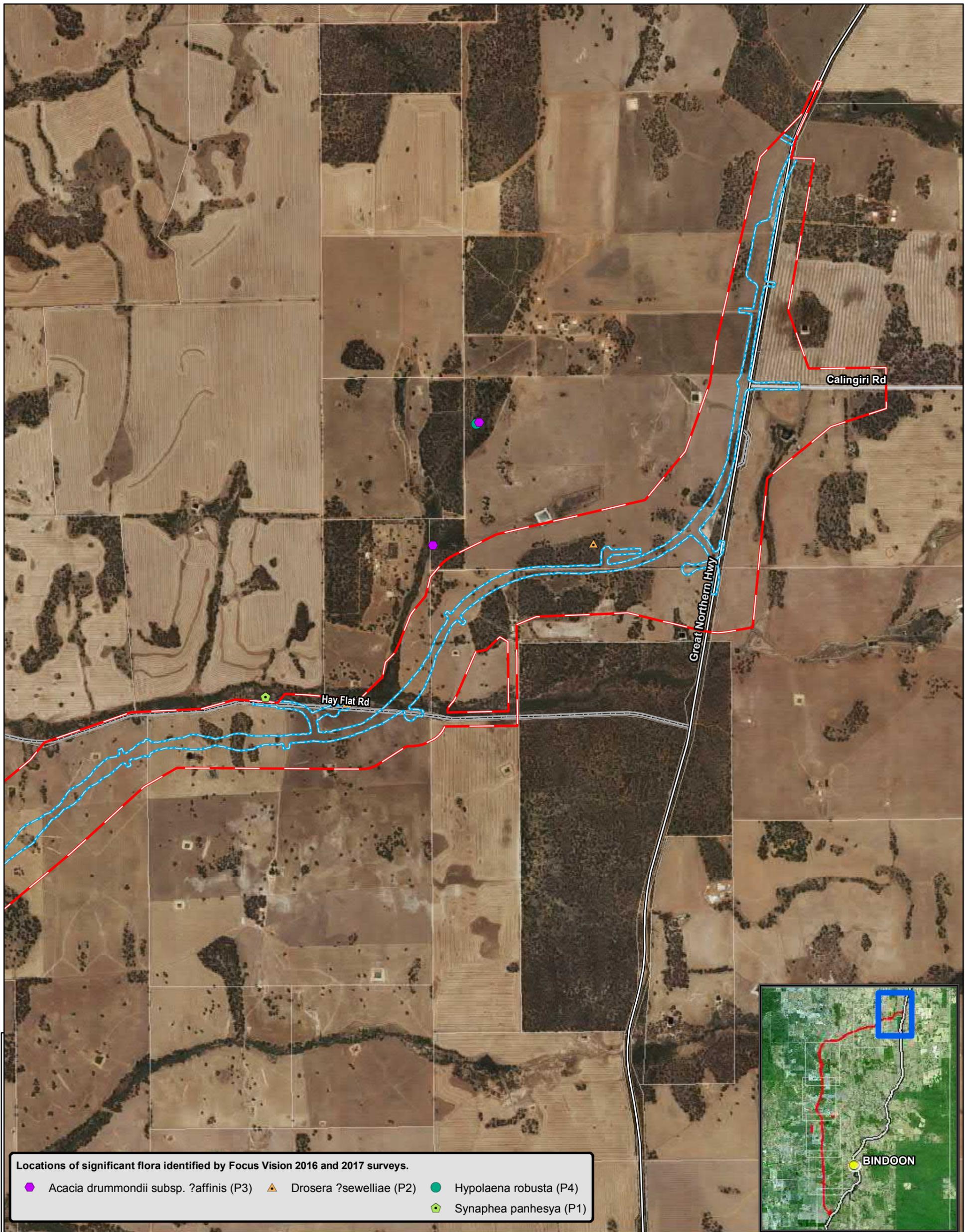
Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

- *Acacia drummondii* subsp. ?affinis (P3)
- ▲ *Drosera sewelliae* (P2)
- ▲ *Hibbertia miniata* (P4)
- *Verticordia ?paludosa* (P4)



<p>Legend</p> <ul style="list-style-type: none"> Development Envelope Development Footprint Cadastral Boundary Minor Road 	<p style="text-align: center;">North Arrow</p> <p style="text-align: center;">Joint Venture Partners:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><small>Anup Pty Ltd Level 14 Exchange Tower 2 The Esplanade Perth WA 6000 Tel +61 8 9327 8300 Fax +61 8 9481 1334 www.anup.com</small></p> </div> <div style="text-align: center;"> </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="text-align: center;"> </div> <div style="text-align: center;"> <p>ARUP <small>TRADING AS ASJV</small></p> <p>JACOBS</p> </div> </div> <p style="text-align: center;"><small>© Main Roads Western Australia</small></p>	<p>Locations of Conservation Significant Flora</p> <p>Figure: 4-3 Page 7 of 8</p> <p>Drawing No: GNH-CN12-EA-PER-0001-F4-3 Issue: 1</p> <table border="1" style="width: 100%; border-collapse: collapse; font-size: 8px;"> <tr> <td>Task No</td> <td colspan="3">Drawing Status / Other</td> </tr> <tr> <td>ERD</td> <td colspan="3">Draft</td> </tr> <tr> <td>Date</td> <td>By</td> <td>Chkd</td> <td>Appd</td> </tr> <tr> <td>13/08/2019</td> <td>BG</td> <td>LB</td> <td>TJ</td> </tr> </table>	Task No	Drawing Status / Other			ERD	Draft			Date	By	Chkd	Appd	13/08/2019	BG	LB	TJ
Task No	Drawing Status / Other																	
ERD	Draft																	
Date	By	Chkd	Appd															
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Locations of significant flora identified by Focus Vision 2016 and 2017 surveys.

- Acacia drummondii subsp. ?affinis (P3)
- ▲ Drosera ?sewelliae (P2)
- Hypolaena robusta (P4)
- ◆ Synaphea panhesya (P1)



<p>Legend</p> <ul style="list-style-type: none"> Development Envelope Development Footprint Cadastral Boundary Highway Major Road Minor Road 	<p>Joint Venture Partners:</p> <p>Anup Pty Ltd Level 14 Exchange Tower 2 The Esplanade Perth WA 6000 Tel +61 8 9327 8300 Fax +61 8 9481 1334 www.anup.com</p> <p>Jacobs Group (Australia) Pty Ltd Durack Centre, 263 Adelaide Terrace, Perth WA 6000 Tel +61 8 9469 4400 Fax +61 8 9469 4488 www.jacobs.com</p> <p>© Main Roads Western Australia</p>		<p>Locations of Conservation Significant Flora</p> <p>Figure: 4-3 Page 8 of 8</p> <p>Drawing No: GNH-CN12-EA-PER-0001-F4-3 Issue: 1</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Task No: ERD</td> <td>Drawing Status / Other: Draft</td> </tr> <tr> <td>Date: 13/08/2019</td> <td>By: BG</td> <td>Chkd: LB</td> <td>Appd: TJ</td> </tr> </table>	Task No: ERD	Drawing Status / Other: Draft	Date: 13/08/2019	By: BG	Chkd: LB	Appd: TJ
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4.2.3.3 Vegetation

Vegetation Associations

Vegetation within the study area has broadly been characterised as Banksia low woodland, Jarrah-Marri woodland, Marri woodland, Bullich and Blackbutt (FVC 2018a). The flora and vegetation surveys identified and mapped 12 vegetation associations (FVC 20189). These are detailed in **Table 4-4**, along with their extent within the Development Envelope and the total mapped extent of each vegetation association (**Figure 4-4**).

Table 4-4: Vegetation Associations of the Development Envelope

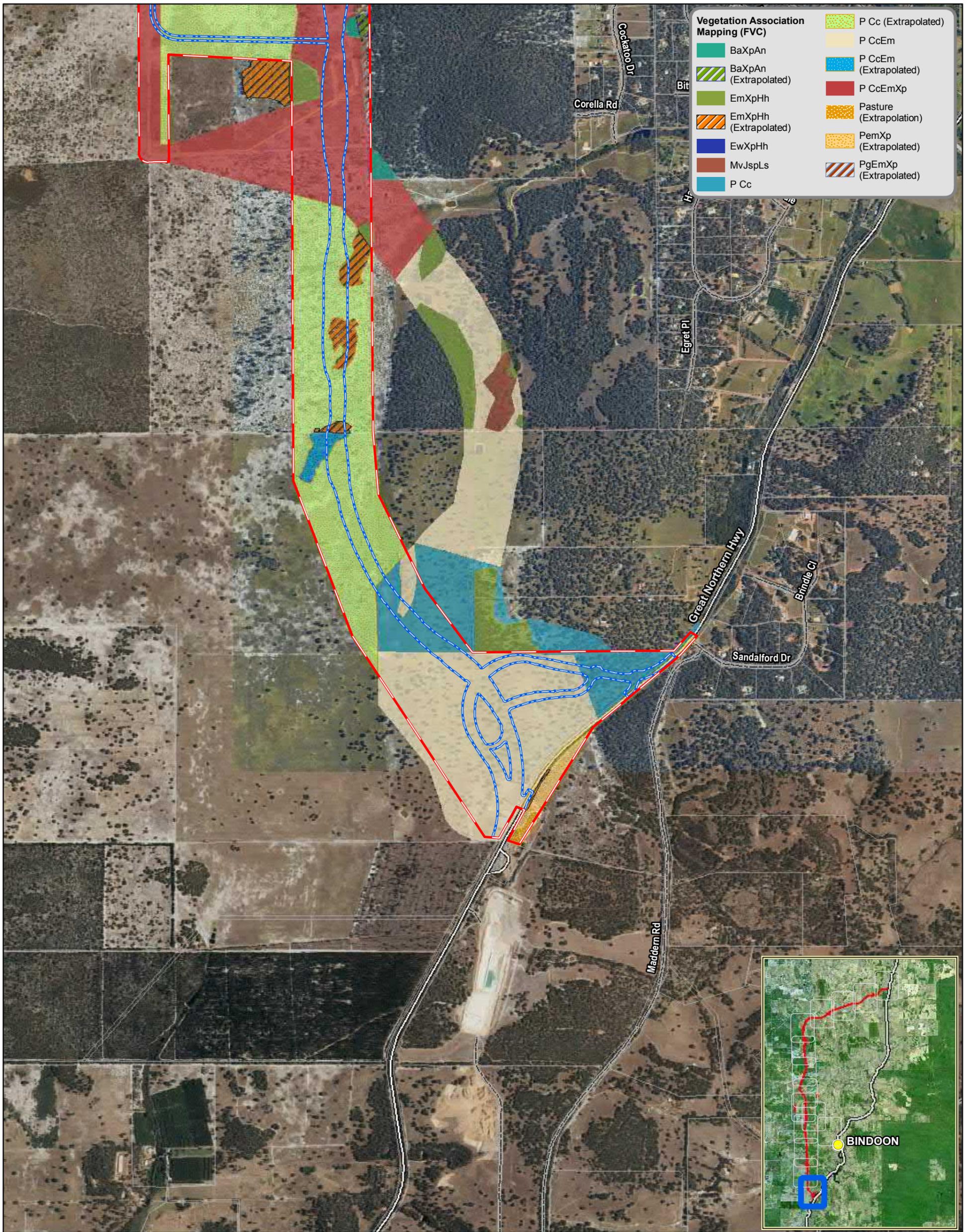
Vegetation Association ¹	Description	Extent within Development Envelope (ha)	Extent Mapped by FVC (ha)
BaXpAn	Banksia spp. sparse woodland <i>Banksia attenuata</i> , <i>Banksia menziesii</i> and <i>Eucalyptus tottiana</i> low sparse woodland over <i>Xanthorrhoea preissii</i> mid isolated to sparse shrubs over <i>Bossiaea eriocarpa</i> , <i>Gompholobium tomentosum</i> and <i>Petrophile linearis</i> low isolated shrubs over <i>Alexgeorgea nitens</i> and <i>Lyginia imberbis</i> sparse sedgeland.	61.0	95.2
BaXpJa	Banksia attenuata sparse woodland <i>Banksia attenuata</i> low sparse woodland (with occasional <i>Banksia menziesii</i>) over <i>Xanthorrhoea preissii</i> mid isolated shrubs over <i>Bossiaea eriocarpa</i> , <i>Hibbertia hypericoides</i> and <i>Petrophile linearis</i> low isolated shrubs over * <i>Ursinia anthemoides</i> , <i>Conostylis aculeata</i> and * <i>Hypochaeris glabra</i> isolated herbs.	41.7	49.1
BmKgHg	Kunzea glabrescens shrubland <i>Banksia menziesii</i> low sparse to open woodland over <i>Kunzea glabrescens</i> and <i>Xanthorrhoea preissii</i> mid shrubland over * <i>Hypochaeris glabra</i> and <i>Drosera erythrorhiza</i> isolated herbs.	8.6	16.8
EmBsHh	Eucalyptus marginata and Banksia sessilis sparse woodland <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> low sparse woodland over <i>Banksia sessilis</i> and <i>Xanthorrhoea preissii</i> tall to mid sparse shrubland over <i>Hibbertia hypericoides</i> and <i>Bossiaea eriocarpa</i> low isolated to sparse shrubland over * <i>Hypochaeris glabra</i> and * <i>Ursinia anthemoides</i> isolated herbs.	115.0	139.6
EmXpAn	Eucalyptus marginata sparse woodland <i>Eucalyptus marginata</i> (and <i>Banksia attenuata</i>) low sparse woodland over <i>Xanthorrhoea preissii</i> mid sparse shrubland over <i>Bossiaea eriocarpa</i> , <i>Hibbertia hypericoides</i> and <i>Petrophile linearis</i> low isolated to sparse shrubland over <i>Alexgeorgea nitens</i> and <i>Lomandra</i> spp. isolated sedges.	13.4	122.8

Vegetation Association ¹	Description	Extent within Development Envelope (ha)	Extent Mapped by FVC (ha)
EmXpHh	<i>Eucalyptus marginata</i> sparse woodland <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> low sparse woodland over <i>Xanthorrhoea preissii</i> mid sparse shrubland over <i>Hibbertia hypericoides</i> , <i>Bossiaea eriocarpa</i> and <i>Banksia dallanneyi</i> low isolated shrubs over <i>Conostylis setosa</i> , <i>Xanthosia</i> sp. and <i>Philothea spicata</i> isolated herbs.	131.3	222.3
ErXpBm	<i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> sparse woodland <i>Eucalyptus rudis</i> , <i>Melaleuca preissiana</i> and <i>Corymbia calophylla</i> low sparse woodland over <i>Xanthorrhoea preissii</i> and <i>Jacksonia furcellata</i> mid isolated shrubs over <i>Hypocalymma angustifolium</i> low shrubland over <i>Lepidosperma tenue</i> isolated sedges and * <i>Briza</i> spp. sparse grassland.	48.1	62.2
EtBeAn	<i>Eucalyptus todtiana</i> sparse woodland <i>Eucalyptus todtiana</i> , <i>Banksia attenuata</i> and <i>Banksia menziesii</i> low sparse woodland over <i>Bossiaea eriocarpa</i> , <i>Hibbertia hypericoides</i> and <i>Petrophile linearis</i> low isolated shrubs over <i>Alexgeorgea nitens</i> , <i>Lyginia imberbis</i> and <i>Mesomelaena pseudostygia</i> sparse sedgeland.	152.2	257.5
EtEpAn	<i>Eucalyptus todtiana</i> sparse woodland <i>Eucalyptus todtiana</i> and <i>Banksia</i> spp. low sparse woodland over <i>Adenanthos cygnorum</i> tall sparse shrubland over <i>Eremaea pauciflora</i> and <i>Stirlingia latifolia</i> mid sparse to isolated shrubland over <i>Bossiaea eriocarpa</i> and <i>Conostephium pendulum</i> low isolated shrubs over <i>Austrostipa hemipogon</i> and <i>Briza maxima</i> grasses and <i>Alexgeorgea nitens</i> sedges.	39.2	59.1
EwBeNa	<i>Eucalyptus wandoo</i> and <i>Casuarina obesa</i> sparse woodland <i>Eucalyptus wandoo</i> and <i>Casuarina obesa</i> mid to low sparse woodland over <i>Bossiaea eriocarpa</i> and <i>Gastrolobium calycinum</i> and <i>Hakea lissocarpa</i> low isolated shrubs over <i>Neurachne alopecuroidea</i> and <i>Lepidosperma tenue</i> isolated grasses and sedges.	4.5	4.6
EwXpHh	<i>Eucalyptus wandoo</i> sparse woodland <i>Eucalyptus wandoo</i> mid sparse woodland over <i>Xanthorrhoea preissii</i> mid isolated shrubs over <i>Hibbertia hypericoides</i> , <i>Bossiaea eriocarpa</i> and <i>Banksia dallanneyi</i> low isolated shrubs over <i>Conostylis setosa</i> , * <i>Hypochoeris glabra</i> and <i>Drosera</i> spp. isolated herbs.	44.5	45.3
MvJspLs	<i>Melaleuca viminea</i> shrubland <i>Melaleuca viminea</i> tall shrubland over <i>Juncus</i> spp. and <i>Isolepis</i> spp. sparse sedgeland and <i>Cotula coronopifolia</i> , <i>Lotus</i> spp. and <i>Utricularia multifida</i> isolated herbs.	0.1	2.1

Vegetation Association ¹	Description	Extent within Development Envelope (ha)	Extent Mapped by FVC (ha)
	Not mapped (not within disturbance footprint)	43.6	43.6
	Pasture (with or without trees)	1,732.8	2,750.9
	Planted/Plantation	36.1	50.5
	Cleared (roads, railway, etc.)	79.5	22.2
Total		2,552.50	3,843.80

Weeds are identified using *

The majority of the vegetation associations that were recorded during field surveys have relatively high average species richness values (at least 20-30 taxa per quadrat). BaXpAn (*Banksia* spp. sparse woodland), EwXpHh (*Eucalyptus wandoo* sparse woodland) and EmXpAn (*E. marginata* sparse woodland) were the most floristically diverse vegetation associations, with average species richness values of 42.2, 39.9 and 38.6 taxa respectively. Vegetation association MvJspLs (*Melaleuca viminea* shrubland), which is a wetland vegetation type, had the lowest average species richness with 8.0 species recorded. As the vegetation associations mapped by FVC (2018a, 2018b, 2019) all support at least one Priority flora species, all vegetation associations are considered locally significant.



Vegetation Association Mapping (FVC)

BaXpAn	P Cc (Extrapolated)
BaXpAn (Extrapolated)	P CcEm
EmXpHh	P CcEm (Extrapolated)
EmXpHh (Extrapolated)	P CcEmXp
EwXpHh	Pasture (Extrapolated)
MvJspLs	PemXp (Extrapolated)
P Cc	PgEmXp (Extrapolated)

Legend

- | | |
|-----------------------|--------------------|
| Development Envelope | Cadastral Boundary |
| Development Footprint | Highway |
| | Major Road |
| | Minor Road |

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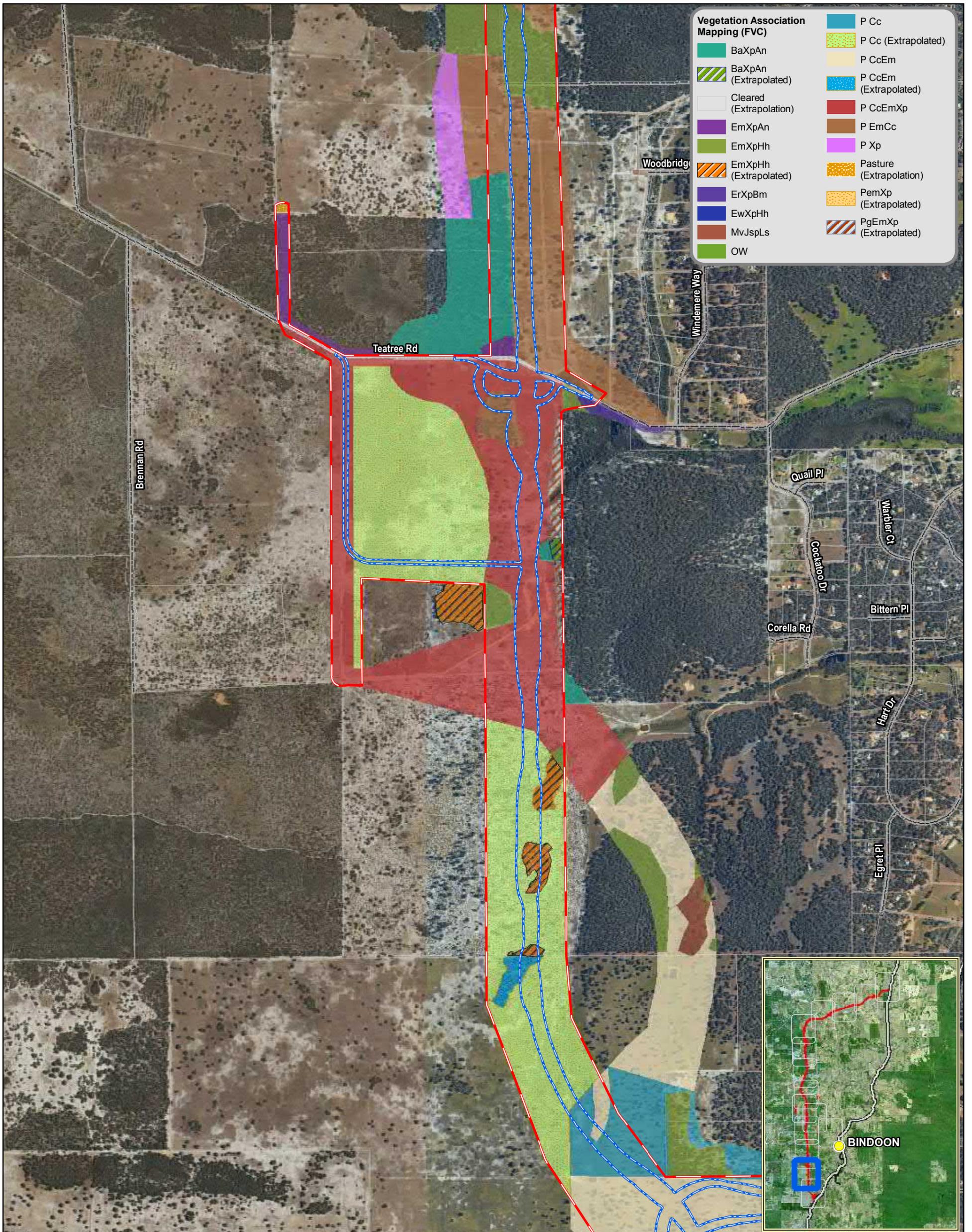
Mapped Vegetation Associations

Figure: 4-4 Page: 1 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpAn	P Cc
BaXpAn (Extrapolated)	P Cc (Extrapolated)
Cleared (Extrapolation)	P CcEm
EmXpAn	P CcEm (Extrapolated)
EmXpHh	P CcEmXp
EmXpHh (Extrapolated)	P EmCc
ErXpBm	P Xp
EwXpHh	Pasture (Extrapolation)
MvJspLs	PemXp (Extrapolated)
OW	PgEmXp (Extrapolated)

Legend

- | | |
|-----------------------|--------------------|
| Development Envelope | Cadastral Boundary |
| Development Footprint | Highway |
| | Minor Road |

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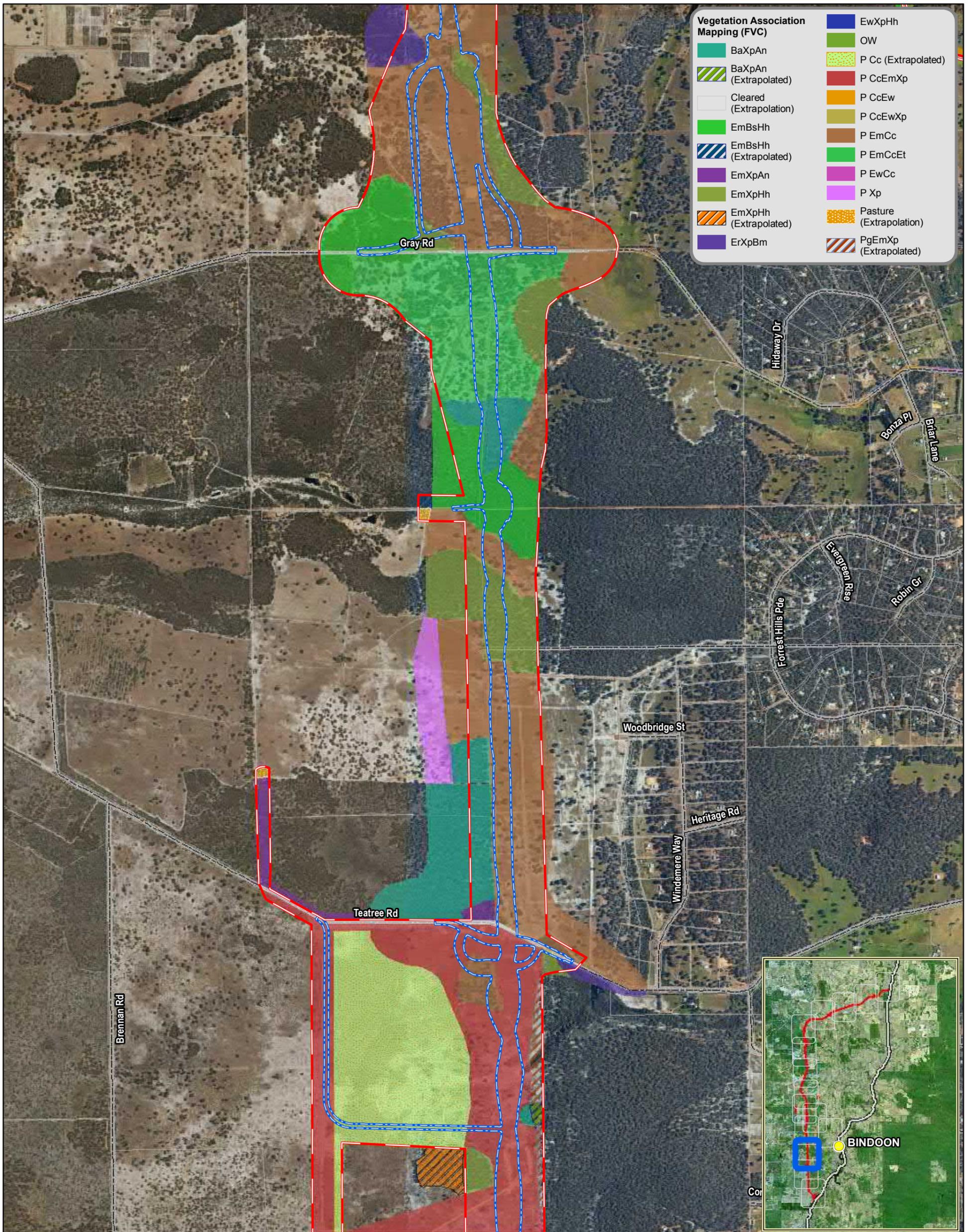
Mapped Vegetation Associations

Figure: 4-4 Page: 2 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpAn	EwXpHh
BaXpAn (Extrapolated)	OW
Cleared (Extrapolation)	P Cc (Extrapolated)
EmBsHh	P CcEmXp
EmBsHh (Extrapolated)	P CcEw
EmXpAn	P CcEwXp
EmXpHh	P EmCc
EmXpHh (Extrapolated)	P EmCcEt
ErXpBm	P EwCc
	P Xp
	Pasture (Extrapolation)
	PgEmXp (Extrapolated)

Legend

- Development Envelope
- Cadastral Boundary
- Development Footprint
- Minor Road

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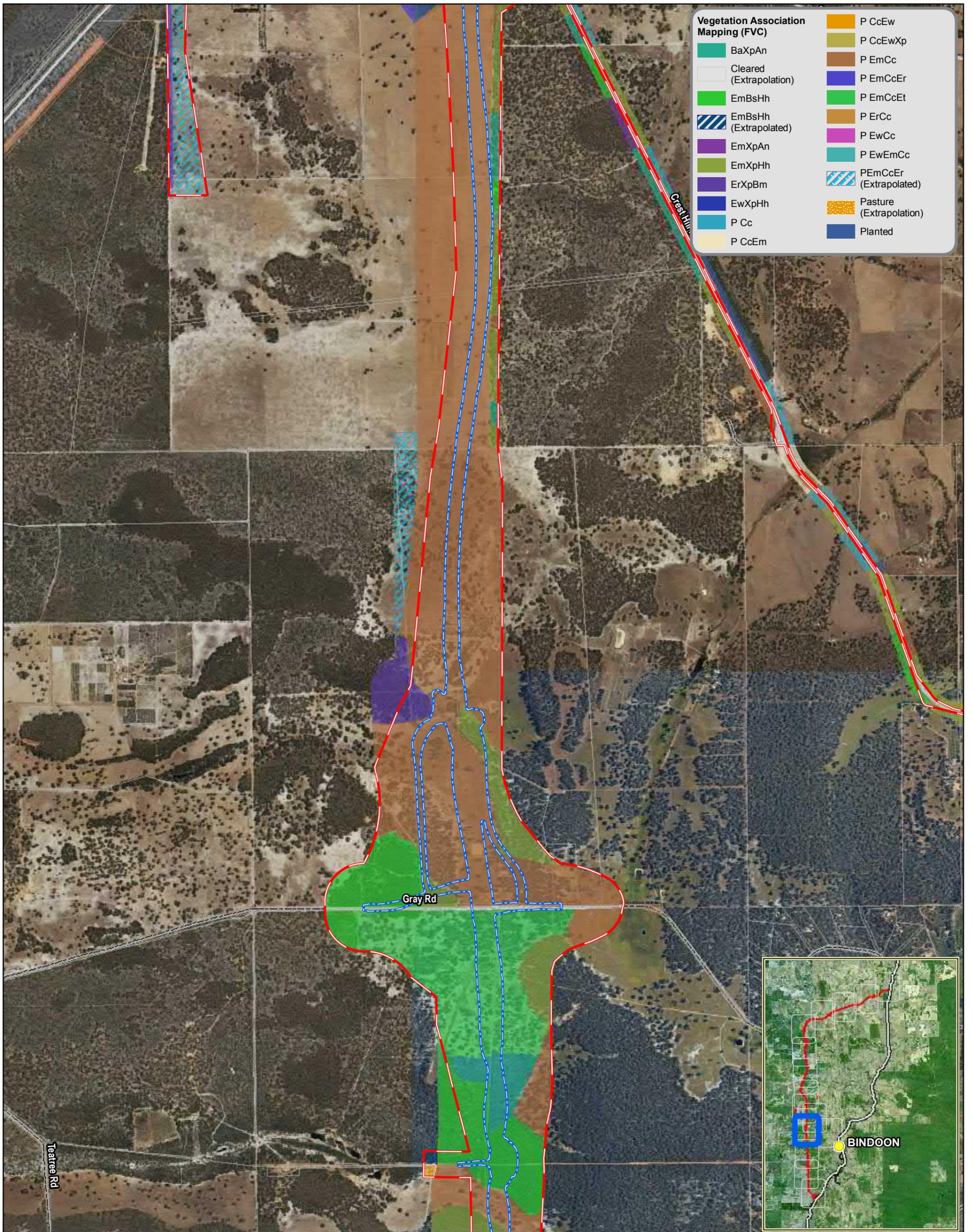
Mapped Vegetation Associations

Figure: 4-4 Page: 3 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

Task: EDR	Drawing Status / Other: Draft		
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Vegetation Association Mapping (FVC)	
BaXpAn	P CcEw
Cleared (Extrapolation)	P CcEwXp
EmBsHh	P EmCc
EmBsHh (Extrapolated)	P EmCcEr
EmXpAn	P EmCcEt
EmXpHh	P ErCc
ErXpBm	P EwCc
EwXpHh	P EwEmCc
P Cc	PEmCcEr (Extrapolated)
P CcEm	Pasture (Extrapolation)
	Planted

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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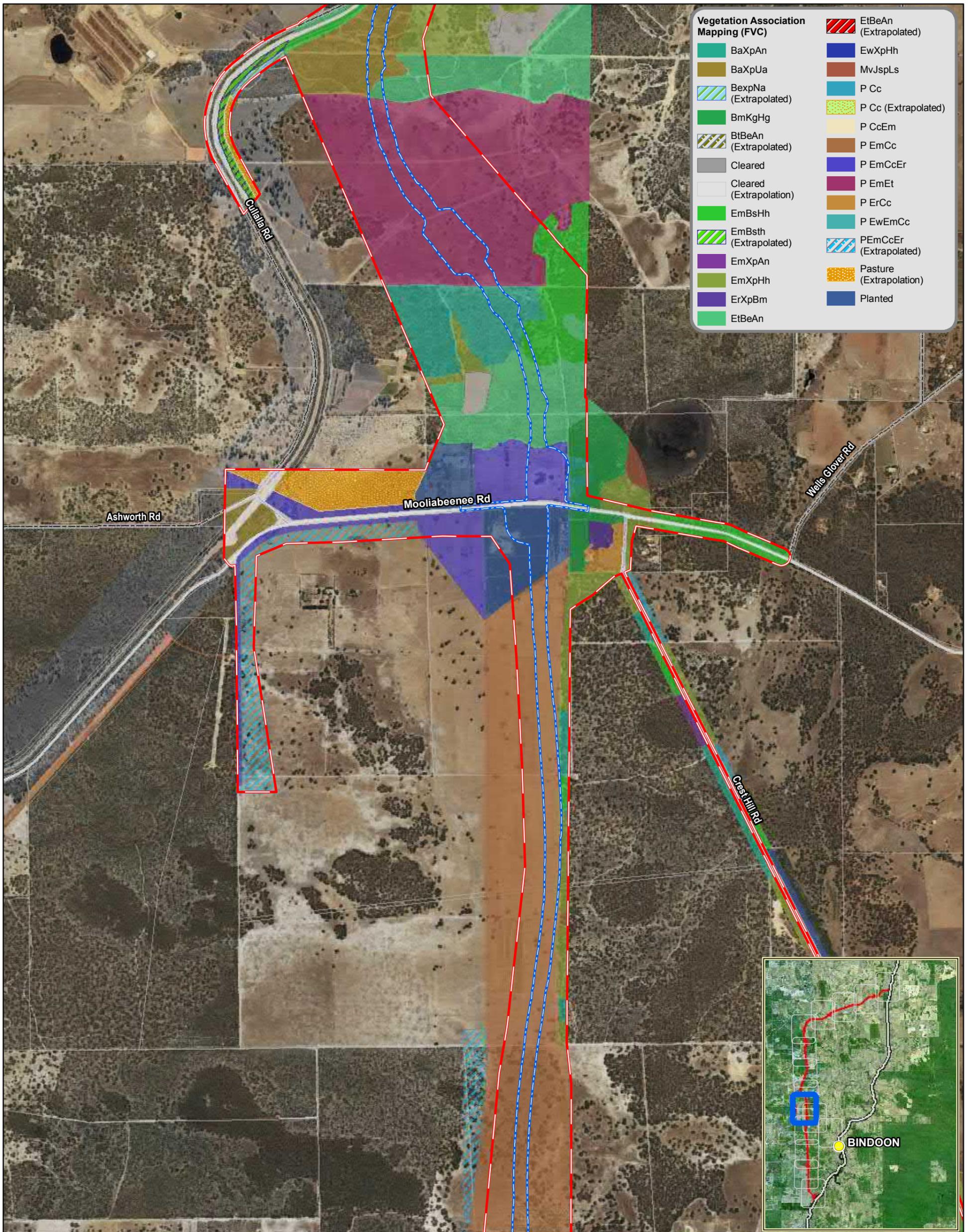
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Mapped Vegetation Associations
Figure: 4-4 Page: 4 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)	
BaXpAn	EtBeAn (Extrapolated)
BaXpUa	EwXpHh
BexpNa (Extrapolated)	MvJspLs
BmKgHg	P Cc
BtBeAn (Extrapolated)	P Cc (Extrapolated)
Cleared	P CcEm
Cleared (Extrapolation)	P EmCc
EmBsHh	P EmCcEr
EmBsth (Extrapolated)	P EmEt
EmXpAn	P ErCc
EmXpHh	P EwEmCc
ErXpBm	PEmCcEr (Extrapolated)
EtBeAn	Pasture (Extrapolation)
	Planted

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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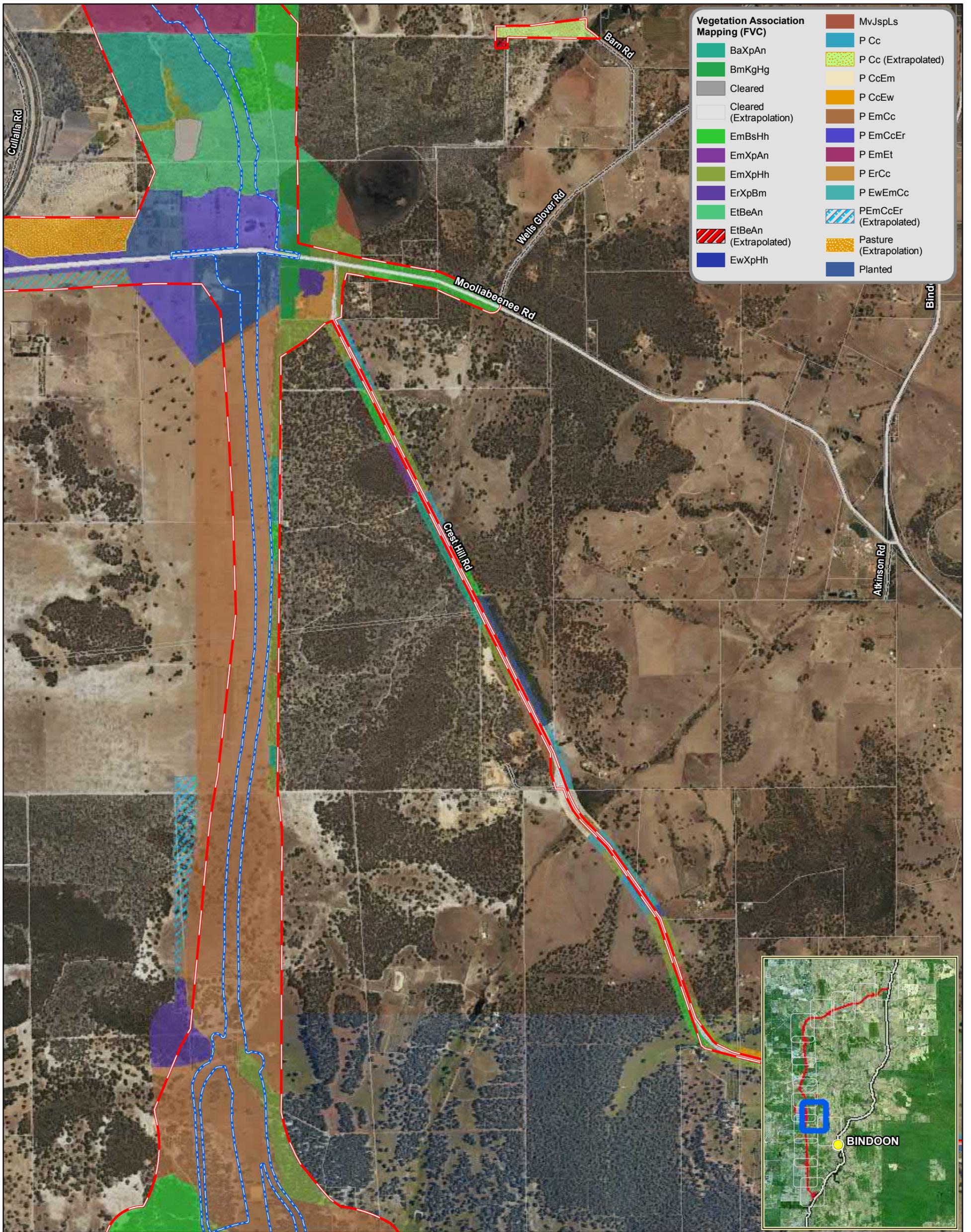
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Figure: 4-4 Page: 5 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpAn	MvJspLs
BmKgHg	P Cc
Cleared	P Cc (Extrapolated)
Cleared (Extrapolation)	P CcEm
EmBsHh	P CcEw
EmXpAn	P EmCc
EmXpHh	P EmCcEr
ErXpBm	P EmEt
EtBeAn	P ErCc
EtBeAn (Extrapolated)	P EwEmCc
EwXpHh	PEmCcEr (Extrapolated)
	Pasture (Extrapolation)
	Planted

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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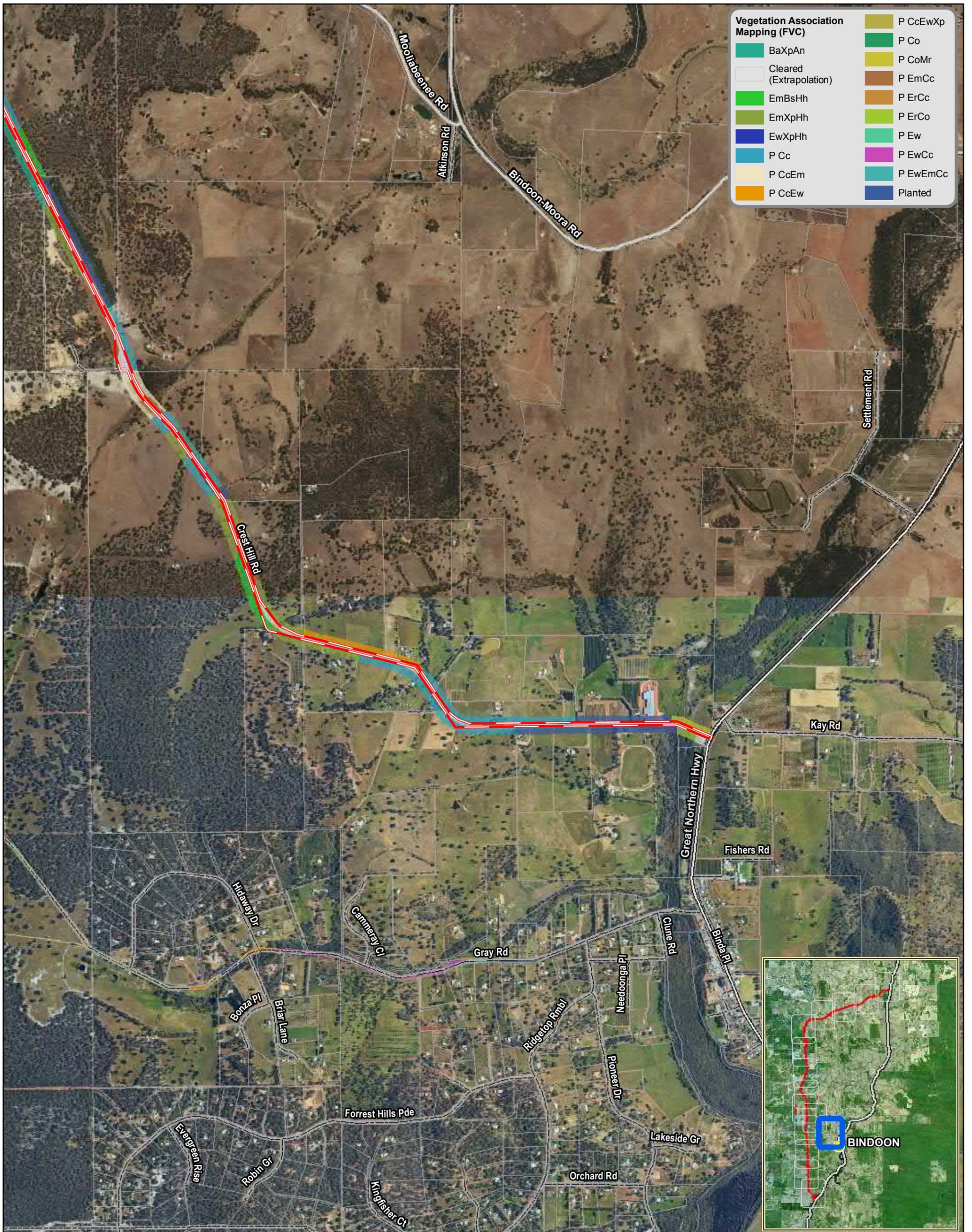
Figure: 4-4 Page: 6 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpAn	P CcEwXp
Cleared (Extrapolation)	P Co
EmBsHh	P CoMr
EmXpHh	P EmCc
EwXpHh	P ErCc
P Cc	P ErCo
P CcEm	P Ew
P CcEw	P EwCc
	P EwEmCc
	Planted

Legend

- Development Envelope
- Cadastral Boundary
- Highway
- Major Road
- Minor Road

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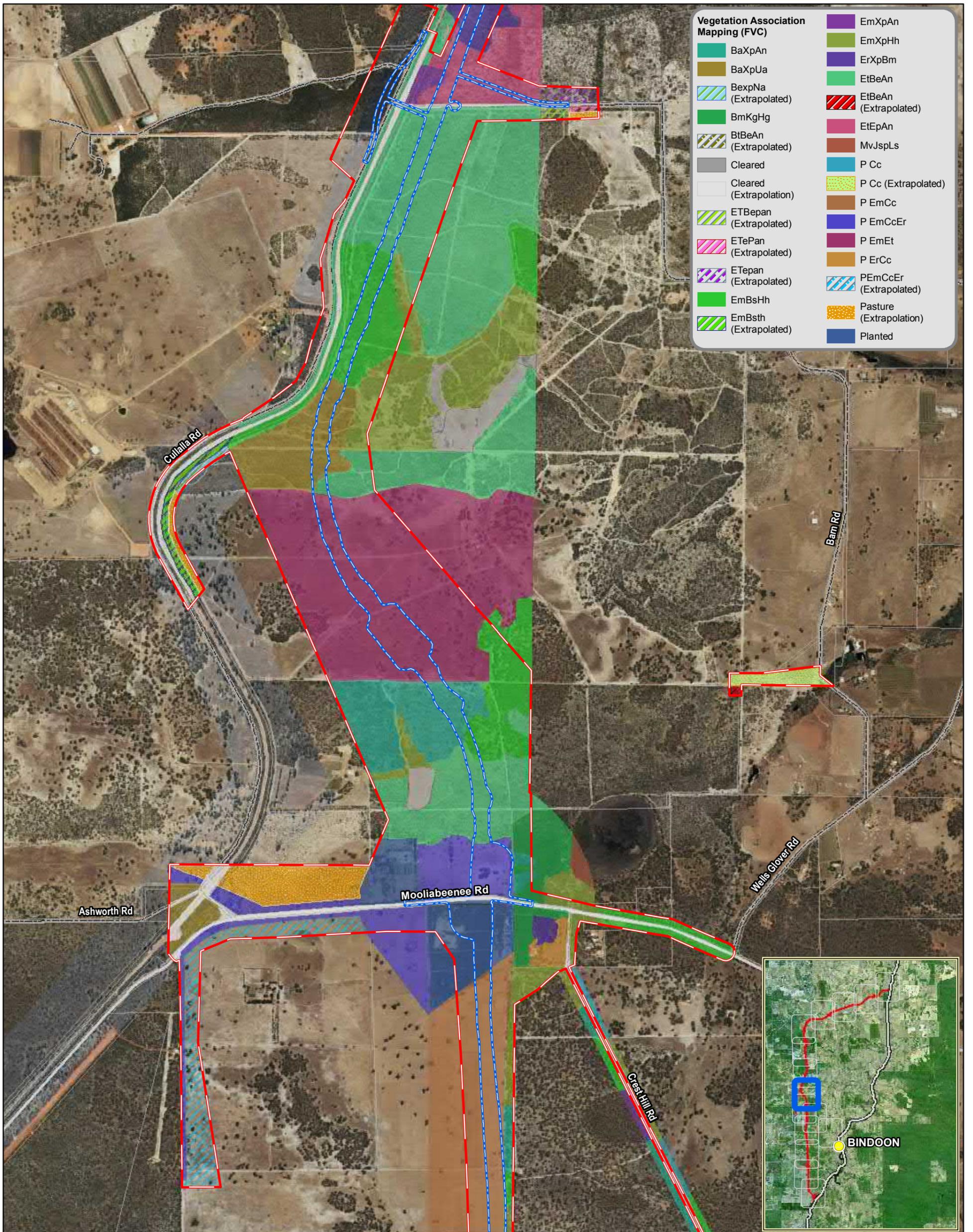
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Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpAn	EmXpAn
BaXpUa	EmXpHh
BexpNa (Extrapolated)	ErXpBm
BmKgHg	EtBeAn
BtBeAn (Extrapolated)	EtBeAn (Extrapolated)
Cleared	EtEpAn
Cleared (Extrapolated)	MvJspLs
ETBepAn (Extrapolated)	P Cc
ETePan (Extrapolated)	P Cc (Extrapolated)
ETepAn (Extrapolated)	P EmCc
EmBsHh	P EmCcEr
EmBsth (Extrapolated)	P EmEt
	P ErCc
	PEmCcEr (Extrapolated)
	Pasture (Extrapolation)
	Planted

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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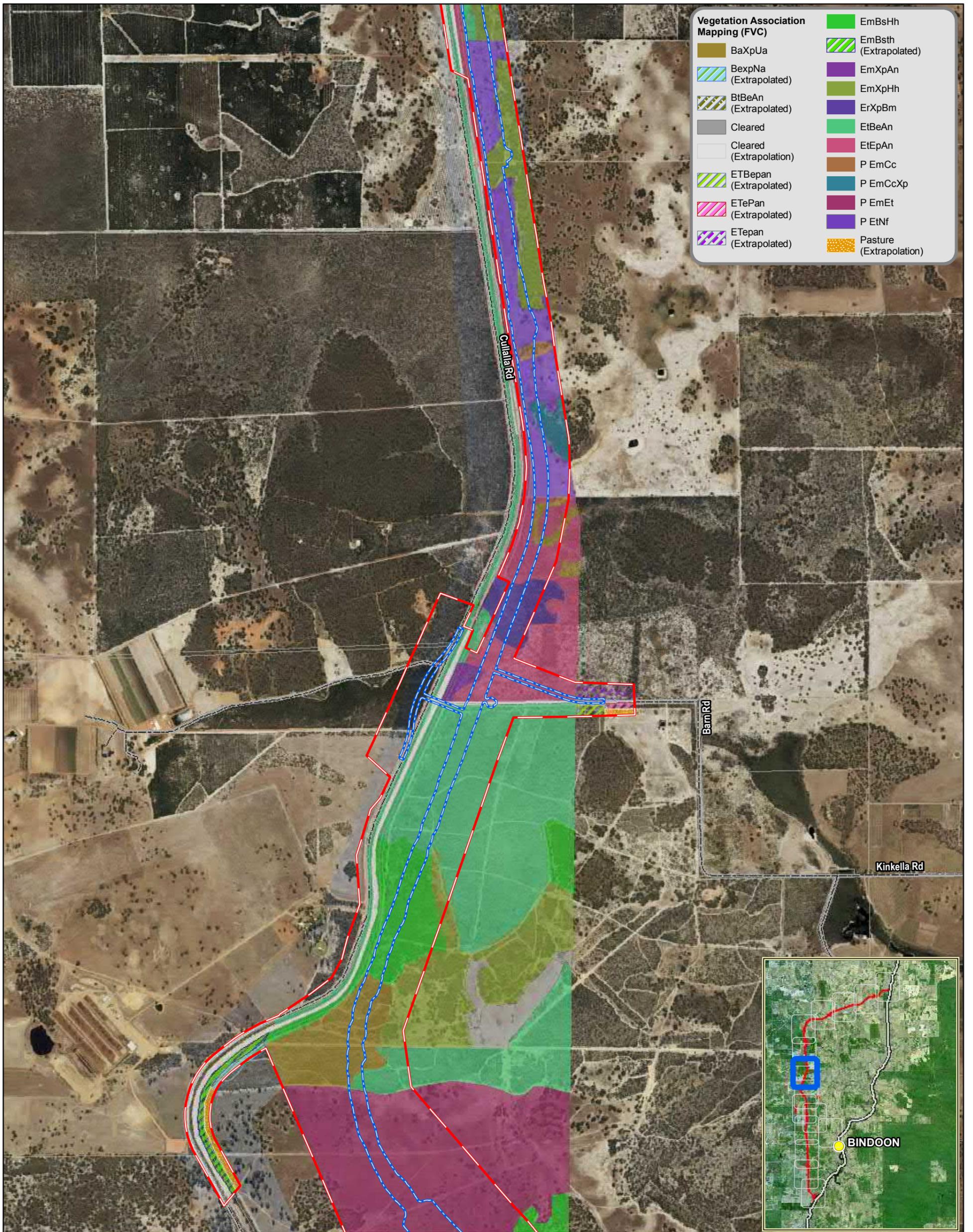
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Figure: 4-4 Page: 8 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

BaXpUa	EmBsHh
BexpNa (Extrapolated)	EmBsth (Extrapolated)
BtBeAn (Extrapolated)	EmXpAn
Cleared	EmXpHh
Cleared (Extrapolation)	ErXpBm
ETBepan (Extrapolated)	EtBeAn
ETePan (Extrapolated)	EtEpAn
ETepan (Extrapolated)	P EmCc
	P EmCcXp
	P EmEt
	P EtNf
	Pasture (Extrapolation)

Legend

- Development Envelope
- Development Footprint
- Cadastral Boundary
- Minor Road

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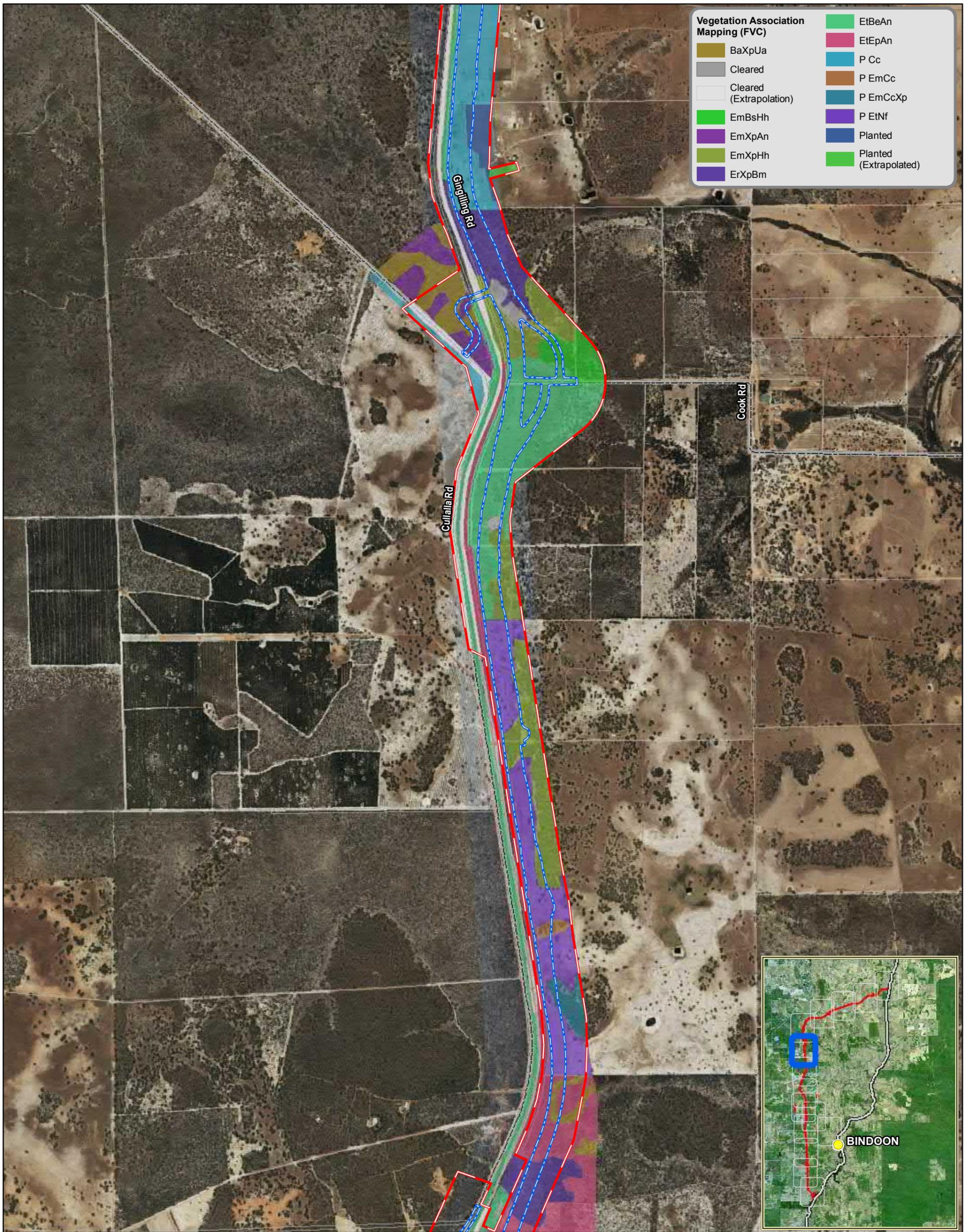
Mapped Vegetation Associations

Figure: 4-4 Page: 9 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)	
BaXpUa	EtBeAn
Cleared	EtEpAn
Cleared (Extrapolation)	P Cc
EmBsHh	P EmCc
EmXpAn	P EmCcXp
EmXpHh	P EtNf
ErXpBm	Planted
	Planted (Extrapolated)

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Minor Road

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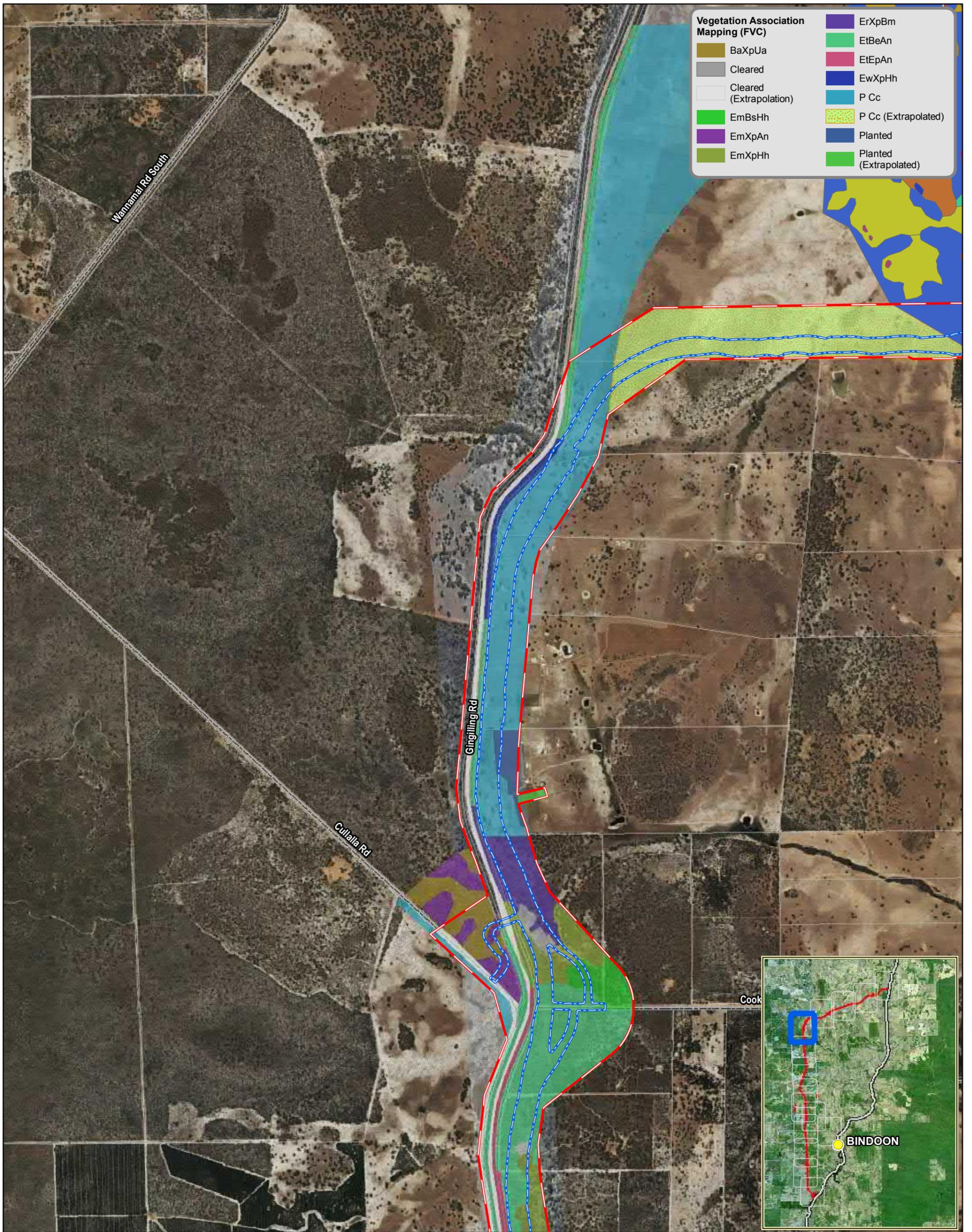
Mapped Vegetation Associations

Figure: 4-4 Page: 10 of 15

Drawing No: **GNH-CN12-EA-PER-00001-F4-4** Issue: **1**

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Vegetation Association Mapping (FVC)

BaXpUa	ErXpBm
Cleared	EtBeAn
Cleared (Extrapolation)	EtEpAn
EmBsHh	EwXpHh
EmXpAn	P Cc
EmXpHh	P Cc (Extrapolated)
	Planted
	Planted (Extrapolated)

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Minor Road

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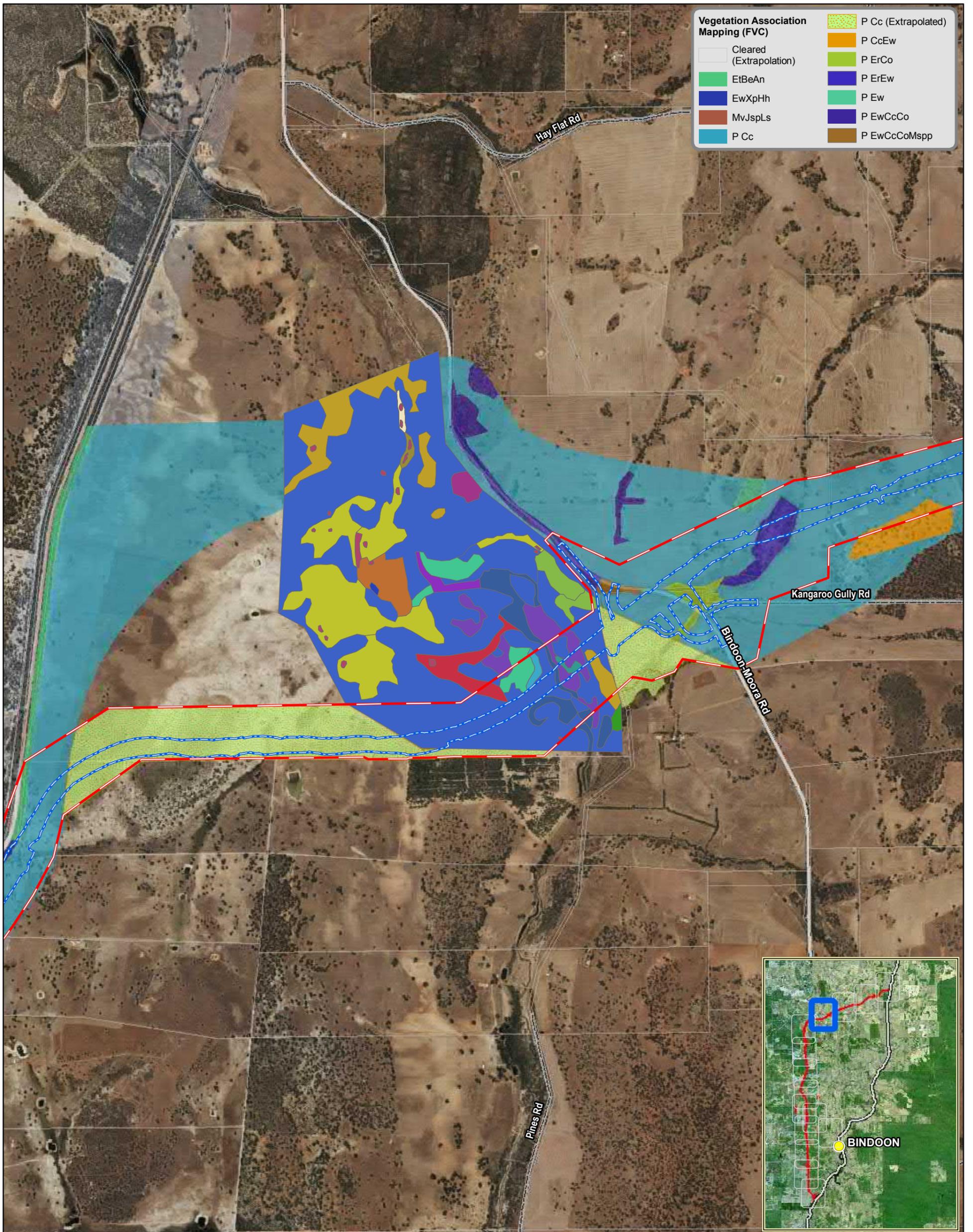
Figure: 4-4 Page: 11 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

Cleared (Extrapolation)	P Cc (Extrapolated)
EtBeAn	P CcEw
EwXpHh	P ErCo
MvJspLs	P ErEw
P Cc	P Ew
	P EwCcCo
	P EwCcCoMspp

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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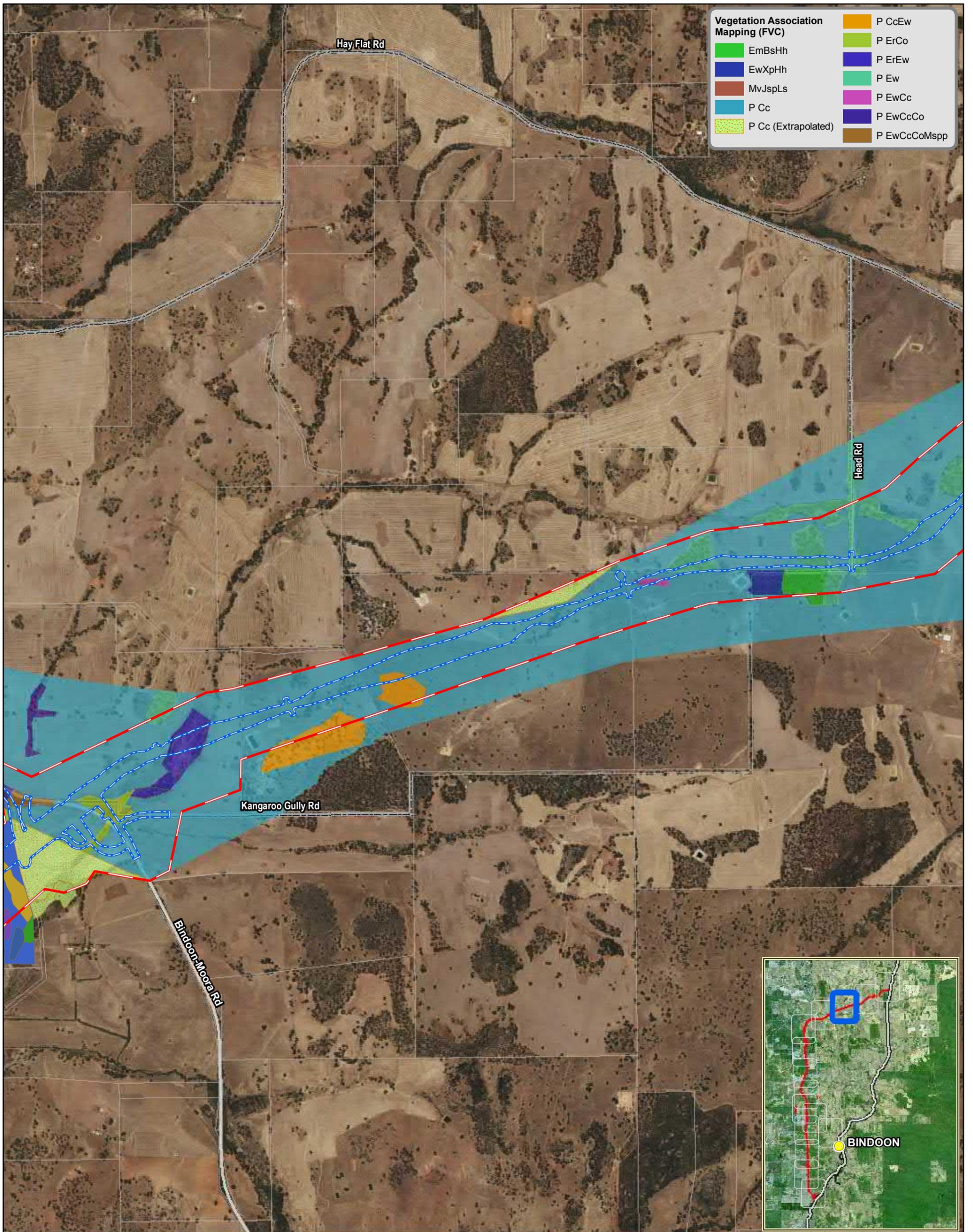
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Figure: 4-4 Page: 12 of 15

Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

Task	Drawing Status / Other
EDR	Draft

Date	By	Chkd	Appd
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Vegetation Association Mapping (FVC)

EmBsHh	P CcEw
EwXpHh	P ErCo
MvJspLs	P ErEw
P Cc	P Ew
P Cc (Extrapolated)	P EwCc
	P EwCcCo
	P EwCcCoMssp

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Major Road
			Minor Road

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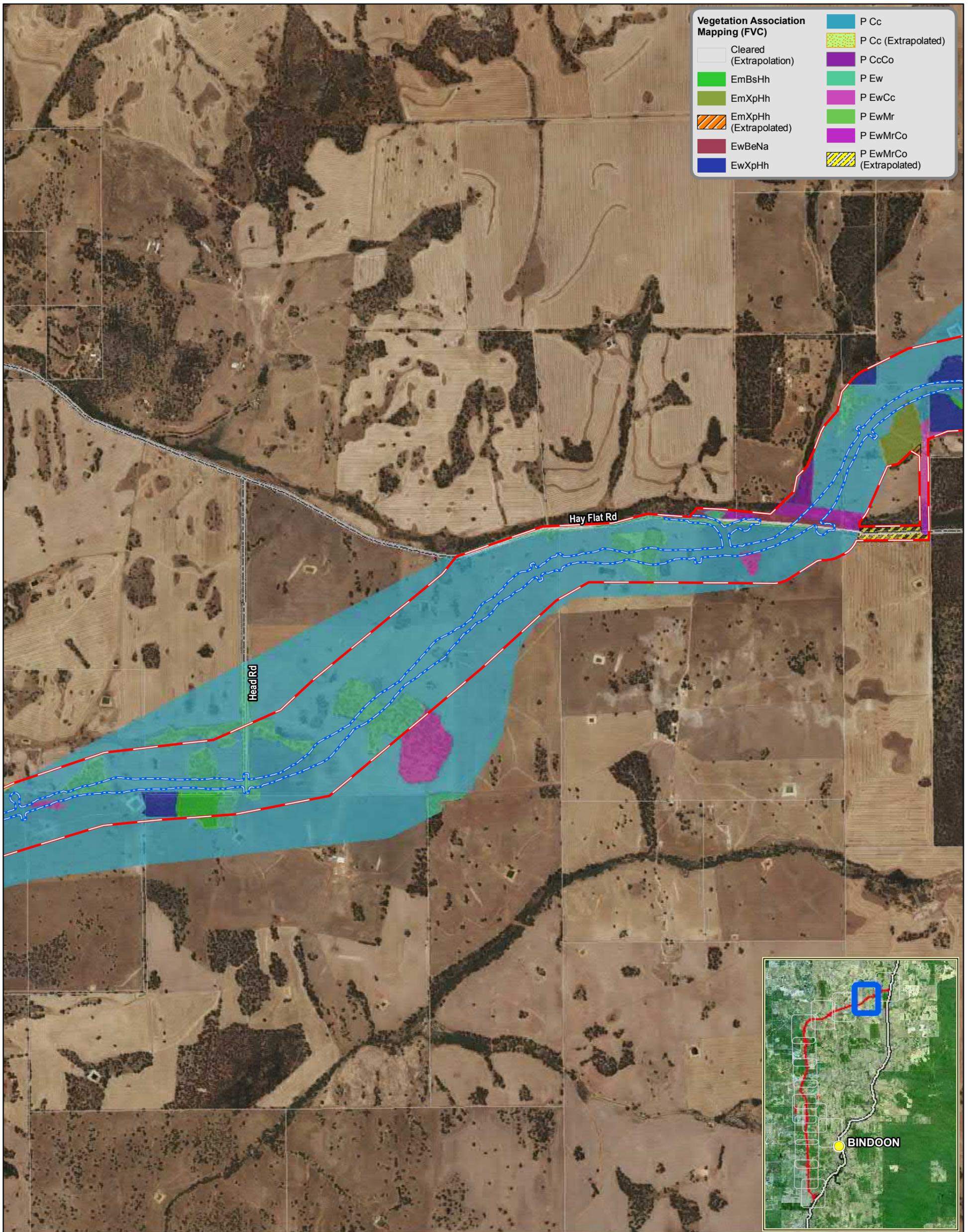
Figure: 4-4 Page: 13 of 15

Drawing No: **GNH-CN12-EA-PER-00001-F4-4** Issue: **1**

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Vegetation Association Mapping (FVC)

Cleared (Extrapolated)	P Cc
EmBsHh	P Cc (Extrapolated)
EmXpHh	P CcCo
EmXpHh (Extrapolated)	P Ew
EwBeNa	P EwCc
EwXpHh	P EwMr
	P EwMrCo
	P EwMrCo (Extrapolated)

Legend

	Development Envelope		Cadastral Boundary
	Development Footprint		Minor Road

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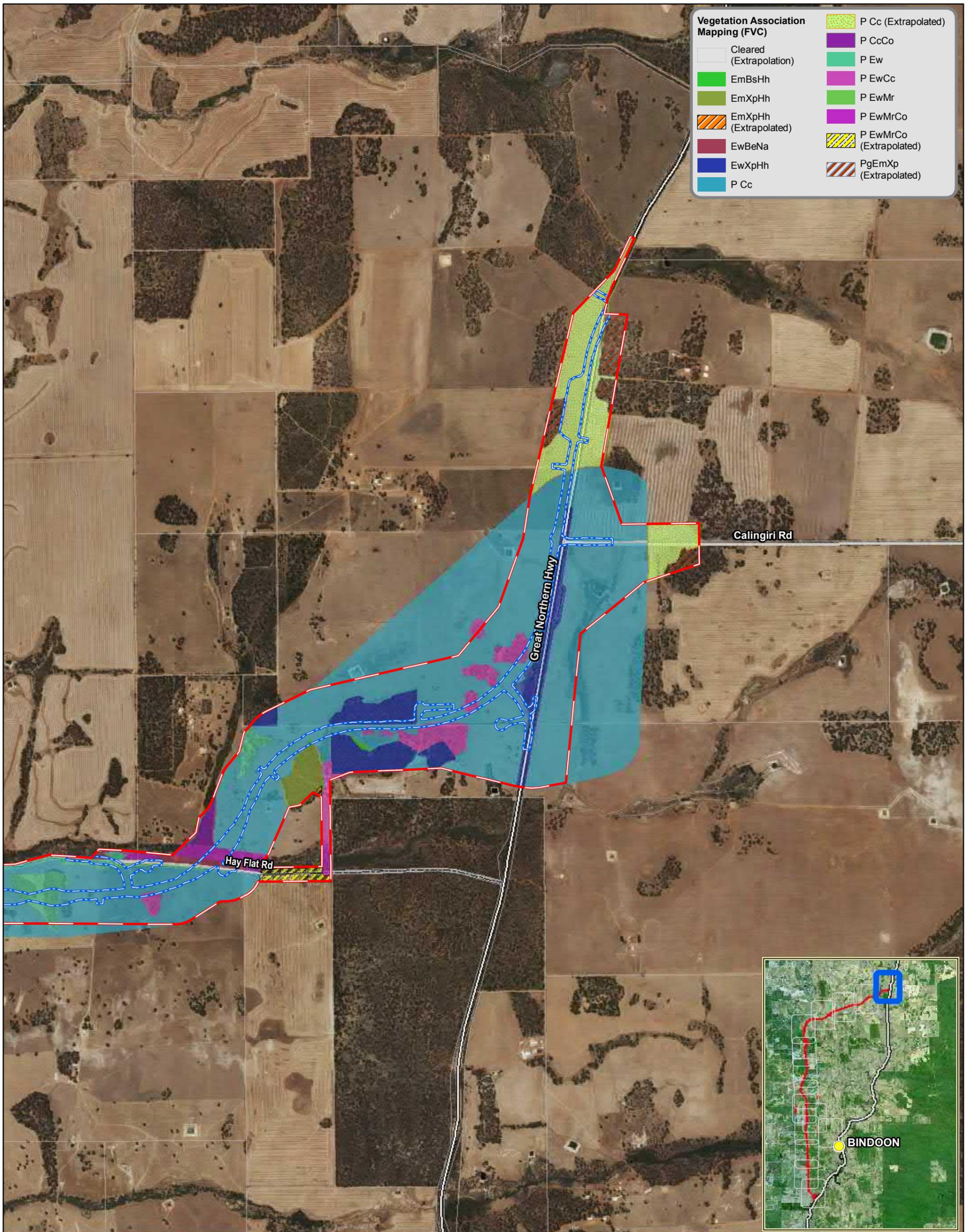
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Drawing No: GNH-CN12-EA-PER-00001-F4-4 Issue: 1

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Vegetation Association Mapping (FVC)

Cleared (Extrapolated)	P Cc (Extrapolated)
EmBsHh	P CcCo
EmXpHh	P Ew
EmXpHh (Extrapolated)	P EwCc
EwBeNa	P EwMr
EwXpHh	P EwMrCo
P Cc	P EwMrCo (Extrapolated)
	PgEmXp (Extrapolated)

Legend

- Development Envelope
- Development Footprint
- Cadastral Boundary
- Highway
- Major Road
- Minor Road

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Figure: 4-4 Page: 15 of 15

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Vegetation Condition

Field surveys also established the quality of the vegetation within the study area. Vegetation condition ranges from Completely Degraded to Excellent, with the majority of the study area being Completely Degraded to Degraded due to the large amount of cleared land and pasture (**Figure 4-5**). Whilst cleared land and pasture do support occasional trees or stands of trees, the absence of understorey reduces the quality of the vegetation and the value that the vegetation presents as habitat for native fauna. **Table 4-5** provides a summary of the condition of vegetation within the Development Envelope, including areas mapped as paddock, while **Table 4-6** details the condition by vegetation association and does not include areas mapped as paddock.

Table 4-5: Vegetation Quality of the Development Envelope

Vegetation Condition Rating	Area Mapped by FVC (ha)	Total in Development Envelope (ha)	Proportion of Development Envelope (%)
Completely Degraded	83.8	126.6	5.0%
Completely Degraded - Degraded	2,758.7	1,727.00	68.8%
Degraded	61.3	28.5	1.1%
Degraded - Good	70.0	34.4	1.4%
Good	85.1	64	2.5%
Good – Very Good	88.2	143.5	5.7%
Very Good	241.5	168.1	6.7%
Very Good – Excellent	228.4	134	5.3%
Excellent	106.9	84.4	3.4%
Total	3,723.9	2,510.50	100.0%

Table 4-6: Condition of Vegetation within the Development Envelope

Vegetation Association	Vegetation Condition (ha)							Total (ha)
	Degraded	Degraded - Good	Good	Good – Very Good	Very Good	Very Good - Excellent	Excellent	
BaXpAn	3.0	0.0	0.1	2.5	16.1	2.8	36.5	61.0
BaXpUa	0.0	14.1	0.0	18.7	3.4	5.6	0.0	41.7
BmKgHg	0.2	0.0	0.0	0.0	0.0	4.3	4.0	8.6
EmBsHh	0.3	7.6	6.4	17.0	45.6	21.4	18.2	116.5
EmXpAn	0.0	0.0	0.0	0.6	0.0	12.8	0.0	13.4
EmXpHh	7.0	7.4	25.2	21.1	54.5	11.7	0.0	127.0
ErXpBm	5.3	4.0	17.3	0.0	5.1	4.0	0.0	35.8
EtBeAn	0.0	0.5	0.0	60.2	13.4	52.5	25.7	152.2
EtEpAn	0.0	0.0	0.0	0.0	25.6	13.6	0.0	39.2
EwBeNa	0.6	0.0	0.0	3.5	0.4	0.0	0.0	4.5
EwXpHh	0.0	0.8	15.1	19.9	3.9	5.3	0.0	45.0
MvJspLs	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	16.6	34.4	64.0	143.5	168.1	134.0	84.4	644.9

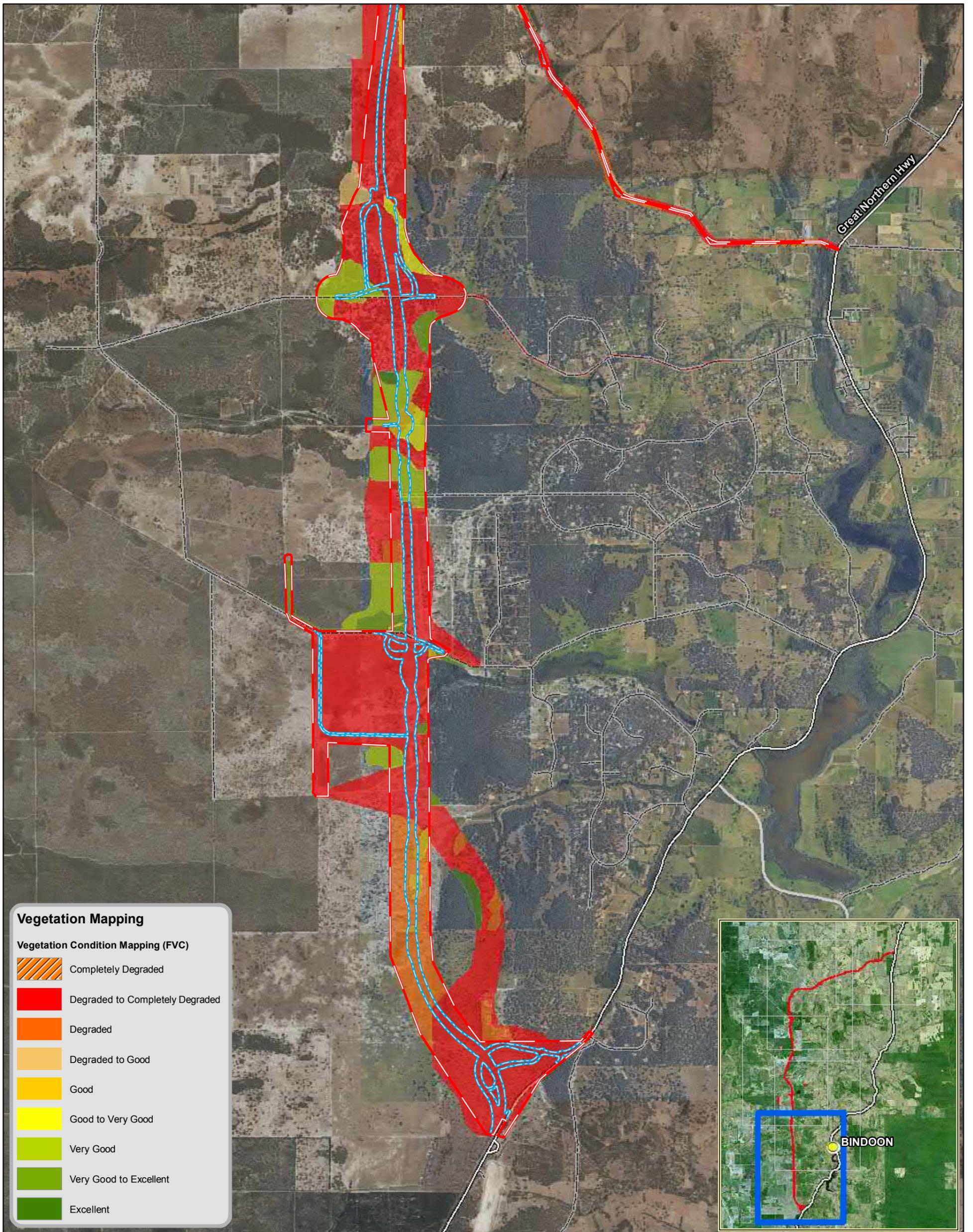
Vegetation Extent

The vegetation associations mapped by FVC (2018a, 2018b, 2019) have been compared to the southwest vegetation complexes defined by Heddle, Loneragan and Havel (1980) and Havel and Mattiske (2000). Due to differences in scale and methods of vegetation mapping, the vegetation associations can be assigned to more than one vegetation complex. FVC concluded that the vegetation associations mapped correspond to nine of the southwest vegetation complexes (2018a, 2019). Details of these vegetation complexes and the FVC vegetation associations assigned to each complex are provided in **Table 4-7** and shown on **Figure 4-6**. The current extent of the vegetation complexes, and the percentage remaining compared to the pre-European extent, are also provided at both a regional (Swan Coastal Plain/South West Forests) and local government (Shire) scale in order to assess impacts at differing scales.

Species loss appears to accelerate at the ecosystem level when less than 30% of the pre-European vegetation extent remains for a particular vegetation complex (ANZECC 2000). Vegetation below this threshold is considered under-represented and at danger of further loss. Within the Shire of Chittering, the Coolakin, Nooning and Wannamal vegetation complexes are below 30% of their pre-European extent. At a regional level (Swan Coastal Plain/South West Forests), the Michibin and Nooning complexes are below 30% of their pre-European extent. The following FVC vegetation associations are considered part of the Nooning complex, and therefore regionally significant:

- BmKgHg;
- ErXpBm;
- MvJspLs;
- EmBsHh;
- EmXpAn; and
- EmXpHh.

The Shire of Chittering accounts for 64% of both the pre-European and current extent of the Nooning vegetation complex. As of 2017 2.33% of the Nooning vegetation complex is within DBCA-managed lands, and therefore afforded additional protection (FVC 2018a).



Vegetation Mapping

Vegetation Condition Mapping (FVC)

- Completely Degraded
- Degraded to Completely Degraded
- Degraded
- Degraded to Good
- Good
- Good to Very Good
- Very Good
- Very Good to Excellent
- Excellent

Legend

- Development Envelope
- Development Footprint
- Highway
- Major Road
- Minor Road

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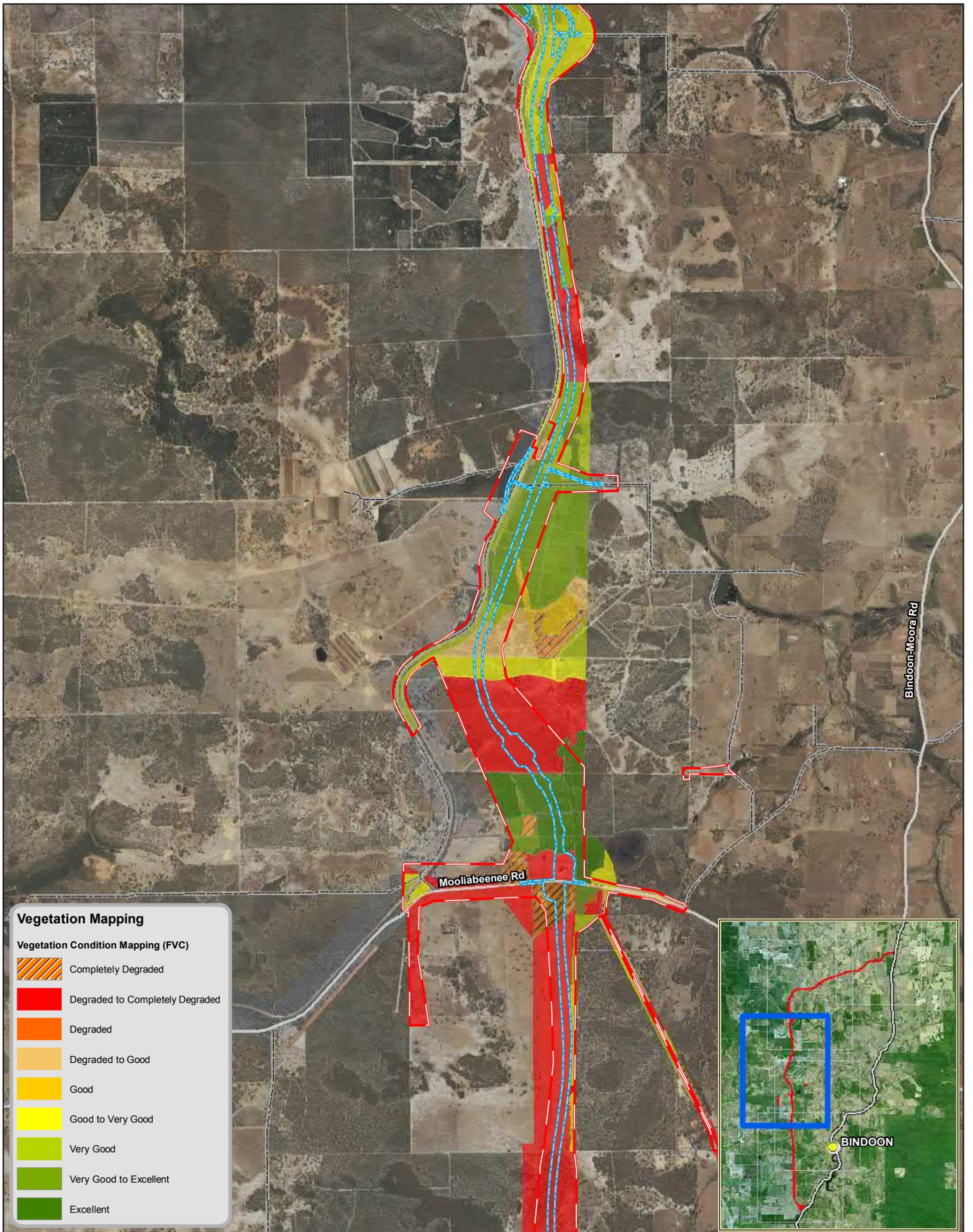
Vegetation Condition

Figure: 4-5 Page 1 of 5

Drawing No: **GNH-CN12-EA-PER-00001** Issue: **1**
 - F4-5

Task: ERD	Drawing Status / Other: Draft		
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Vegetation Mapping

Vegetation Condition Mapping (FVC)

-  Completely Degraded
-  Degraded to Completely Degraded
-  Degraded
-  Degraded to Good
-  Good
-  Good to Very Good
-  Very Good
-  Very Good to Excellent
-  Excellent

Legend

-  Development Envelope
-  Development Footprint
-  Major Road
-  Minor Road

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Vegetation Condition

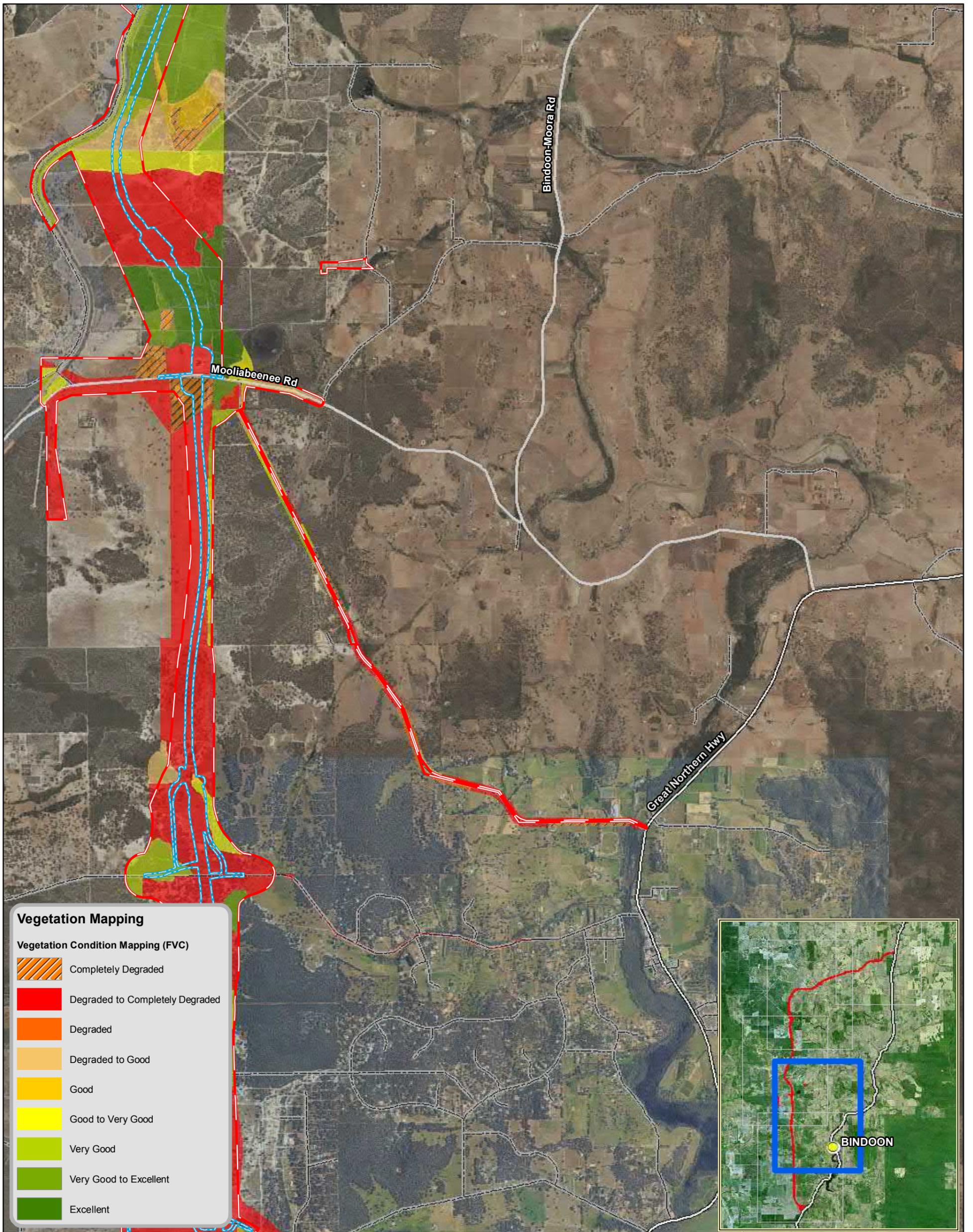
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Drawing No: GNH-CN12-EA-PER-00001 - F4-5 Issue: 1

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Vegetation Mapping

Vegetation Condition Mapping (FVC)

- Completely Degraded
- Degraded to Completely Degraded
- Degraded
- Degraded to Good
- Good
- Good to Very Good
- Very Good
- Very Good to Excellent
- Excellent

Legend

- Development Envelope
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- Highway
- Major Road
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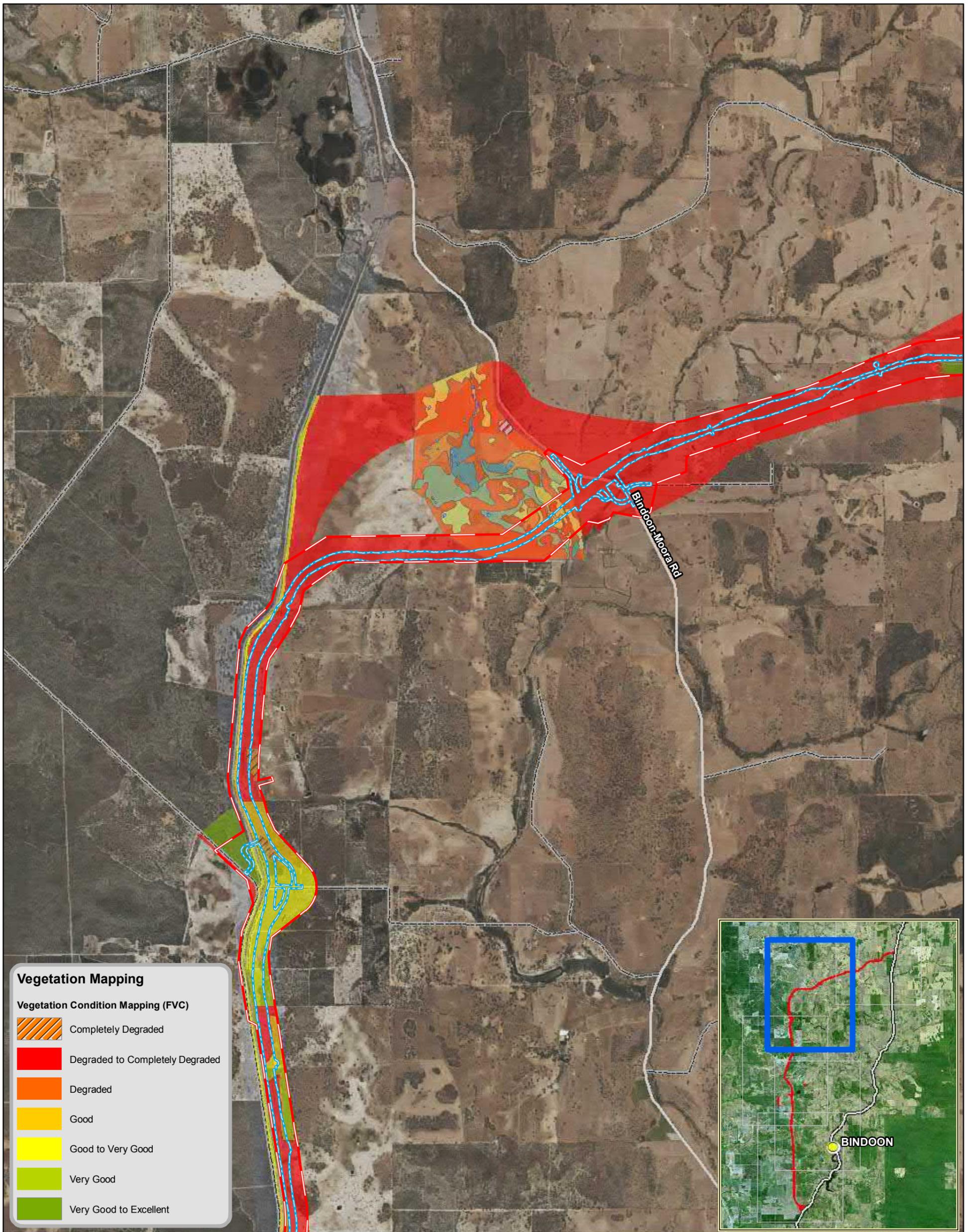
Vegetation Condition

Figure: 4-5 Page 3 of 5

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Task: ERD	Drawing Status / Other: Draft		
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Vegetation Mapping

Vegetation Condition Mapping (FVC)

-  Completely Degraded
-  Degraded to Completely Degraded
-  Degraded
-  Good
-  Good to Very Good
-  Very Good
-  Very Good to Excellent

Legend

-  Development Envelope
-  Development Footprint
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Vegetation Condition

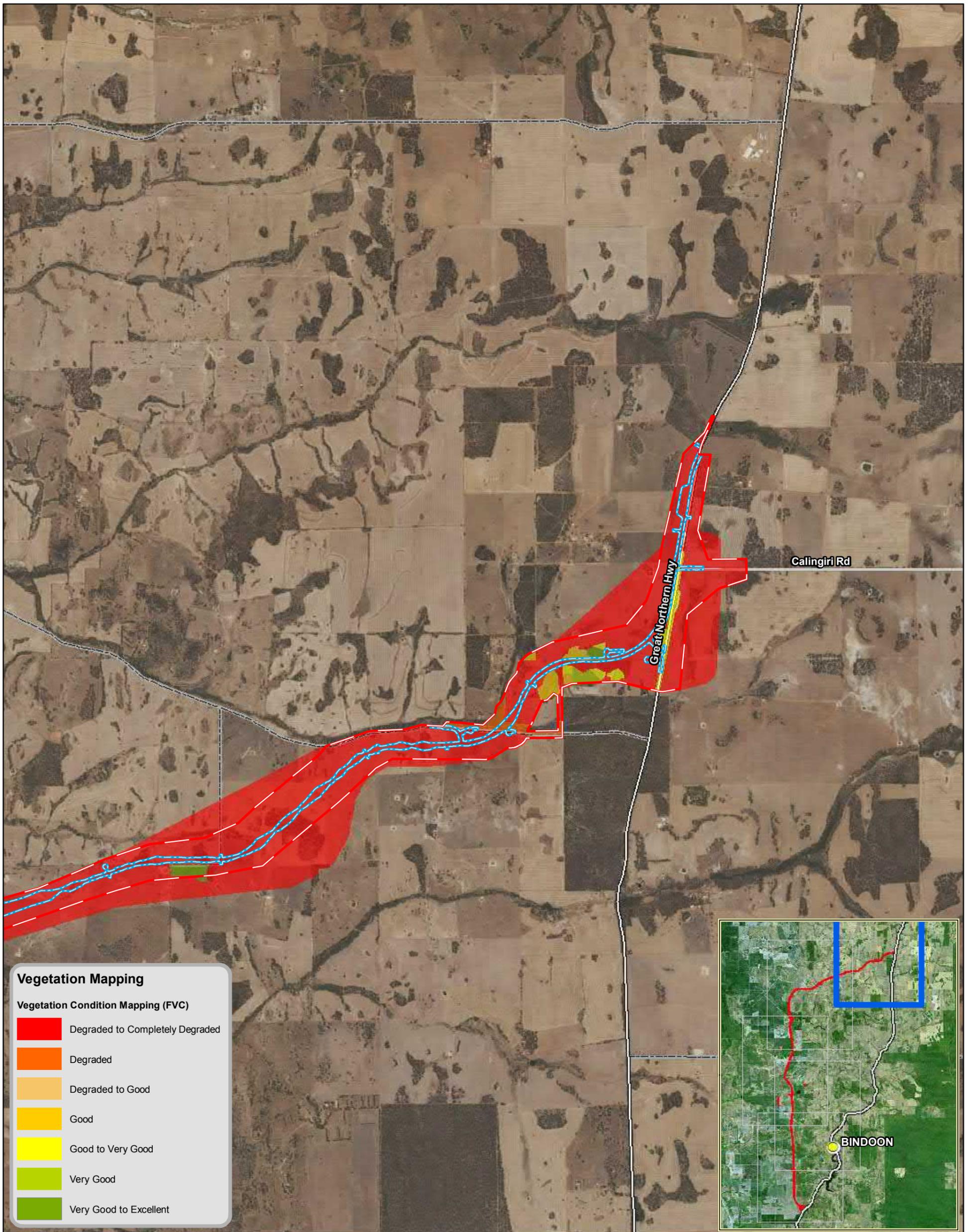
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Drawing No: GNH-CN12-EA-PER-00001 - F4-5 Issue: 1

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Vegetation Mapping

Vegetation Condition Mapping (FVC)

- Degraded to Completely Degraded
- Degraded
- Degraded to Good
- Good
- Good to Very Good
- Very Good
- Very Good to Excellent

Legend

- Development Envelope
- Highway
- Development Footprint
- Major Road
- Minor Road

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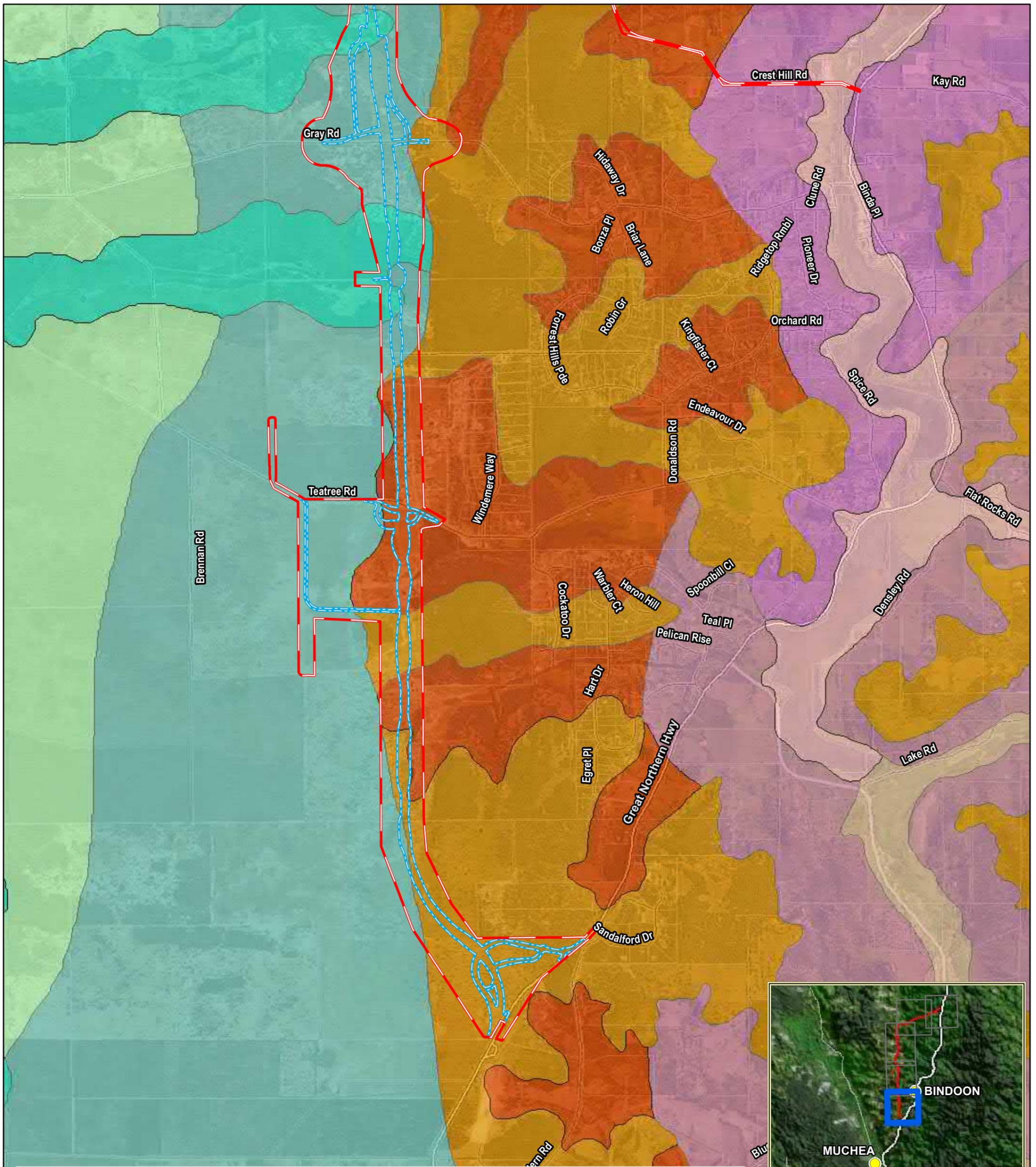
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- F4-5

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Regional complexes

Southwest Forests	Murray 2	Swan Coastal Plain	Mogumber Complex-South
Darling Plateau Sub Region	Nooning	Dandaragan Plateau Land System	Moondah
Bindoon	Williams	Karamal Complex-South	
Coolakin	Yalanbee		

Legend

Development Envelope	Highway
Development Footprint	Major Road
	Minor Road
	Cadastral Boundary

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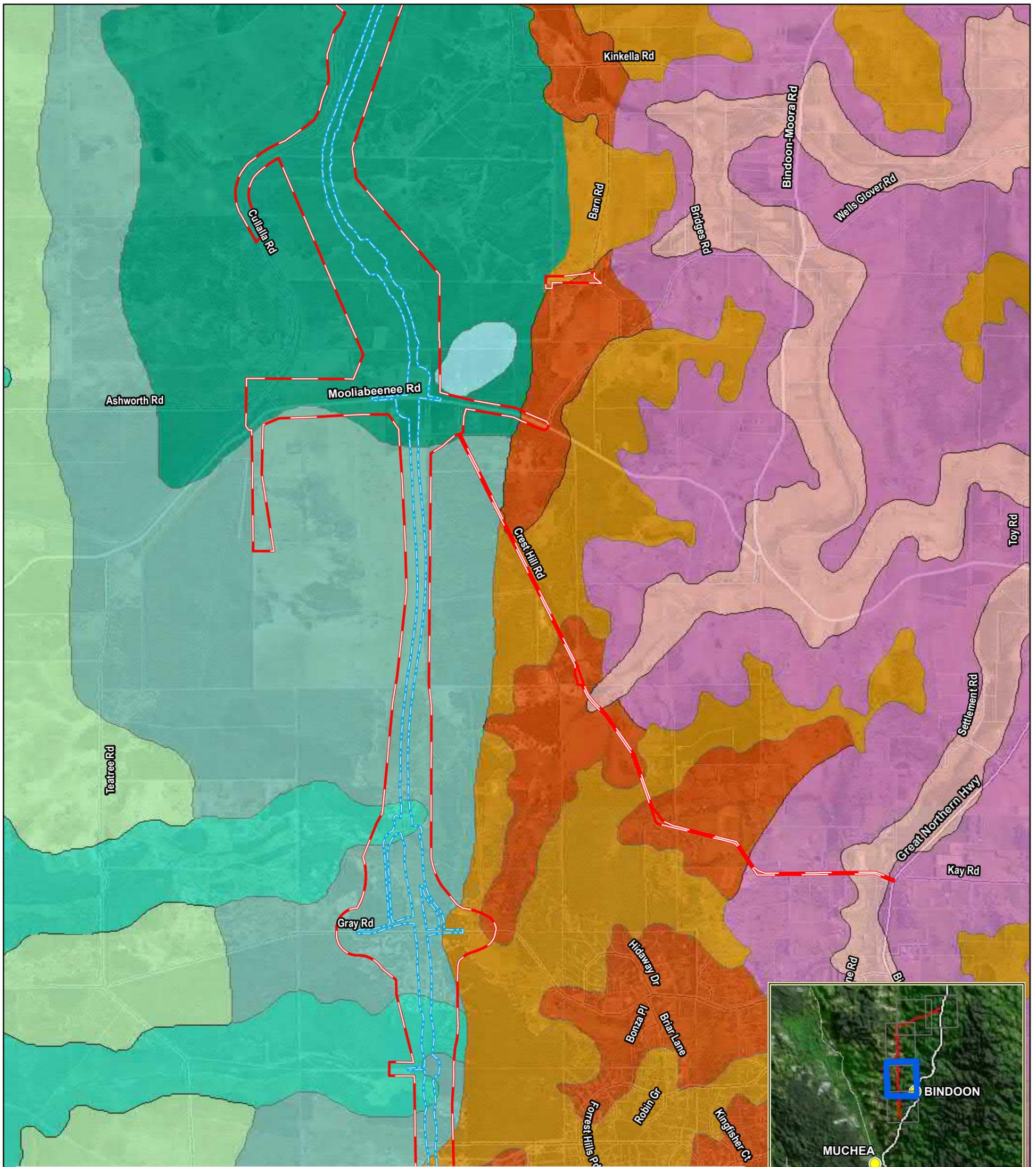
Regional Vegetation Complexes
Figure: 4-6 Page 1 of 5

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Issue: 1

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Regional complexes

Southwest Forests	Murray 2	Swan Coastal Plain	Mogumber Complex-South
Darling Plateau Sub Region	Nooning	Dandaragan Plateau Land System	Moondah
Bindoon	Yalanbee	Cullula	Wannamal
Coolakin		Karamal Complex-South	

Legend

Development Envelope	Highway
Development Footprint	Major Road
	Minor Road
	Cadastral Boundary

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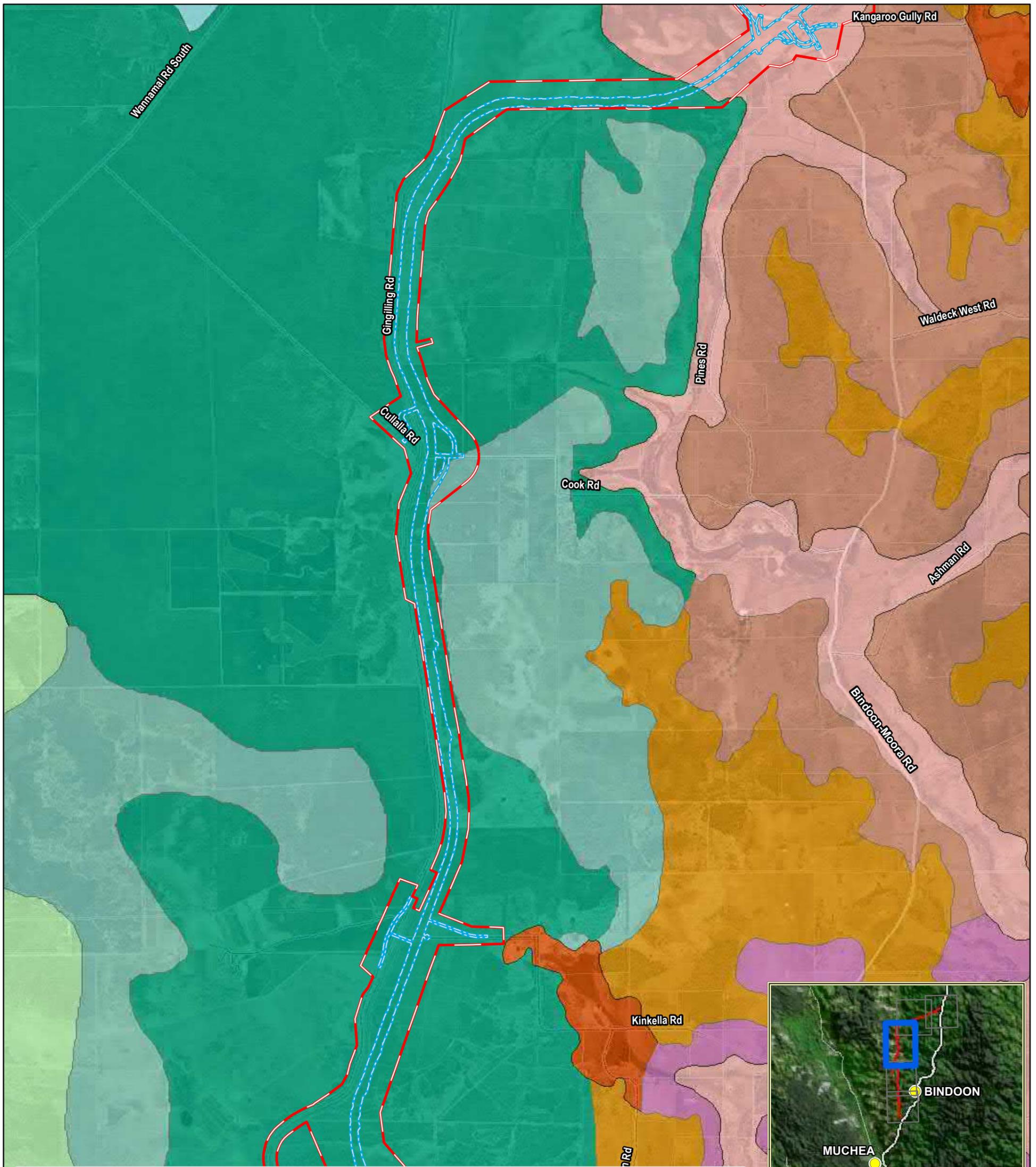
Regional Vegetation Complexes
Figure: 4-6 Page 2 of 5

Drawing No: **GNH-CN12-EA-PER-00001 - F4-6** Issue: **1**

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Regional complexes

Southwest Forests	Michibin	Swan Coastal Plain	Mogumber Complex-South
Darling Plateau Sub Region	Nooning	Dandaragan Plateau Land System	Moondah
Bindoon	Yalanbee	Cullula	Wannamal
Coolakin		Karamal Complex-South	

Legend

- Development Envelope
- Development Footprint
- Major Road
- Minor Road
- Cadastral Boundary

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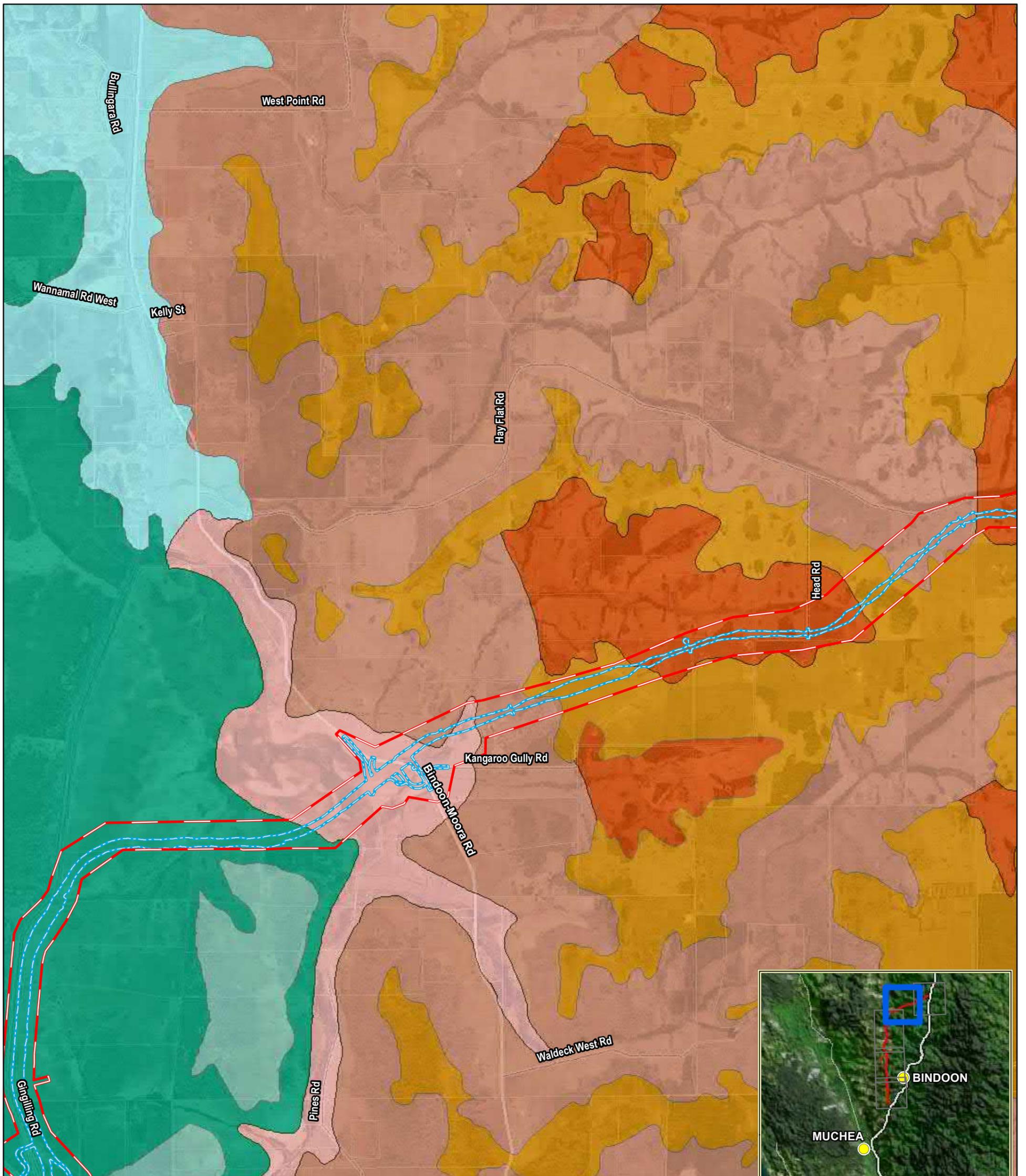
Regional Vegetation Complexes
Figure: 4-6 Page 3 of 5

Drawing No: **GNH-CN12-EA-PER-00001 - F4-6** Issue: **1**

Task No: **ERD** Drawing Status / Other: **Draft**

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Regional complexes

Southwest Forests	Michibin	Swan Coastal Plain	Mogumber Complex-South
Darling Plateau Sub Region	Nooning	Dandaragan Plateau Land System	Wannamal
Coolakin	Yalanbee	Cullula	

Legend

	Development Envelope
	Development Footprint
	Major Road
	Minor Road
	Cadastral Boundary

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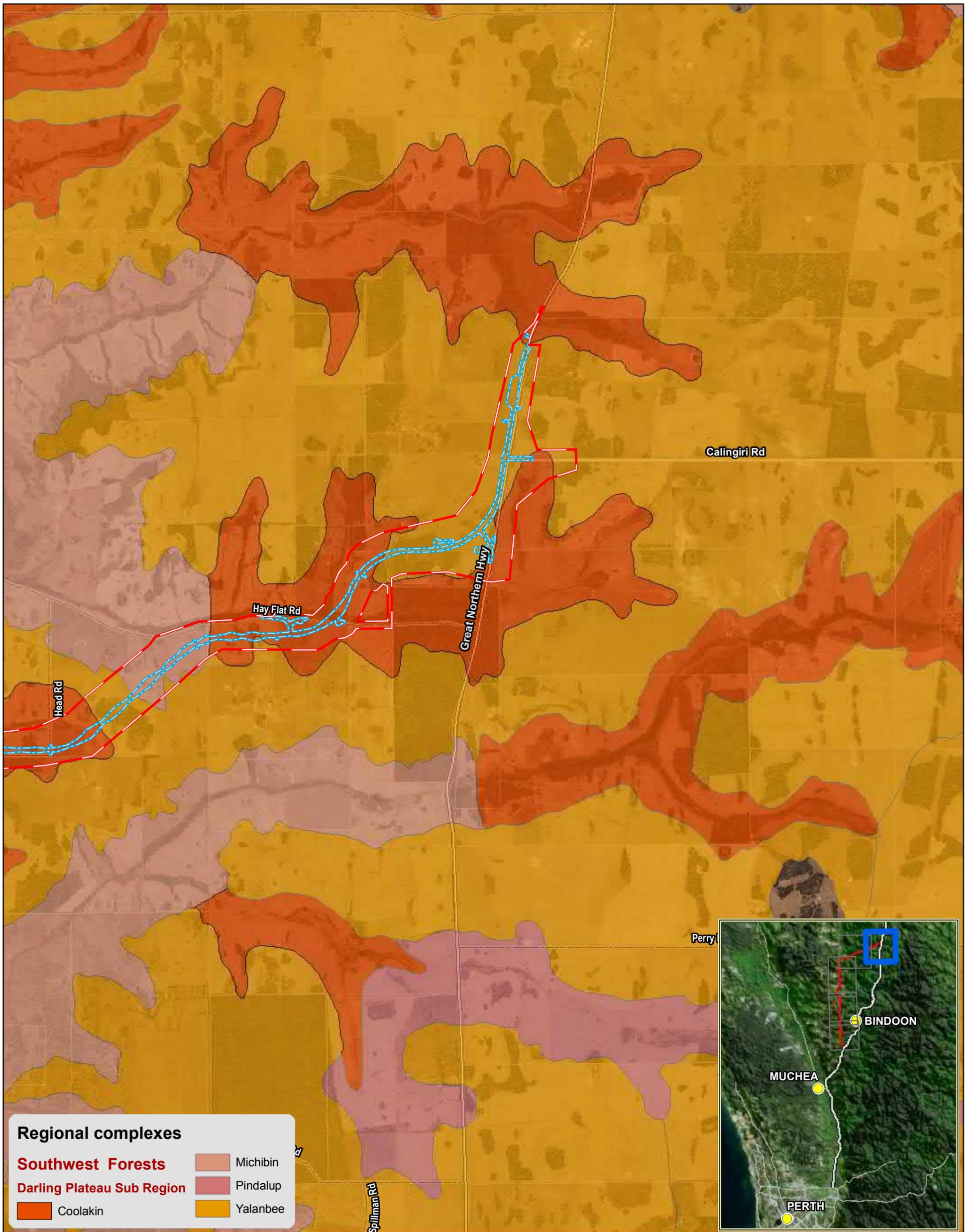
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Regional Vegetation Complexes
Figure: 4-6 Page 4 of 5

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Regional complexes

Southwest Forests	Michibin
Darling Plateau Sub Region	Pindalup
Coolakin	Yalanbee

Legend

Development Envelope	Highway
Development Footprint	Major Road
	Minor Road
	Cadastral Boundary

North Arrow

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Regional Vegetation Complexes
Figure: 4-6 Page 5 of 5

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Table 4-7: Regional Vegetation Complexes (Source: FVC 2018a)

South West Vegetation Complex ¹	Corresponding FVC Vegetation Association						Shire of Chittering			Shire of Gingin			Swan Coastal Plain/South West Forests		
	BaXpAn, BaXpUa	BmKgHg, ErXpBm, MvJspLs	EmBsHh, EmXpAn, EmXpHh	EtBeAn, EtEpAn	EwBeNa, EwXpHh	ErMrF, MpS, MrF, MrMtFH	Pre-European Extent (ha)	Current Extent (ha)	% Remaining	Pre-European Extent (ha)	Current Extent (ha)	% Remaining	Pre-European Extent (ha)	Current Extent (ha)	% Remaining
Coolakin					X		11 439.10	3 048.64	26.65				163 991.68	64 205.83	39.15
Cullula	X		X	X			2 994.16	1 099.47	36.72	18 583.99	10 878.89	58.54	25 973.28	13 274.04	51.11
Mogumber – south	X		X	X			11 778.54	4 507.42	38.27	1 322.60	679.74	51.39	14 821.71	5 720.00	38.59
Moondah	X	X	X	X			2 311.28	992.06	42.92	15 402.17	6 241.13	40.52	17 713.44	7 233.19	40.83
Nooning		X	X			X	4 166.74	743.56	17.85				6 467.28	1 156.36	17.88
Wannamal	X	X	X	X			269.46	63.47	23.55	2 150.72	1 172.27	54.51	2,492.00	1 263.49	50.70
Yalanbee (Y6)					X		27 643.32	8 412.48	30.43				197 849.01	92 083.48	46.54

¹ Government of Western Australia 2018

Only vegetation complexes occurring within the Development Envelope are included. Red-shaded cells denote vegetation complexes below 30% of their pre-European extent for the scale specified (e.g. within the Shire)

4.2.3.4 Conservation Significant Vegetation

WA Minister for Environment-Endorsed TECs and DBCA-Listed PECs

The DBCA database search showed that the Development Envelope and immediate surrounds support one TEC endorsed by the WA Minister for Environment, and two DBCA-listed PECs (**Figure 4-7**). These are:

- floristic community type (FCT) SCP 20a – *Banksia attenuata* woodlands over species rich dense shrublands (Endangered TEC). The closest known occurrence is 700 m west of the Development Envelope, near Cook Road.
- Banksia woodlands of the Gingin area restricted to soils dominated by yellow to orange sands (P2 PEC—previously referred to as ‘Banksia Woodlands of the Gingin Area PEC’). The Development Envelope intersects two known occurrences of this PEC.
- FCT SCP 23b – northern Swan Coastal Plain *Banksia attenuata* – *B. menziesii* woodlands (P3 PEC). The closest known occurrence is over 5 km southwest of the Development Envelope.

In relation to the mapped occurrences of the Banksia Woodlands of the Gingin Area PEC, DBCA describes this PEC as species-rich Banksia woodlands on deep yellow-red sands that appear restricted to the western Dandaragan Plateau. Further, the vegetation is described as scattered *Eucalyptus todtiana* and *Corymbia calophylla* over *Banksia menziesii* and *Banksia attenuata* low open woodland over *Jacksonia sternbergiana* and *Adenanthos cygnorum* high open shrubland over *Allocasuarina humilis* and *Chamelaucium* sp. Gingin (N.G. Marchant 6) open shrubland over *Eremaea pauciflora* and *Astroloma xerophyllum* low shrubland over *Mesomelaena pseudostygia* open sedgeland (DBCA 2019 in FVC 2019). Based on this description and the absence of the characteristic yellow or orange sands, FVC (2019) determined that the PEC is not present within the study area.

EBPC Act-Listed TECs

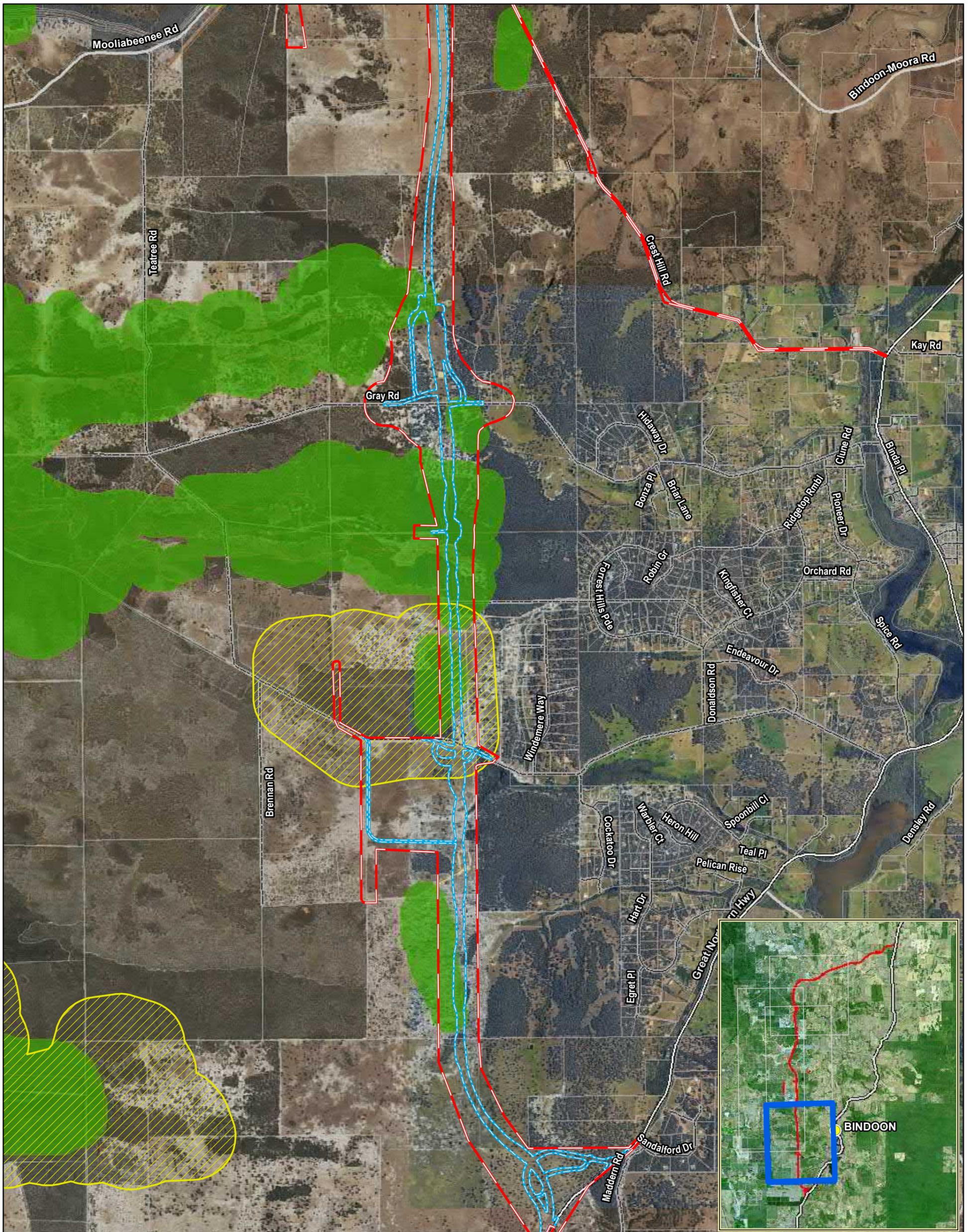
Desktop and field surveys included characterisation of the EPBC Act listed Banksia woodlands of the Swan Coastal Plain TEC (also referred to as ‘Banksia Woodlands TEC’). Five vegetation associations are considered to represent this TEC: BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn (FVC 2018a, 2019). Analysis of the quadrats within the Banksia woodlands vegetation associations was undertaken with the aim to determine the Floristic Community Types (FVCs) represented by the vegetation associations. An analysis against the presence-absence species data of Gibson *et al.* (1994) and Keighery (2008) datasets (**Table 6-4**) suggests the Banksia woodland vegetation associations are mostly representative of FCT 28 or FCT 23a (FVC 2019).

The total area of the EPBC Act listed Banksia Woodlands TEC has been mapped within the study area, based on data recorded from 55 quadrats. In accordance with conservation advice (Threatened Species Scientific Committee 2016), each area of mapped TEC has been grouped with other relevant areas of TEC connected to form patches. The condition of each patch has also been assessed against condition thresholds to determine whether the patch, as a whole, retains sufficient conservation values to be considered part of the Banksia Woodlands TEC. On this basis, patches that are in ‘Degraded’ or worse condition are not considered to be part of the TEC, unless they are connected or closely located to other areas of applicable TEC.

The resulting amount of EPBC Act listed Banksia Woodlands TEC within the study area is 467.1 ha. Within the Development Envelope, 307.5 ha of Banksia Woodlands TEC has been mapped by FVC (2018a—**Table 4-8; Figure 4-8**).

Table 4-8: EPBC Act listed Banksia Woodlands TEC within the Development Envelope

Vegetation Association	Vegetation Condition (ha)							Total (ha)
	Degraded	Degraded – Good	Good	Good – Very Good	Very Good	Very Good – Excellent	Excellent	
BaXpAn	3.0	0.0	0.1	2.5	16.1	2.8	36.5	61.0
BaXpJa	0.0	14.1	0.0	18.7	3.4	5.6	0.0	41.7
EmXpAn	0.0	0.0	0.0	0.6	0.0	12.8	0.0	13.4
EtBeAn	0.0	0.5	0.0	60.2	13.4	52.5	25.7	152.2
EtEpAn	0.0	0.0	0.0	0.0	25.6	13.6	0.0	39.2
Total (ha)	3.0	14.5	0.1	81.9	58.5	87.3	62.2	307.5



Legend

- Development Envelope
- Development Footprint
- PEC (DBCAs)
- TEC (DBCAs)
- Cadastral Boundary
- Highway
- Major Road
- Minor Road

North Arrow

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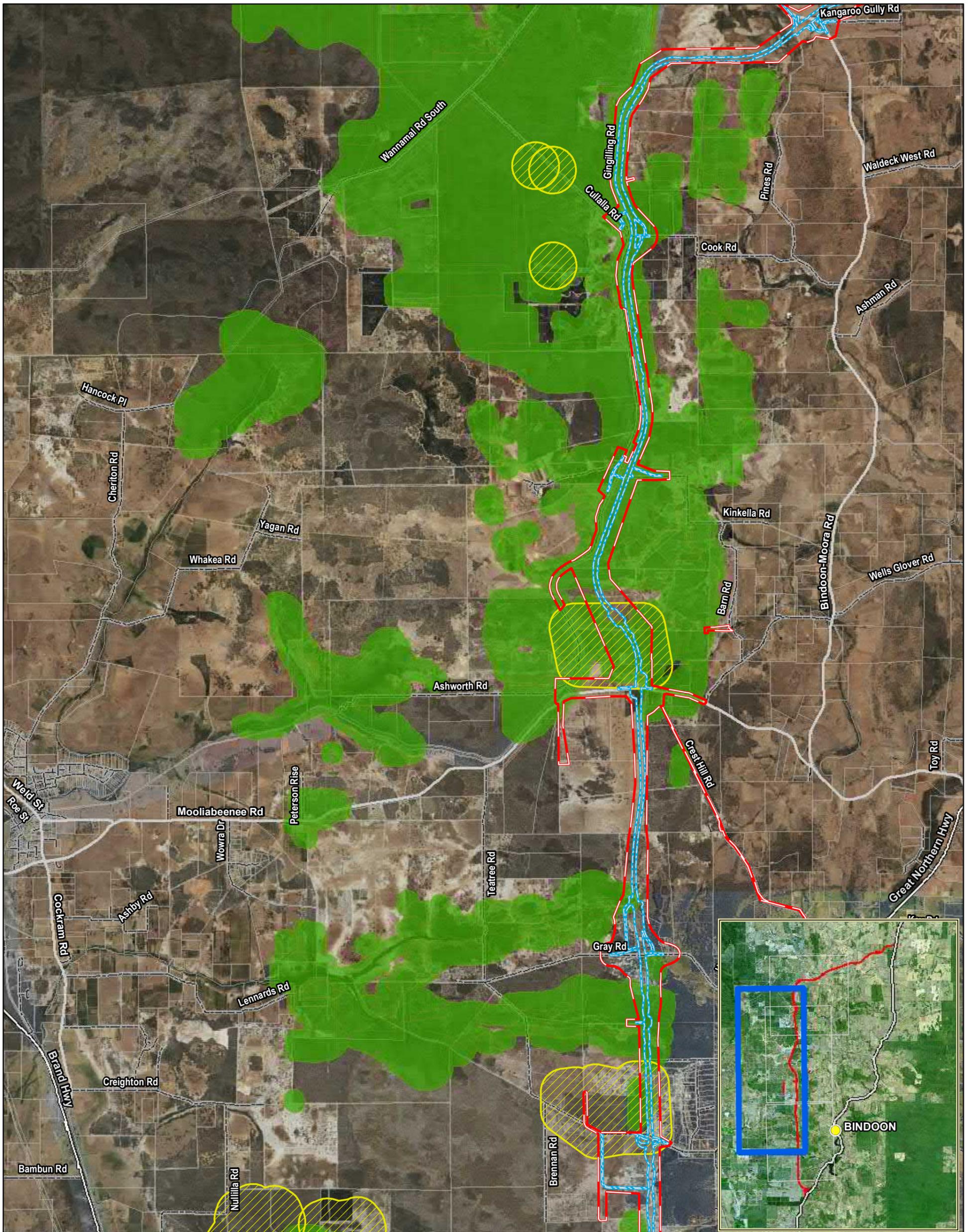
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DBCA Recorded Occurrences of EPBC-listed
TECs. TECs Endorsed by the WA Minister
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Figure: 4-7 Page 1 of 4

Drawing No GNH-CN12-EA-PER-00001 - F4 - 7	Issue 1
Task No ERD	Drawing Status / Other Draft
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Chkd LB	Appd TJ

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Legend

- Development Envelope
- Development Footprint
- PEC (DBCA)
- TEC (DBCA)
- Cadastral Boundary
- Highway
- Major Road
- Minor Road

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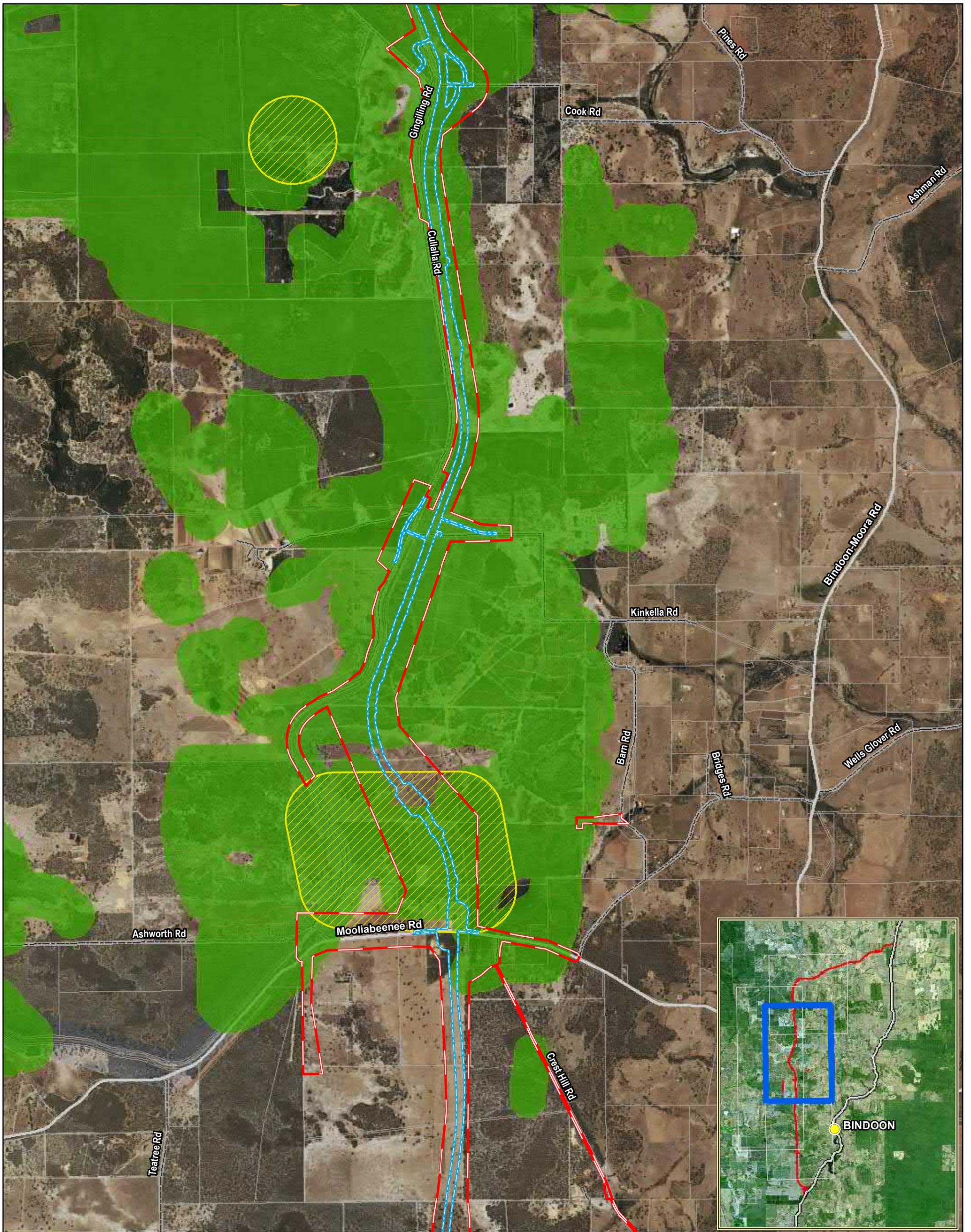
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DBCA Recorded Occurrences of EPBC-listed
 TECs, TECs Endorsed by the WA Minister
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Figure: 4-7 Page 2 of 4

Drawing No GNH-CN12-EA-PER-00001 - F4 - 7	Issue 1		
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Legend

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DBCA Recorded Occurrences of EPBC-listed
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Figure: 4-7 Page 3 of 4

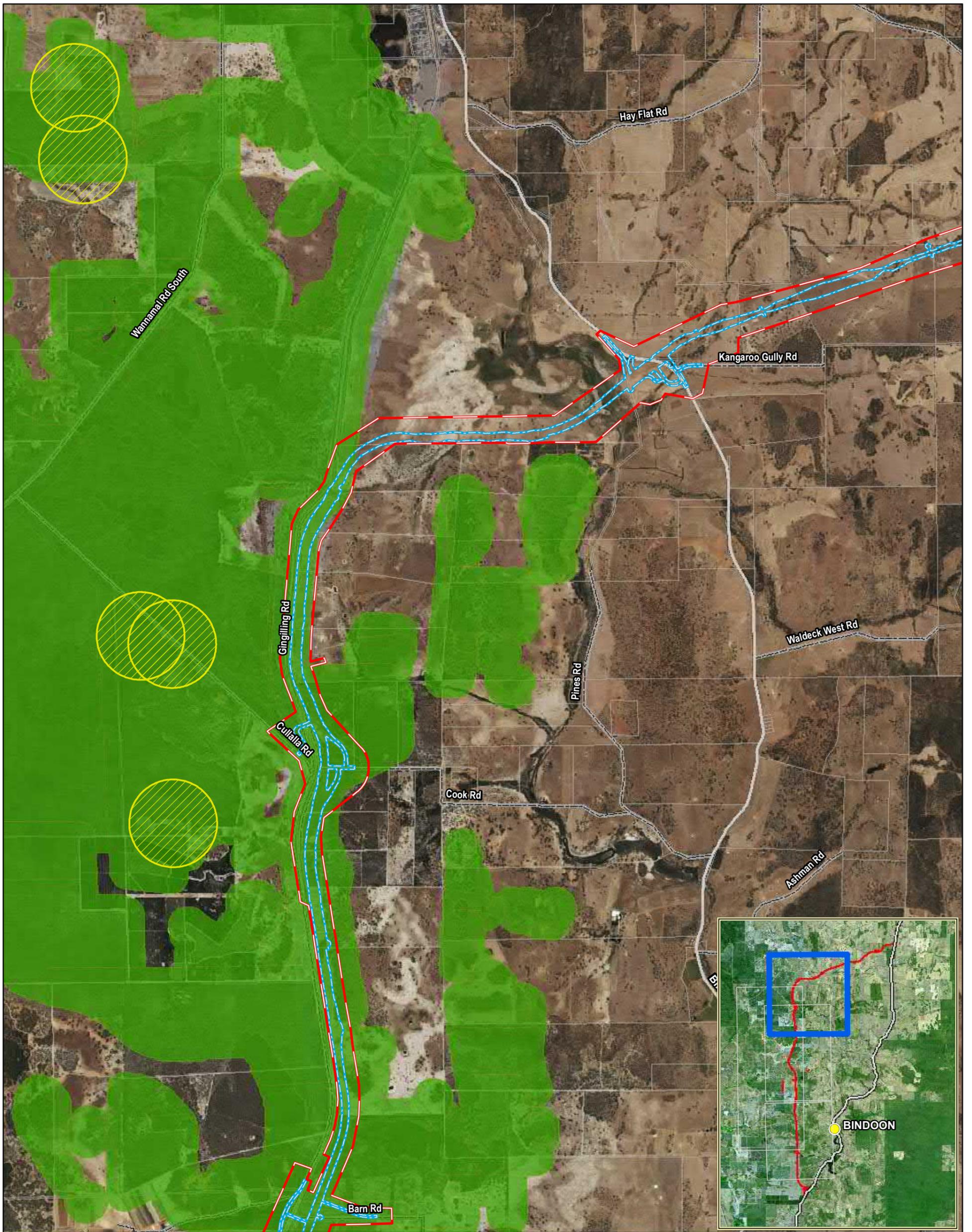
Drawing No
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 - F4 - 7

Issue
1

Task No
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Date	By	Chkd	Appd
23/08/2019	BG	LB	TJ



Legend

- Development Envelope
- Development Footprint
- PEC (DBCA)
- TEC (DBCA)
- Cadastral Boundary
- Major Road
- Minor Road

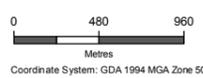


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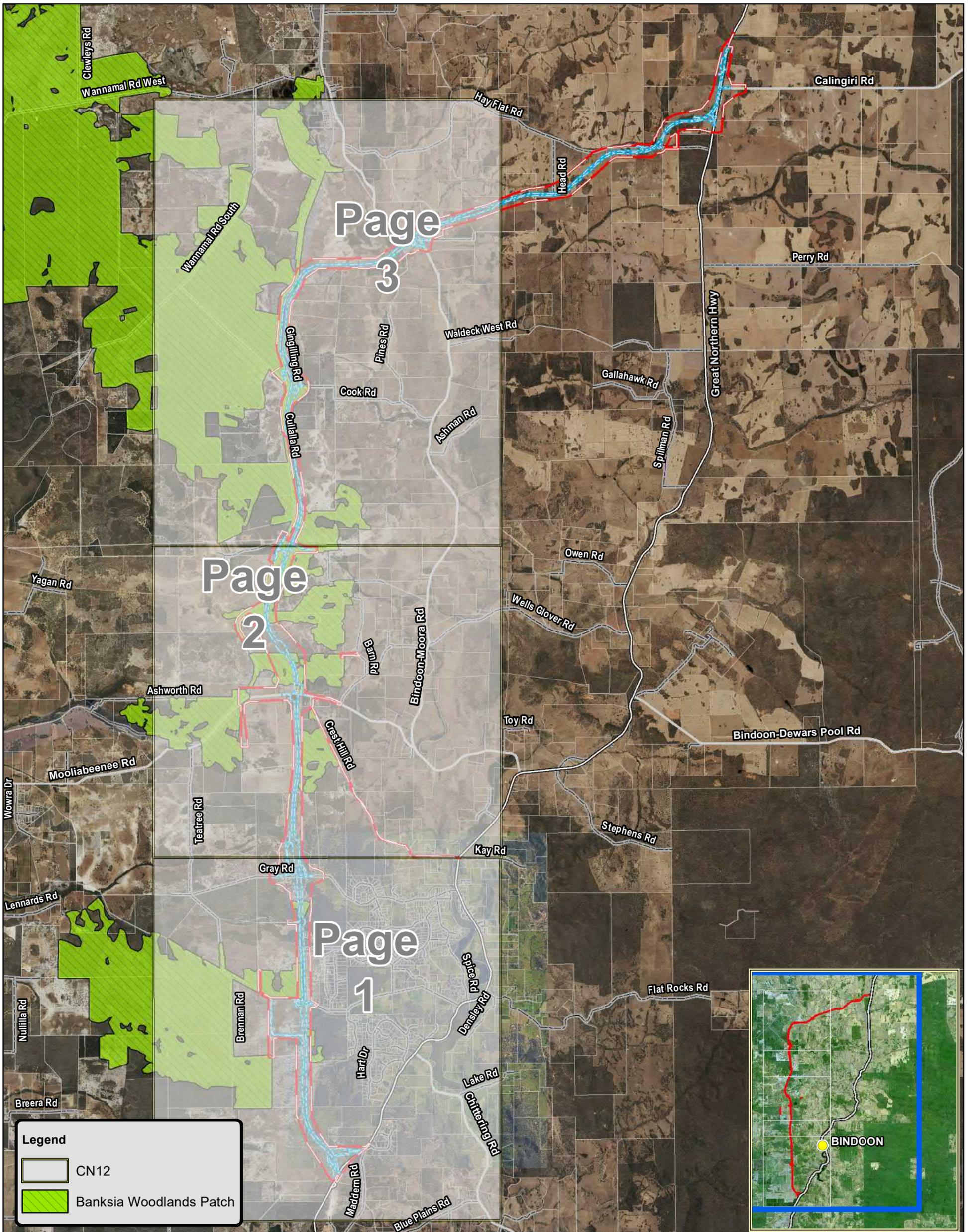
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Figure: 4-7 Page 4 of 4

Drawing No GNH-CN12-EA-PER-00001 - F4 - 7	Issue 1
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Task No ERD	Drawing Status / Other Draft
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Date 23/08/2019	By BG	Chkd LB	Appd TJ
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Legend

- CN12
- Banksia Woodlands Patch

Legend

- Development Envelope
- Development Footprint
- Cadastral Boundary
- Highway
- Major Road
- Minor Road

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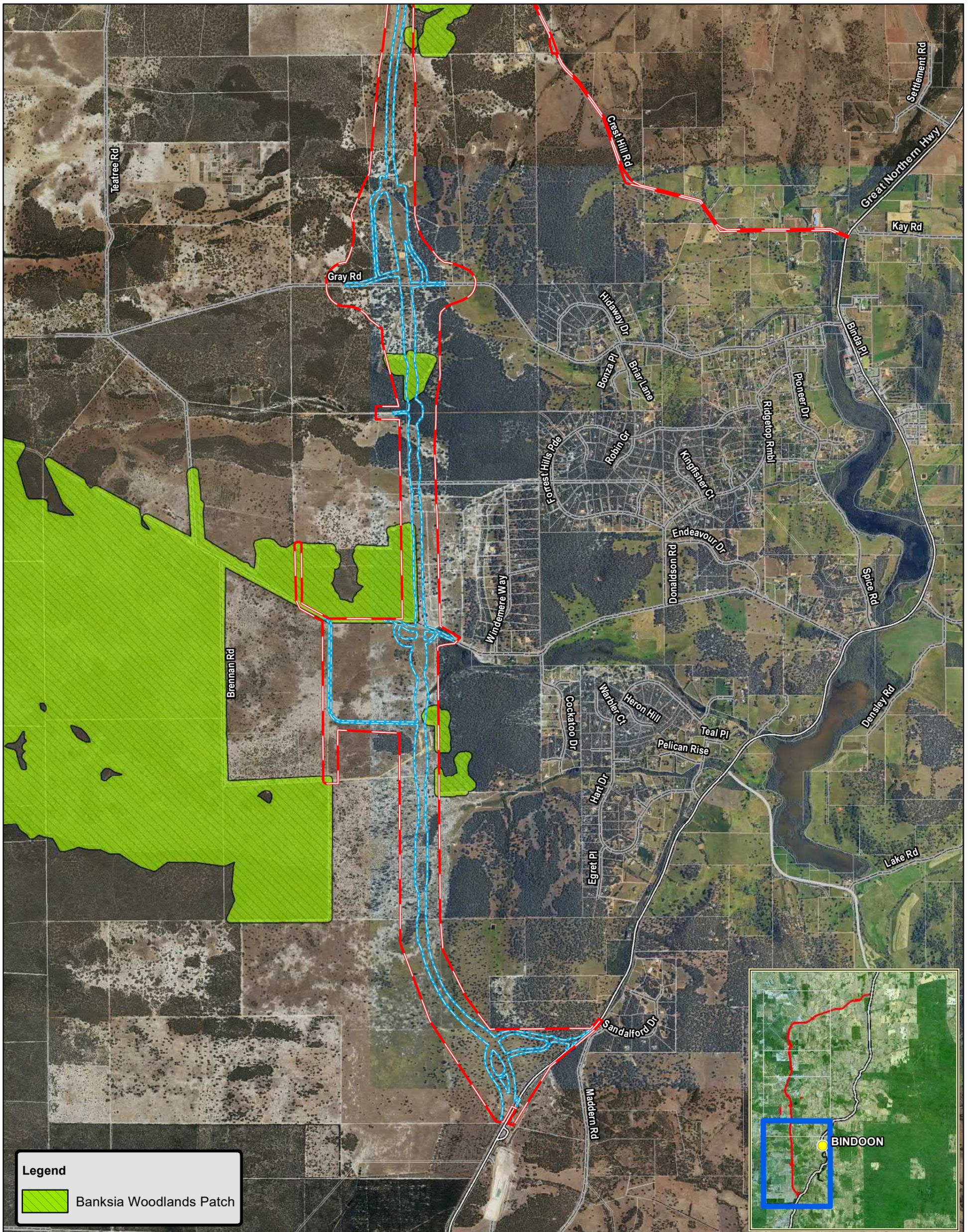
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Banksia Woodlands of the Swan Coastal Plain TEC (Source: FVC 2018a) Figure: 4 - 8

Drawing No GNH-CN12-EA-PER-0001	Issue 1		
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Legend

Banksia Woodlands Patch

Legend

Development Envelope

Development Footprint

Cadastral Boundary

Highway

Major Road

Minor Road

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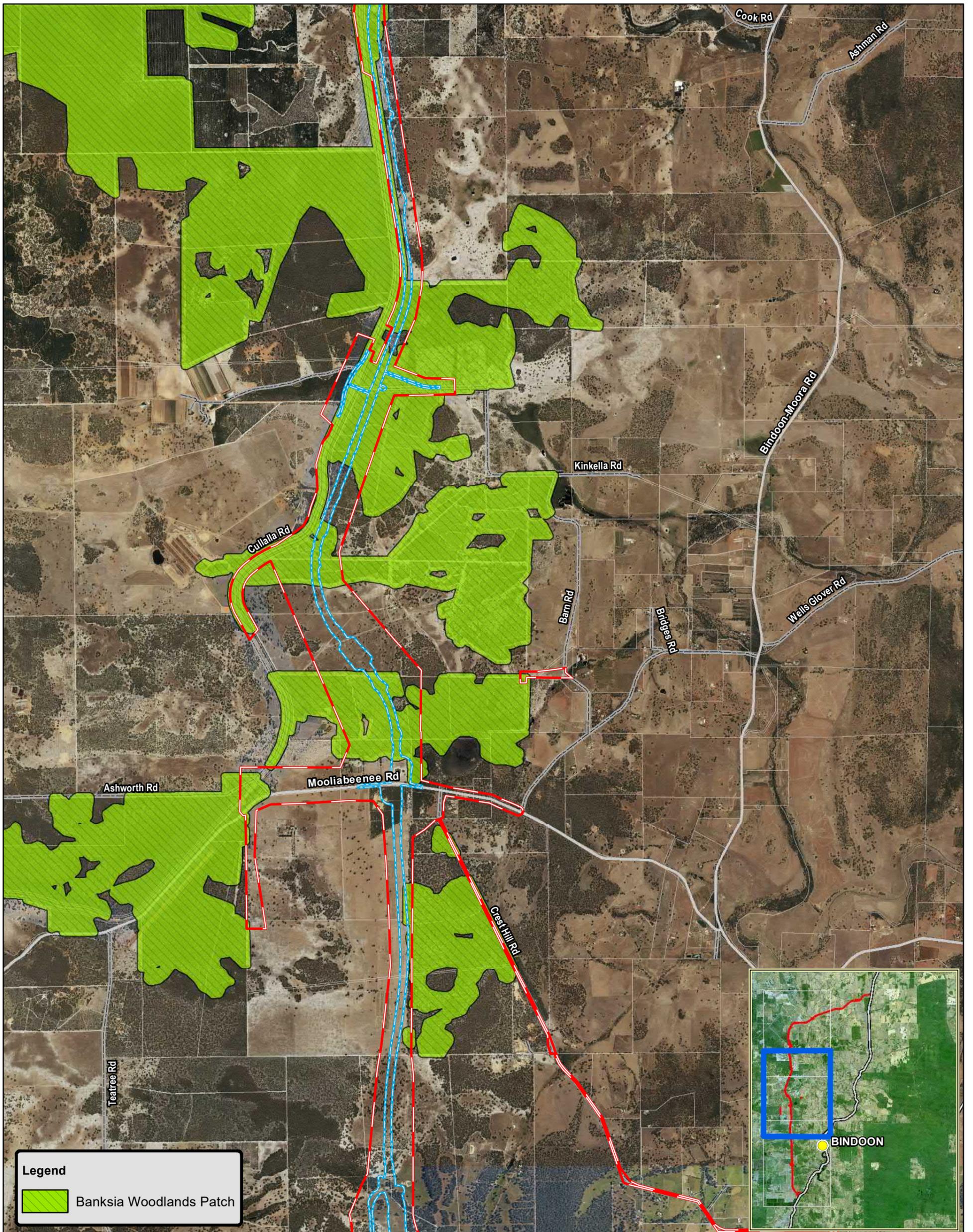
Banksia Woodlands of the Swan Coastal Plain TEC
(Source: FVC 2018a)
Figure: 4 - 8 Page 1 of 3

Drawing No: **GNH-CN12-EA-PER-0001** Issue: **1**
4-8

Task No: **ERD** Drawing Status / Other: **Draft**

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Legend

Banksia Woodlands Patch

Legend

	Development Envelope		Cadastral Boundary		Major Road
	Development Footprint		Highway		Minor Road

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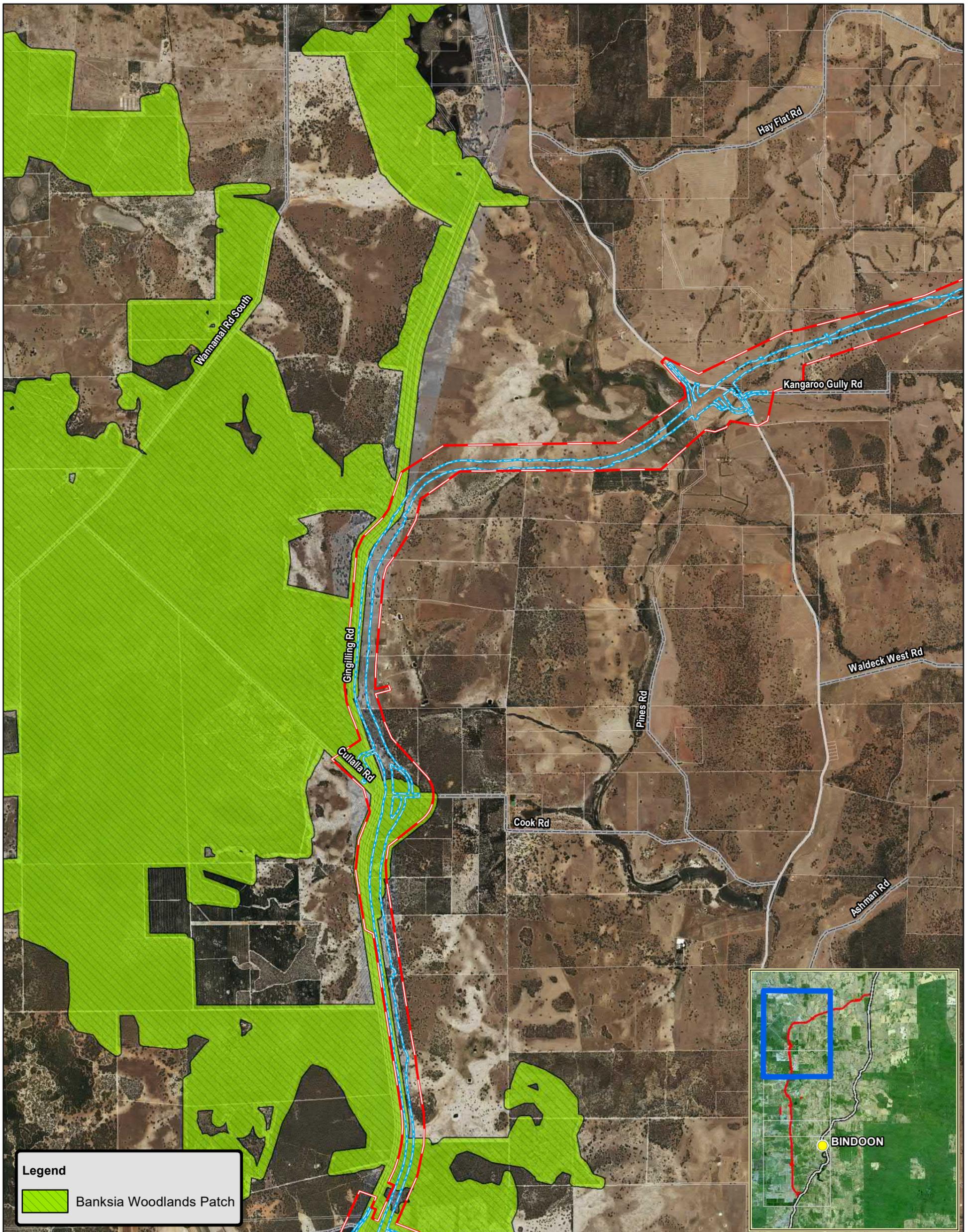
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Banksia Woodlands of the Swan
Coastal Plain TEC
(Source: FVC 2018a)
Figure: 4 - 8 Page 2 of 3

Drawing No GNH-CN12-EA-PER-0001 4-8	Issue 1		
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Legend

Banksia Woodlands Patch

Legend

Development Envelope

Development Footprint

Cadastral Boundary

Major Road

Minor Road

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Banksia Woodlands of the Swan
Coastal Plain TEC
(Source: FVC 2018a)
Figure: 4 - 8 Page 3 of 3

Drawing No
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4-8

Issue
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Task No
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4.2.3.5 Wetlands and Riparian Vegetation

The field surveys and vegetation mapping identified three vegetation associations in good or better condition that represent wetland or riparian vegetation in the study area (**Table 4-9**). Dominant species in these vegetation associations include *Eucalyptus rudis*, *Melaleuca preissiana*, *M. viminea* and *Casuarina obesa*. A further seven vegetation associations consisting largely of trees over cleared paddocks and pasture (i.e. there is not native understorey remaining)

Riparian vegetation associated with Udumung Brook is likely to provide habitat for the Water-rat, secondary evidence of which was recorded near Hay Flat Road. The Water-rat and its habitat are discussed in greater detail in **Chapter 4.3**.

Table 4-9: Vegetation Associations Representing Wetland or Riparian Vegetation

Vegetation Association		Extent within Development Envelope (ha)	Extent Mapped by FVC (ha)
ErXpBm	<i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> sparse woodland	48.2	62.2
EwBeNa	<i>Eucalyptus wandoo</i> and <i>Casuarina obesa</i> sparse woodland	4.5	4.6
MvJspLs	<i>Melaleuca viminea</i> shrubland	0.1	2.1
Total (ha)		52.8	68.9

Table 4-10: Riparian and Wetland Vegetation Associations Mapped as Paddock or Pasture

Vegetation Association		Extent within Development Envelope (ha)
P EmCcEr	<i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>E. rudis</i> over pasture	19.4
P ErCo	<i>E. rudis</i> and <i>Casuarina obesa</i> over pasture	4.3
P ErEw	<i>E. rudis</i> and <i>E. wandoo</i> over pasture	7.6
P EwCcCo	<i>E. wandoo</i> , <i>C. calophylla</i> and <i>C. obesa</i> over pasture	2.0
P EwCcCoMspp	<i>E. wandoo</i> , <i>C. calophylla</i> , <i>C. obesa</i> and <i>Melaleuca</i> species over pasture	1.5
P EwMr	<i>E. wandoo</i> , <i>M. raphiophylla</i> over pasture	0.8
P EwMrCo	<i>E. wandoo</i> , <i>M. raphiophylla</i> and <i>C. obesa</i> over pasture	5.0
Total (ha)		40.6

Ten wetlands defined by the DBCA (2016) occur within or adjacent to the Development Envelope (**Table 4-38**). Four of these are conservation category (CC) wetlands, three are classified as resource enhancement (RE) wetlands and the remaining three are multiple use (MU) wetlands. The wetlands associated with the Brockman River and MU wetland 12778 have historically been cleared for rural activities, although some intact native vegetation remains in some wetland areas (DBCA 2016; FVC 2018b). Vegetation associated with wetlands and waterways ranges from Completely Degraded to Excellent (**Table 4-12**).

Table 4-11: Geomorphic Wetlands within or Adjacent to the Development Envelope

Wetland (UFI)	Management Category	Wetland type
12840	CC wetland (Brockman River)	Floodplain
12838	RE wetland (Brockman River)	Sumpland
12762	MU wetland (Brockman River)	Palusplain
12841	MU wetland (Brockman River)	Dampland
12839	RE wetland (Brockman River)	Palusplain
12777	CC wetland (Lake Nangar)	Sumpland
12776	RE wetland	Sumpland
12778	MU wetland	Palusplain
12779	CC wetland (Teatree Road)	Floodplain
15154	CC wetland (Teatree Road)	Palusplain

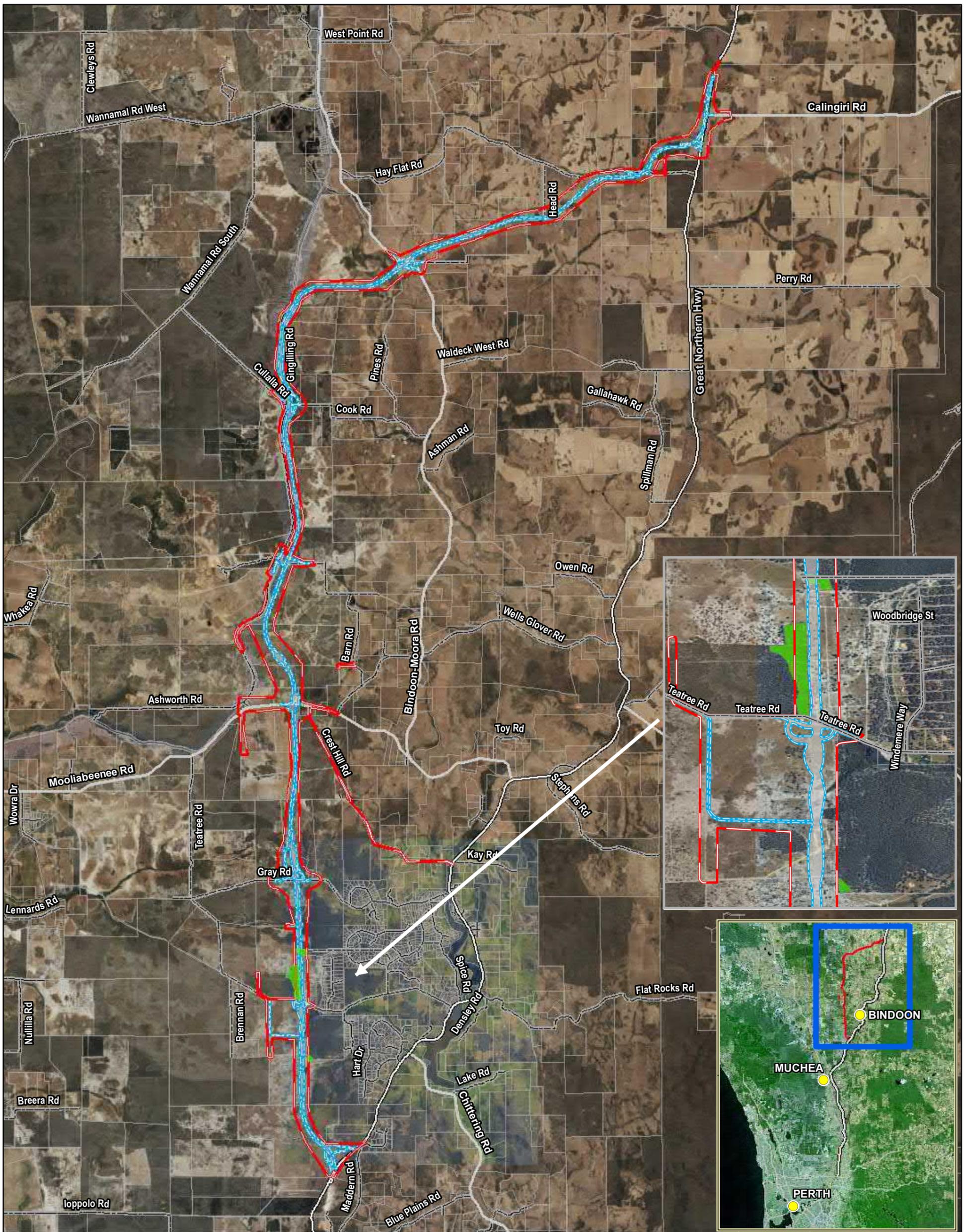
Table 4-12: Condition of Riparian and Wetland Vegetation within the Development Envelope

Vegetation Association	Vegetation Condition (ha)						Total (ha)
	Degraded	Degraded - Good	Good	Good – Very Good	Very Good	Very Good - Excellent	
ErXpBm	5.3	4.0	17.3	0.0	5.1	4.0	35.8
EwBeNa	0.6	0.0	0.0	3.5	0.4	0.0	4.5
MvJspLs	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Total (ha)	6.0	4.0	17.3	3.5	5.5	4.0	40.4

4.2.3.6 Weeds

A total of 30 introduced flora species (weeds) were recorded in areas of native vegetation during the 2016, 2017 and 2018 surveys (FVC 2018a; 2019). The number of weeds identified is not unexpected, given that the Development Envelope and surrounding area includes large areas of paddock that are used for grazing of stock (and therefore seeded with pasture grasses and other species such as clover), cropping and horticulture. A full listing of weed species identified during the surveys is provided in Appendix B of FVC (2019). Weed species are denoted by an asterisk (*).

Of the weed species identified (**Figure 4-9**), one species is a Declared Plant under the BAM Act: *Chondrilla juncea* (Skeleton Weed). Skeleton Weed is a category C2 plant (eradication required) in the Shires of Chittering and Gingin, and other areas of the State, and is the subject of a Department of Agriculture eradication program. No Weeds of National Significance (WoNS) were recorded within the Development Envelope or the study area.



Legend

- Development Envelope
- Development Footprint
- Skeleton Weeds (FVC, 02/07/2018)
- Chondrilla juncea
- Highway
- Major Road
- Minor Road
- Cadastral Boundary

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Skeleton Weed Locations Within the Development Envelope
(Source: FVC 2018a)
Figure: 4-9

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Task No ERD	Drawing Status / Other Draft		
Date 22/08/2019	By BG	Chkd LB	Appd TJ

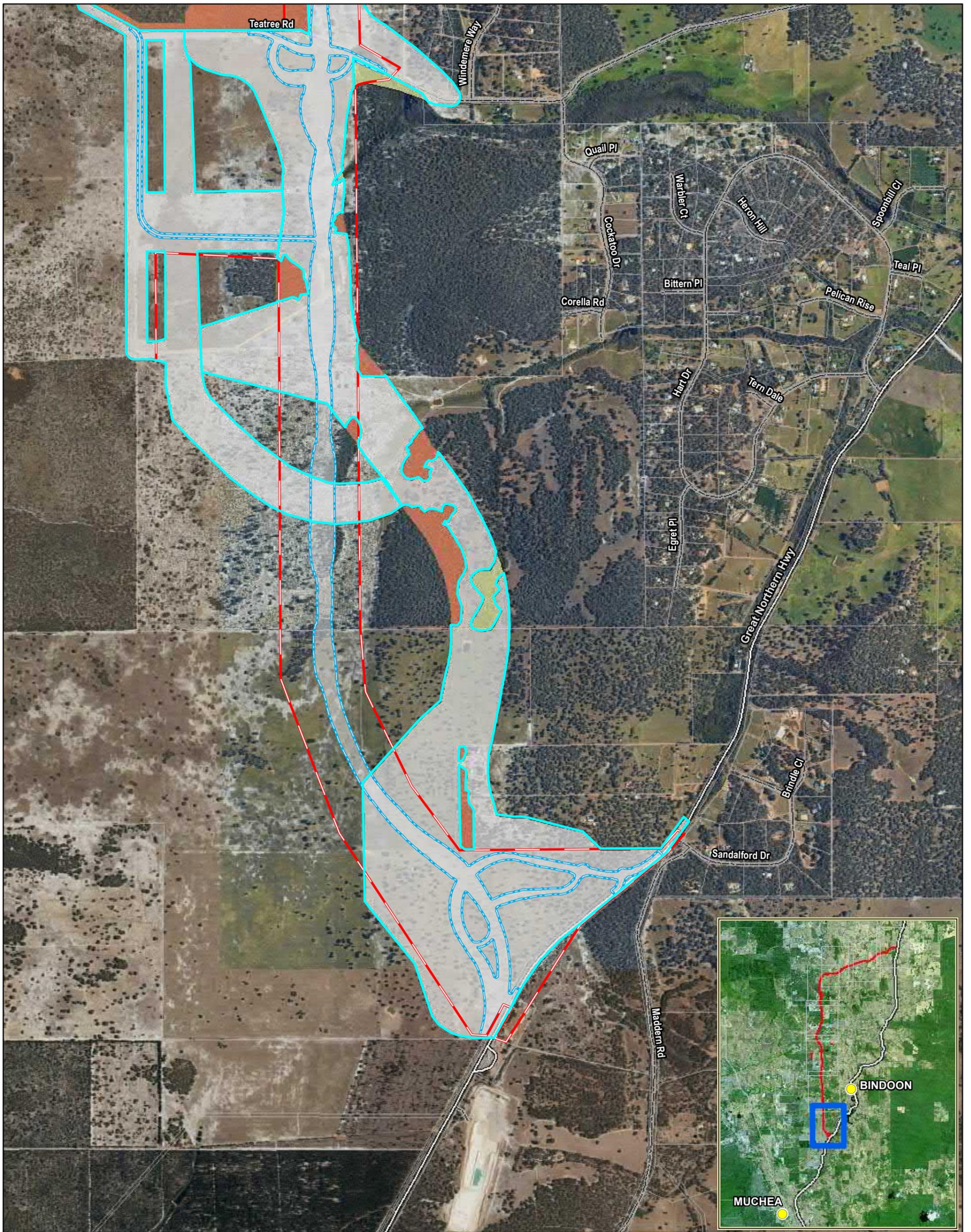
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4.2.3.7 Phytophthora Dieback

Terratree Pty Ltd (Terratree) were commissioned to undertake an assessment of the Bindoon Bypass to determine whether *Phytophthora cinnamomi* (dieback) was present. The field assessment was conducted in March and April 2018 by DBCA-registered dieback interpreters at Terratree. Field assessments comprised visual assessment of native vegetation, and collection of soil and tissue samples of recently dead disease indicator species, in accordance with the guidelines (DPaW 2015; Terratree 2018).

From a total of 17 samples, three returned positive results for *Phytophthora cinnamomi*, and one returned a positive result for a *Phytophthora* species that is yet to be determined. Dieback was predominantly found to be present on lower slopes and in areas that showed evidence of ground disturbance activities. The resulting total area mapped as infested is 27.15 ha (representing 0.83% of the study area; **Figure 4-10**). Disease expression has been described as good within infested areas, with multiple disease indicator species deaths as well as disease pattern, chronology and obvious changes to the vegetation structure, composition and cover.

A total of 13 samples showed negative results for dieback, and visual evidence confirmed that a total of 402.57 ha (12.37%) of the study area are uninfested. There are 35.55 ha (1.09%) of the study area that are uninterpretable, with this vegetation occurring along drainage lines or surrounding wetland areas. Of the remaining area, 2,320.30 ha (71.28%) was mapped as 'excluded'. This comprised areas of pasture or planted vegetation that was unable to be assessed due to the lack of susceptible native vegetation (Terratree 2018). A total of 469.69 ha could not be assessed due to access restrictions. Prior to construction, Dieback mapping will be updated and any areas not previously mapped will be surveyed.



Legend

- Development Envelope
 - Development Footprint
 - Highway
 - Major Road
 - Minor Road
 - Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Uninfested
 - Uninterpretable
 - Not Assessed

North Arrow

Scale at A3: 1:20,000

0 240 480 Metres

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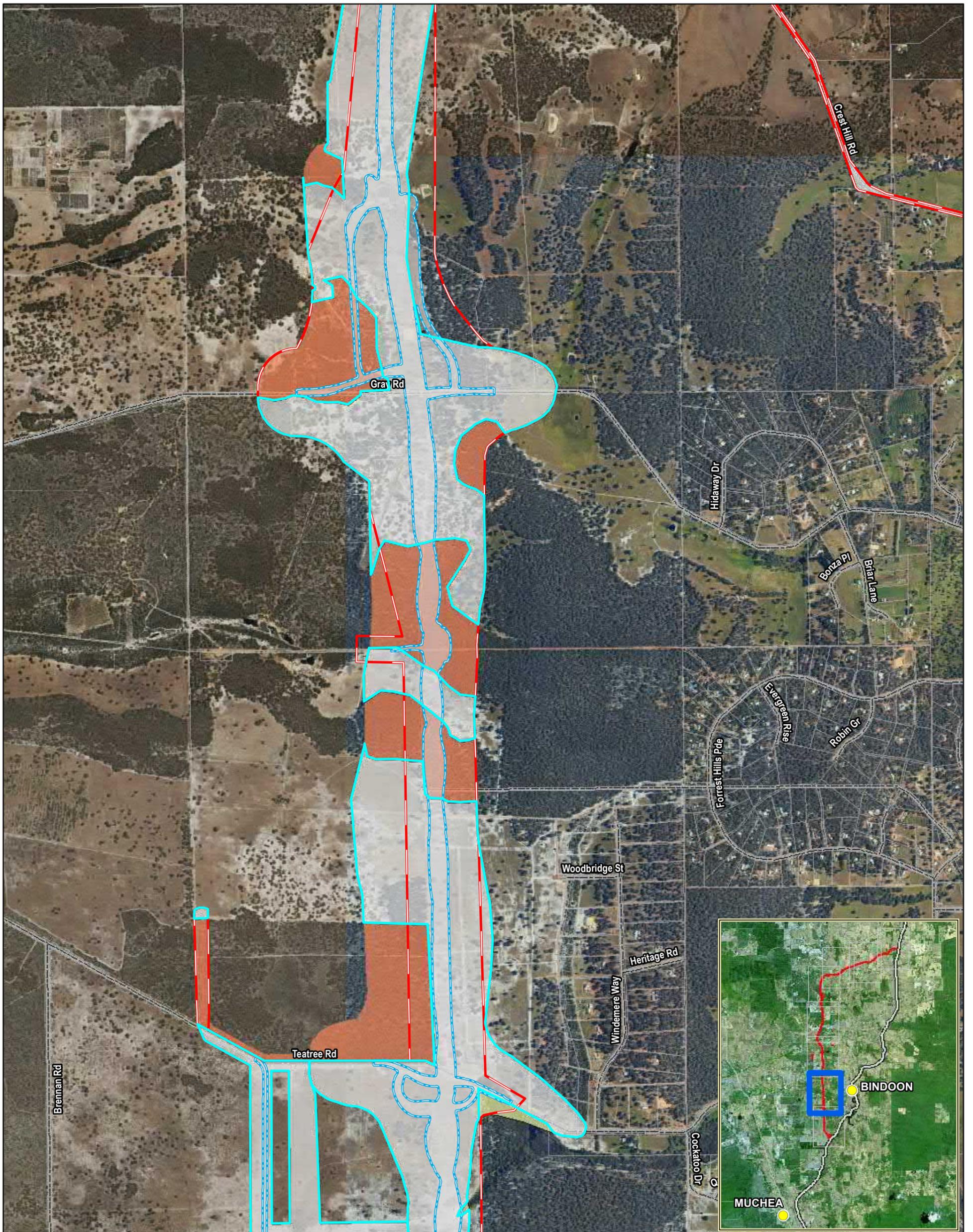
Phytophthora Dieback Mapping
(Source: Terratree 2018)

Figure: 4-10 Page 1 of 8

Drawing No: GNH-CN12-EA-PER-00001 - F4-10 Issue: 1

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Legend

- Development Envelope
- Development Footprint
- Minor Road
- Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Uninfested
- Not Assessed
- Uninterpretable

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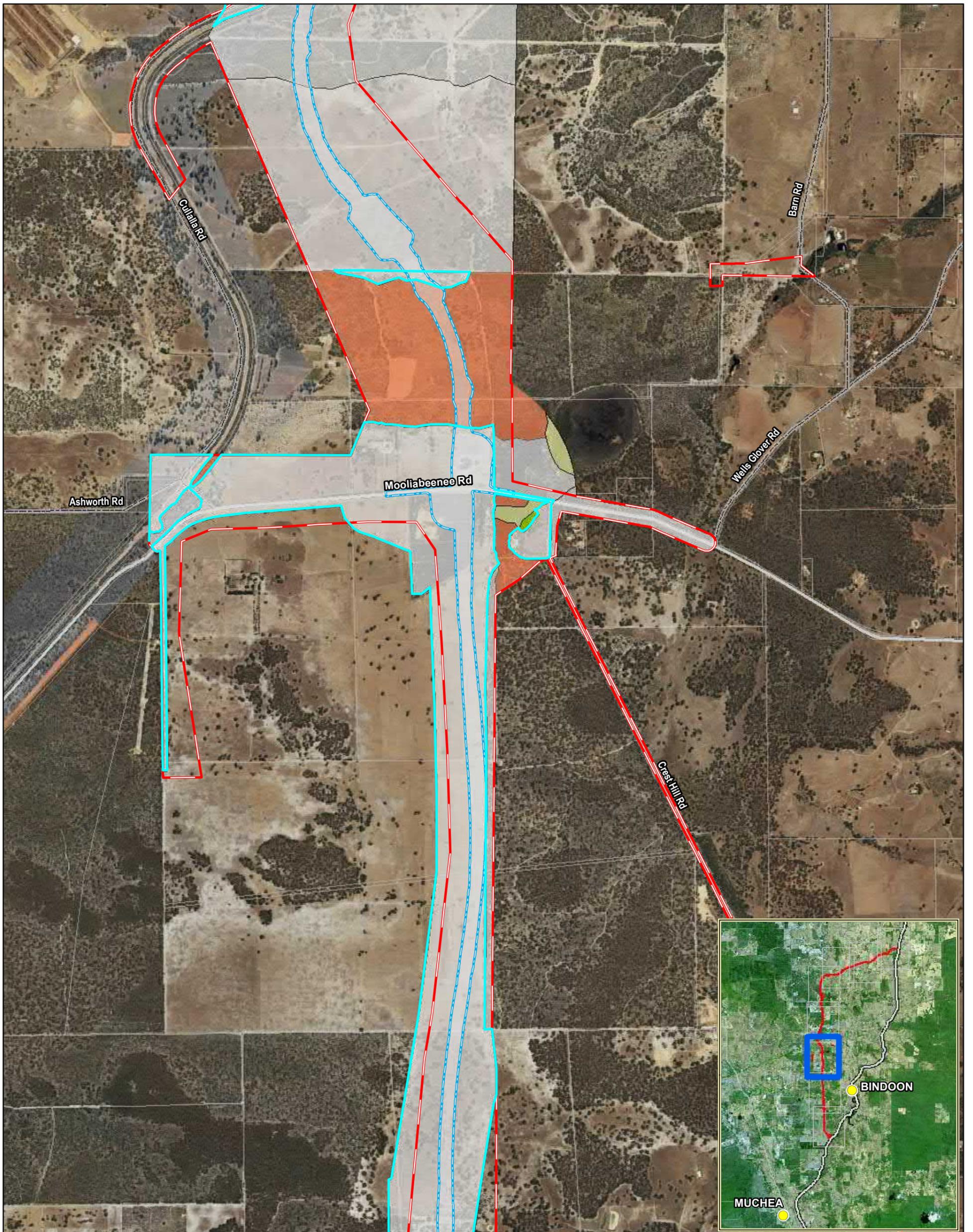
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Phytophthora Dieback Mapping
 (Source: Terratree 2018)
 Figure: 4-10 Page 2 of 8

Drawing No GNH-CN12-EA-PER-00001 - F4-10		Issue 1	
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Legend

- Development Envelope
 - Development Footprint
 - Major Road
 - Minor Road
 - Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Infested
 - Uninfested
 - Uninterpretable
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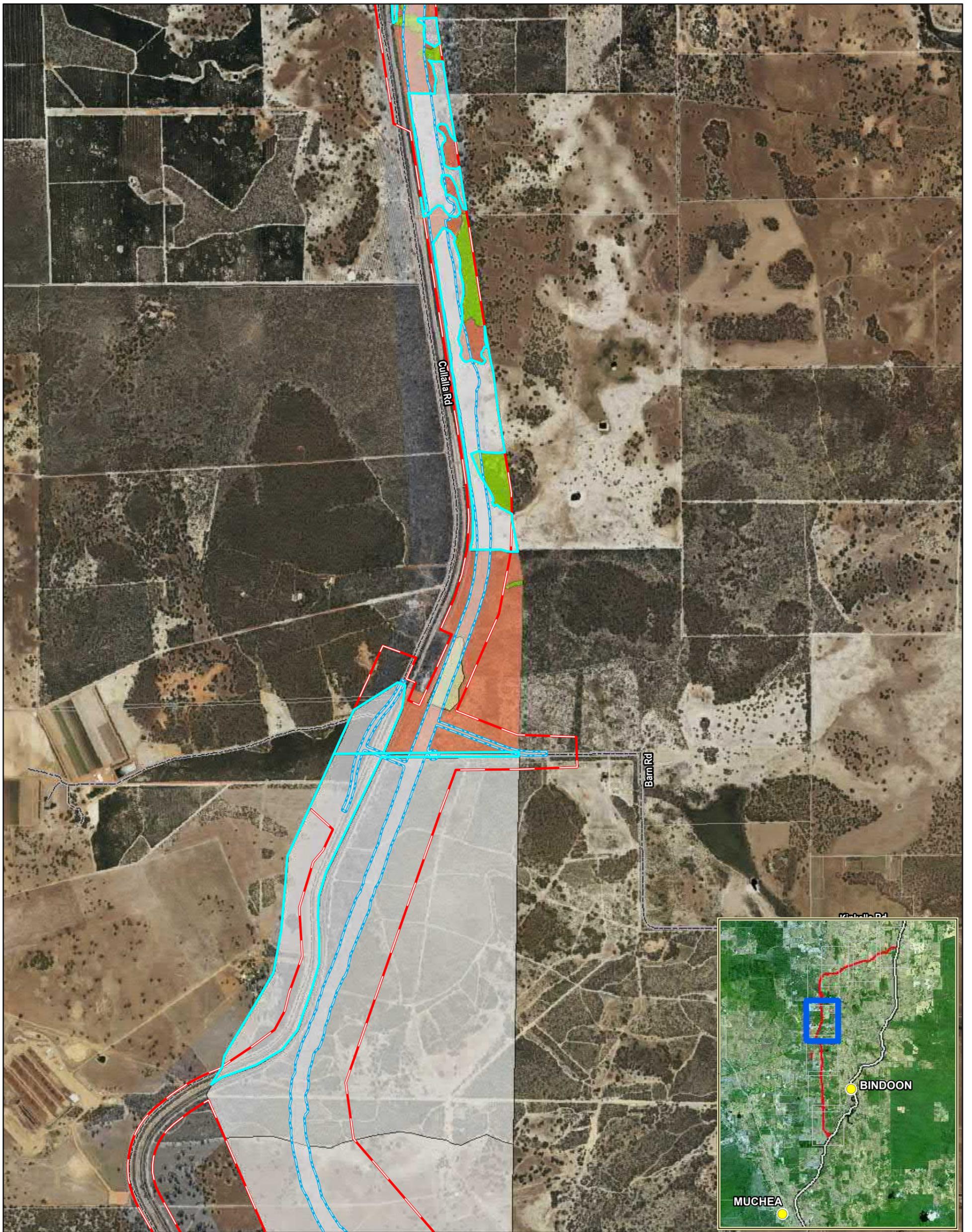
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Phytophthora Dieback Mapping
(Source: Terratree 2018)

Figure: 4-10 Page 3 of 8

Drawing No GNH-CN12-EA-PER-00001 - F4-10	Issue 1		
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Legend

- Development Envelope
 - Development Footprint
 - Minor Road
 - Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Infested
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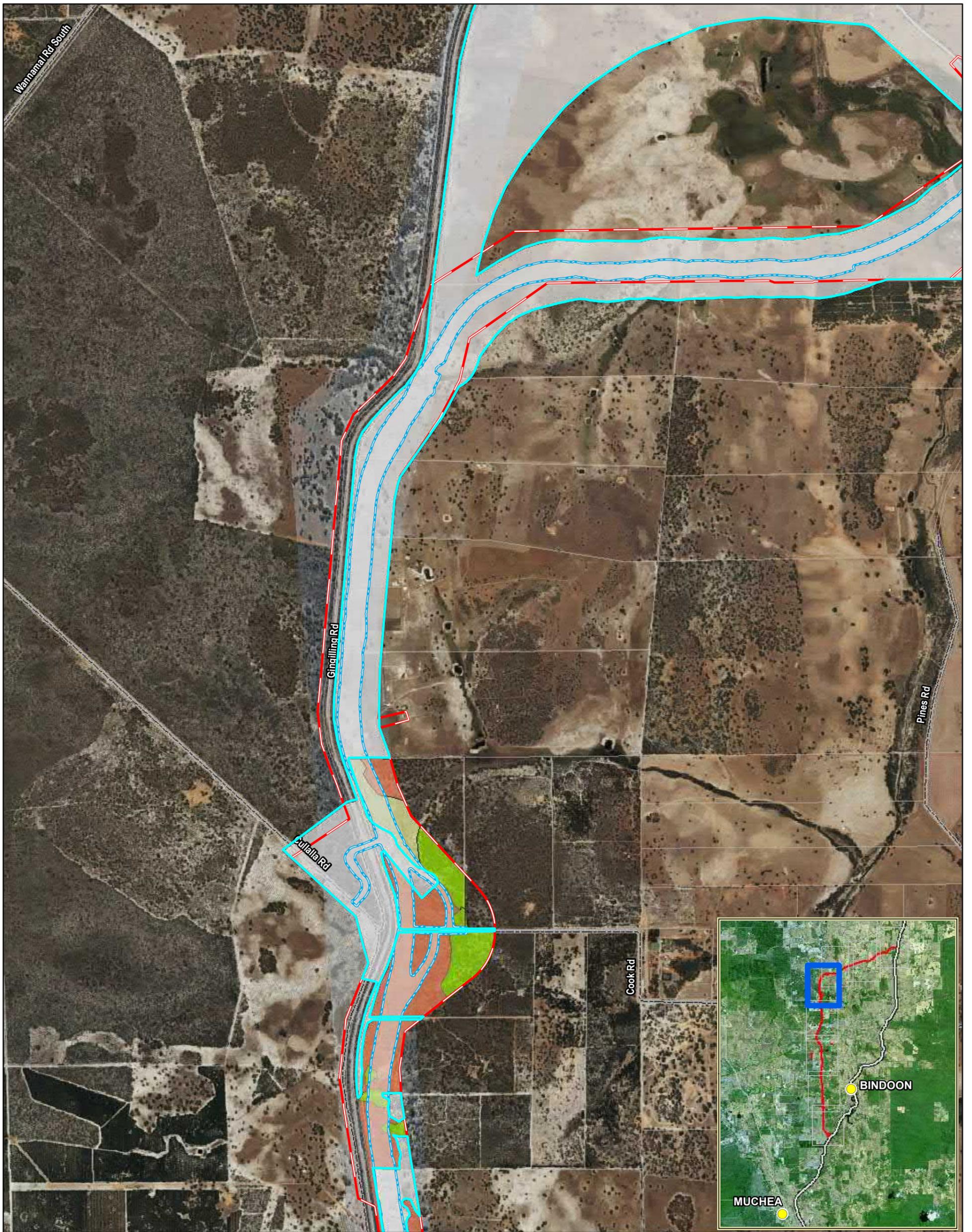
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Phytophthora Dieback Mapping
 (Source: Terratree 2018)

Figure: 4-10 Page 4 of 8

Drawing No GNH-CN12-EA-PER-00001 - F4-10	Issue 1		
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Legend

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| Development Footprint | Infested | Not Assessed |
| Major Road | Uninfested | |
| Minor Road | | |
| Cadastral Boundary | | |

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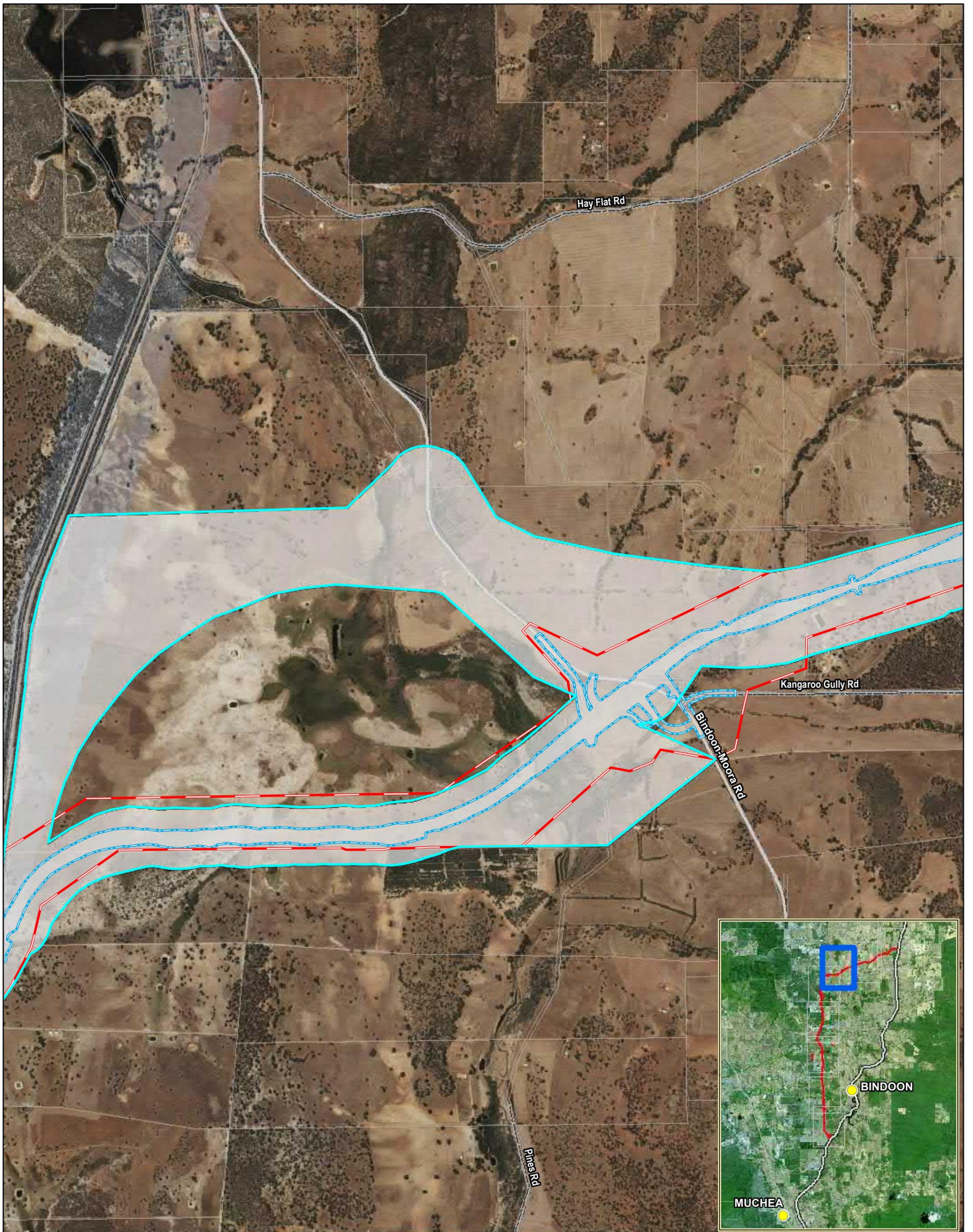
Great Northern Highway Bindoon Bypass Environmental Review Document

Phytophthora Dieback Mapping
 (Source: Terratree 2018)

Figure: 4-10 Page 5 of 8

Drawing No GNH-CN12-EA-PER-00001 - F4-10	Issue 1		
Task No ERD	Drawing Status / Other Draft		
Date 22/08/2019	By BG	Chkd LB	Appd TJ

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Legend

- Development Envelope
 - Development Footprint
 - Major Road
 - Minor Road
 - Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Not Assessed

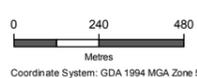


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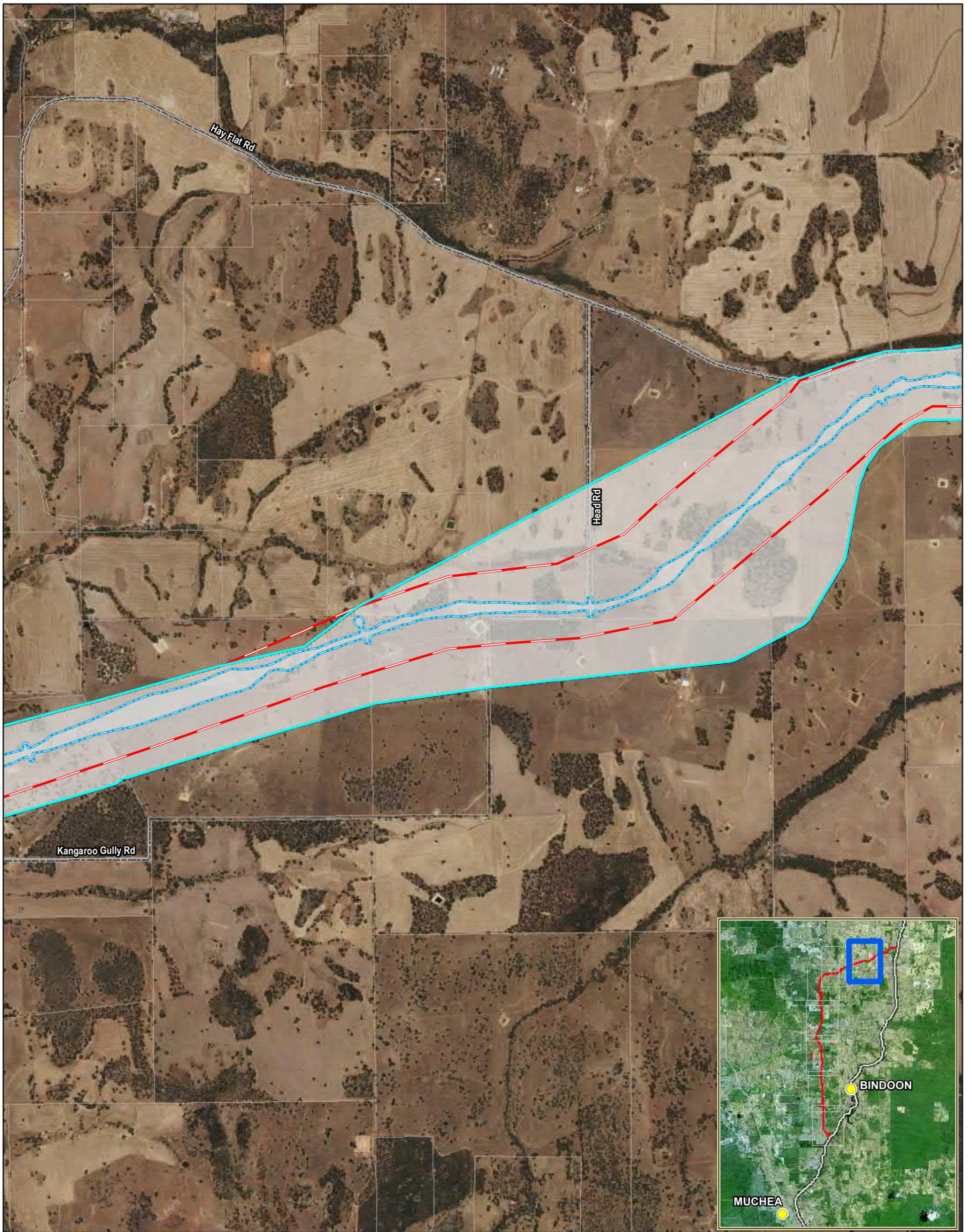
Phytophthora Dieback Mapping
 (Source: Terratree 2018)

Figure: 4-10 Page 6 of 8

Drawing No: GNH-CN12-EA-PER-00001 Issue: 1

Task No: ERD Drawing Status / Other: Draft

Date	By	Chkd	Appd
22/08/2019	BG	LB	TJ



Legend

- Development Envelope
- Development Footprint
- Minor Road
- Cadastral Boundary
- Dieback Assessment Mapping (Terratree)
- Not Assessed

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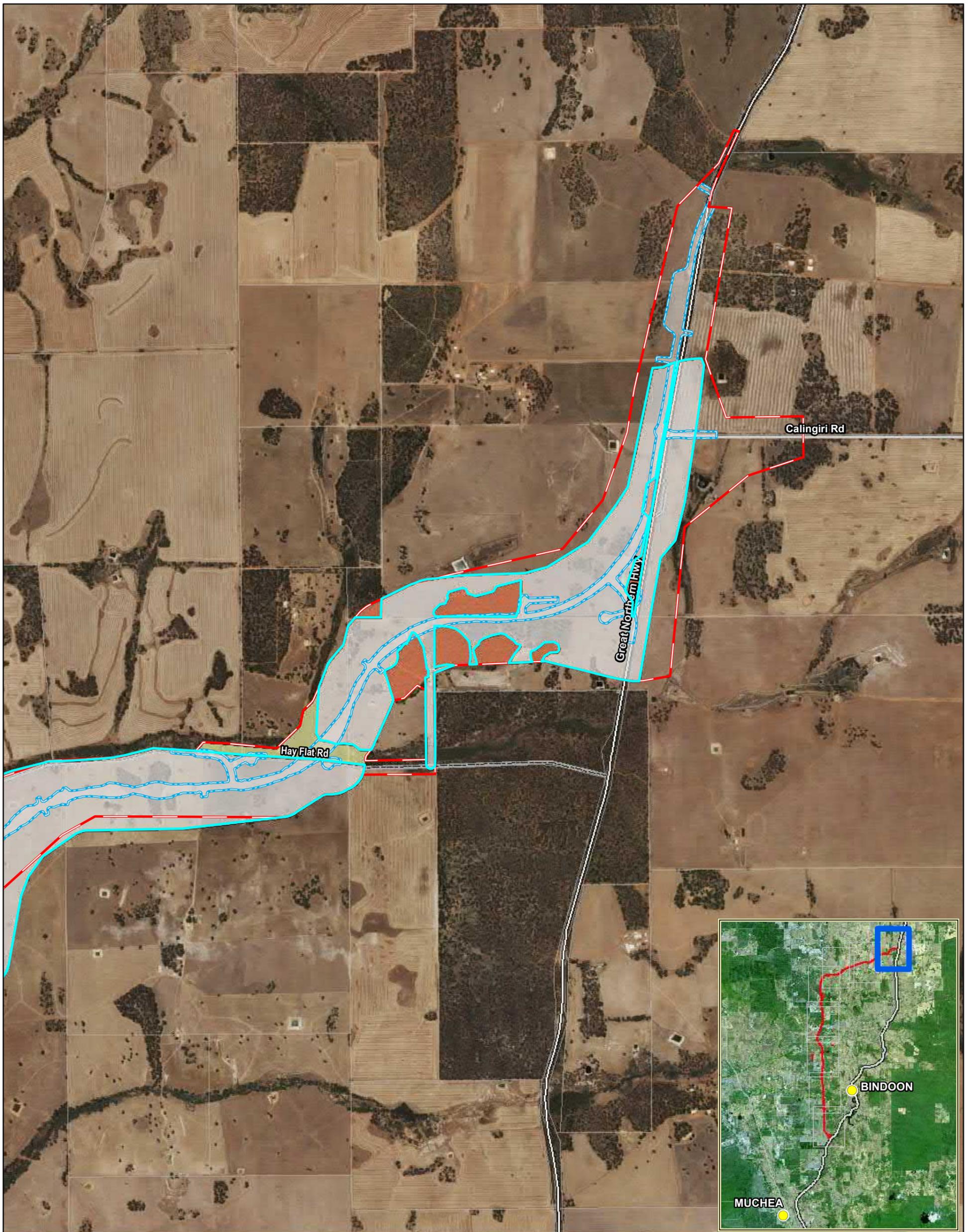
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 Project: **Environmental Review Document**

Phytophthora Dieback Mapping
 (Source: Terratree 2018)
 Figure: 4-10 Page 7 of 8
 Drawing No: **GNH-CN12-EA-PER-00001**
 - F4-10 Issue: **1**
 Task No: **ERD** Drawing Status / Other: **Draft**

Date	By	Chkd	Appd
22/08/2019	BG	LB	TJ

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Legend

- Development Envelope
- Development Footprint
- Highway
- Major Road
- Minor Road
- Cadastral Boundary
- Dieback Assessment Mapping (Terratree)**
- Uninfested
- Uninterpretable
- Not Assessed

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 Figure: 4-10 Page 8 of 8

Drawing No GNH-CN12-EA-PER-00001 - F4-10		Issue 1	
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4.2.4 Potential Impacts

The implementation, construction and operation of the Proposal will have both direct and indirect impacts to flora and vegetation. Potential impacts to flora and vegetation may arise within the Development Envelope as a result of the following activities:

- vegetation clearing, topsoil stripping and earthmoving
- vehicle movements
- watercourse and wetland crossings
- water abstraction for construction water and/or during bridge construction
- road reserve fencing.

The following impacts are anticipated as a result of implementation of the Proposal:

- permanent loss of native vegetation within the Development Footprint due to clearing for construction
- permanent loss of individuals of conservation significant flora species in the Development Footprint due to clearing for construction
- permanent loss of the EPBC Act listed Banksia Woodlands TEC within the Development Footprint due to clearing for construction
- fragmentation of native vegetation, TEC and/or conservation significant flora populations.

The following indirect impacts may arise as a result of implementation of the proposal:

- degradation of native vegetation associations or TEC due to altered ground and surface water hydrology
- degradation of native vegetation associations or TEC due to introduction and/or spread of weeds or *Phytophthora* dieback

4.2.4.1 Conservation Significant Flora

No BC Act or EPBC Act listed flora species have been recorded in the Development Envelope.

Of the eight DBCA-listed Priority flora species recorded by FVC (2018a), five (*Drosera sewelliae*—P2, *Leucopogon squarrosus* subsp. *trigynus*—P2, *Verticordia rutilastra*—P3, *Anigozanthos humilis* subsp. *chrysanthus*—P4, *Verticordia paludosa*—P4) are located within the Development Footprint; a further two (*Hibbertia miniata*—P4, *Acacia drummondii* subsp. *affinis*—P3) are within 20 m of the Development Footprint (**Table 4-13**). Four occurrences of the P2 species *Drosera sewelliae* are within the Development Footprint. Three of these occurrences, consisting of 41 individuals, are considered part of a larger population of this species. This population will be fragmented by the Development Footprint. The remaining occurrence consists of a single plant.

A total of 57 occurrences, consisting of 108 individuals, of the P4 species *Verticordia paludosa* are within the Development Footprint. These occurrences are part of three groupings that are likely to represent separate populations; however, population mapping is yet to be completed. One of these populations, consisting of six individual plants, is completely within the Development Footprint. The remaining two populations are partially within the Development Footprint. Clearing will not fragment these populations as the remaining plants are on the same side of the Development Footprint.

Four occurrences of the P4 species *Hibbertia miniata*, and two occurrences of the P4 species *Acacia drummondii* subsp. *affinis*, are located within 20 m of the Development Footprint.

Table 4-13: Impacts to Conservation Significant Flora

Species name	Number of Occurrences (Individuals)			% of Individuals Recorded by FVC (2018a, 2019) Cleared	Number of Occurrences within 20 m of the Development Footprint
	Recorded by FVC (2018a, 2019)	within the Development Envelope	within the Development Footprint		
<i>Drosera sewelliae</i> (with <i>Drosera ?sewelliae</i>) - P2	46 occurrences (206 individuals)	24 occurrences (158 individuals)	4 occurrences (42 individuals)	20	2 occurrences
<i>Leucopogon squarrosus</i> subsp. <i>trigynus</i> - P2	5 occurrences (5 individuals)	5 occurrences (5 individuals)	4 occurrences (4 individuals)	80	None
<i>Acacia drummondii</i> subsp. <i>affinis</i> (with <i>Acacia drummondii</i> subsp. <i>?affinis</i>) - P3	92 occurrences (342 individuals)	16 occurrences (49 individuals)	None	N/A	2 occurrences
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i> - P3	240 occurrences (260 individuals)	1 occurrence (1 individual)	None	N/A	None
<i>Halgania corymbosa</i> - P3	2 occurrences (2 individuals)	2 occurrences (2 individuals)	None	N/A	None
<i>Verticordia rutilastra</i> - P3	2 occurrences (2 individuals)	2 occurrences (2 individuals)	2 occurrences (2 individuals)	100	None
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i> - P4	7 occurrences (11 individuals)	3 occurrences (3 individuals)	1 occurrence (1 individual)	9	2 occurrences
<i>Hibbertia miniata</i> - P4	853 occurrences (1,493 individuals)	851 occurrences (1,352 individuals)	None	N/A	4 occurrences
<i>Hypolaena robusta</i> - P4	4 occurrences (4 individuals)	1 occurrence (1 individual)	None	N/A	None
<i>Verticordia paludosa</i> (with <i>Verticordia ?paludosa</i>) - P4	154 occurrences (281 individuals)	126 occurrences (239 individuals)	57 occurrences (108 individuals)	38	3 occurrences

4.2.4.2 Conservation Significant Vegetation

Potential impacts specifically to the EPBC Act listed Banksia Woodlands TEC include the following (Threatened Species Scientific Committee 2016):

- introduction or spread of dieback or invasive weed species
- changes to groundwater levels due to abstraction for construction water
- loss of keystone Banksia species and fragmenting of nectar/pollen nutritional networks; e.g. loss of *Banksia ilicifolia* in water drawdown areas.

The Proposal will directly impact 60 ha of the Banksia Woodlands TEC (**Table 4-14**).

Table 4-14: TECs and PECs within the Development Footprint

Ecological Community	Status	Extent within Study Area (ha)	Extent within Development Envelope (ha)	Extent within Development Footprint (ha)	% of Extent within Study Area Cleared
EPBC Act listed Banksia Woodlands of the Swan Coastal Plain TEC	Endangered (EPBC Act)	483.7	307.5	60	12.4

4.2.4.3 Native Vegetation

Approximately 119.1 ha of native vegetation, of which 107.9 ha is in good or better condition, will be cleared in order to implement the Proposal. Clearing will predominately occur within EtBeAn – *Eucalyptus todtiana* sparse woodland (33.7 ha), EmXpHh – *E. marginata* sparse woodland (22.6 ha) and EmBsHh – *E. marginata* and *Banksia sessilis* sparse woodland vegetation associations. The breakdown of clearing by vegetation association is presented in **Table 4-15**. Vegetation associations that were recorded as ‘agricultural areas with small pockets of vegetation maybe present’, representing 311 ha within the Development Footprint, have not been included in this table, as the vegetation association has been recorded as ‘pasture’ and represent predominantly cleared areas or areas that are highly altered.

The Development Footprint will predominantly impact areas that are mapped as Degraded or worse condition. These areas mainly comprise paddocks and other cleared areas. The majority of native vegetation to be cleared is in Good or Very Good condition. (**Table 4-16**).

Clearing of the Development Footprint will result in fragmentation of native vegetation. The Development Footprint will fragment continuous patches of vegetation between Teatree Road and Gray Road, including one occurrence of the EPBC Act listed Banksia Woodlands TEC, between Mooliabeenee Road and (north of) Barn Road, including three occurrences of the Banksia Woodlands TEC, at Cook Road, including an occurrence of the Banksia Woodlands TEC, and at Hay Flat Road where the Proposal crosses Udumung Brook.

Seven South West vegetation complexes occur within the Development Footprint (**Table 4-17**). None of the vegetation complexes will be reduced below 30% of the remaining extent as a result of the Proposal. For those that are already below 30%, the Proposal will not reduce the extent below 10%. The required clearing will result in a reduction in extent of less than 1% for all vegetation complexes within the Development Footprint.

Table 4-15: Clearing Required by Vegetation Association

Vegetation Association	Extent within Development Envelope (ha)	Extent to be Cleared (ha)	% Extent to be Cleared
BaXpAn	61.0	8.5	13.9
BaXpUa	41.7	7.5	18.0
BmKgHg	8.6	0.1	1.2
EmBsHh	116.5	16.0	13.7
EmXpAn	13.4	2.0	14.9
EmXpHh	127.0	24.0	18.9
ErXpBm	35.8	12.5	35.0
EtBeAn	152.2	34.0	22.3
EtEpAn	39.2	8.0	20.4
EwBeNa	4.5	1.0	22.2
EwXpHh	45.0	5.5	12.2
MvJspLs	0.1	0	0.0
Total	644.9	119.1	18.5

Table 4-16: Condition of Vegetation to be Cleared

Vegetation Association	Vegetation Condition (ha)							Total (ha)
	Degraded	Degraded - Good	Good	Good – Very Good	Very Good	Very Good - Excellent	Excellent	
BaXpAn	0.0	0.0	0.0	0.0	4.3	0.0	4.2	8.5
BaXpUa	0.0	4.0	0.0	1.7	1.3	0.5	0.0	7.5
BmKgHg	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
EmBsHh	0.0	0.0	3.0	3.0	4.0	5.0	1.0	16.0
EmXpAn	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
EmXpHh	4.7	0.0	1.8	4.5	13.0	0.0	0.0	24.0
ErXpBm	2.5	0.0	7.0	0.0	2.5	0.5	0.0	12.5
EtBeAn	0.0	0.0	0.0	19.5	1.5	8.0	5.0	34.0
EtEpAn	0.0	0.0	0.0	0.0	4.5	3.5	0.0	8.0
EwBeNa	0.0	0.0	0.0	0.7	0.3	0.0	0.0	1.0
EwXpHh	0.0	0.0	2.0	3.0	0.0	0.5	0.0	5.5
Total	7.2	4.0	13.8	32.4	31.4	20.0	10.3	119.1

Table 4-17: Impacts to Vegetation Complexes in the Development Footprint

Vegetation Complex	Extent to be Cleared (ha)			Pre-European Extent Remaining Following Development of the Proposal								
	Region	Shire of Chittering	Shire of Gingin	Region			Shire of Chittering			Shire of Gingin		
				Hectares Remaining	% Extent Remaining	% Change	Hectares Remaining	% Extent Remaining	% Change	Hectares Remaining	% Extent Remaining	% Change
Coolakin	2	2		64,202.7	39.1	0.001	3,046.70	26.63	0.02			
Cullala	73.6	71.6	2	13,234.4	51.0	0.28	1,027.87	34.33	2.39	10,910.88	58.71	0.01
Mogumber-south	16.6	16.6	0	5,704.1	38.5	0.11	4,494.13	38.16	0.14	No change		
Moondah	8	8	0	7,225.2	40.8	0.05	984.06	42.58	0.35	No change		
Nooning	2.5	2.5		1,153.9	17.8	0.04	741.06	17.79	0.06			
Yalanbee (Y6)	9	9		92,071.9	46.5	0.005	8,402.35	30.40	0.03			

4.2.4.4 Wetlands and Riparian Vegetation

Based on the vegetation mapping undertaken by FVC (2018a), 13.5 ha of riparian and wetland vegetation in a Good or better condition will be cleared during implementation of the Proposal (**Table 4-18**). A further 15.5 ha of riparian vegetation in Degraded to Completely Degraded condition will be cleared (**Table 4-19**). While this vegetation has been mapped as ‘paddock’ or ‘pasture’ and retains little to no understorey, it provides ecological services such as stabilising the banks of waterways and providing cover to fauna species.

Five wetlands defined by DBCA (2016) are intersected by the Development Footprint. The total area of these wetlands impacted is 3.37 ha; however, the majority of this (3.1 ha) is Degraded or Completely Degraded, comprising mostly pasture grasses with little remnant native vegetation. A total of 0.5 ha of native vegetation in Good or better condition will be cleared within these wetland areas (**Table 4-20**).

Further information in relation to wetlands and hydrological processes is provided in **Chapter 4.4**.

Table 4-18: Riparian and Wetland Vegetation Associations within the Development Footprint

Vegetation Association		Extent within Development Envelope (ha)	Extent Cleared (ha)
ErXpBm	<i>E. rudis</i> and <i>M. preissiana</i> sparse woodland	48.2	12.5
EwBeNa	<i>E. wandoo</i> and <i>Casuarina obesa</i> sparse woodland	4.5	1.0
MvJspLs	<i>M. viminea</i> shrubland	0.1	0.0
Total (ha)		36.9	13.5

Areas mapped as ‘pasture’ not included

Table 4-19: Riparian and Wetland Vegetation Associations Mapped as Paddock or Pasture within the Development Footprint

Vegetation Association		Extent within Development Envelope (ha)	Extent Cleared (ha)
P EmCcEr	<i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>E. rudis</i> over pasture	19.4	7.0
P ErCo	<i>E. rudis</i> and <i>Casuarina obesa</i> over pasture	4.3	1.5
P ErEw	<i>E. rudis</i> and <i>E. wandoo</i> over pasture	7.6	2.5
P EwCcCo	<i>E. wandoo</i> , <i>C. calophylla</i> and <i>C. obesa</i> over pasture	2.0	1.5
P EwCcCoMssp	<i>E. wandoo</i> , <i>C. calophylla</i> , <i>C. obesa</i> and <i>Melaleuca</i> species over pasture	1.5	1.0
P EwMr	<i>E. wandoo</i> , <i>M. raphiophylla</i> over pasture	0.8	1.0
P EwMrCo	<i>E. wandoo</i> , <i>M. raphiophylla</i> and <i>C. obesa</i> over pasture	5.0	1.0
Total (ha)		40.6	15.5

Table 4-20: Condition of Geomorphic Wetland Areas within the Development Footprint

Wetland UFI	Wetland Classification	Condition (ha) ¹									Total (ha)
		CD	CD – D	D	D – G	G	G – VG	VG	VG – E	E	
12778	MU	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5
12779	CC	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.4
12838	RE	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
12840	CC	0.0	1.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.0
15154	CC	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3
Total (ha)		0.6	2.5	0.0	0.0	0.2	0.1	0.0	0.2	0.0	3.6

¹ CD - Completely Degraded; D - Degraded; G - Good; VG - Very Good; E - Excellent

4.2.5 Assessment of Impacts

4.2.5.1 Impacts to Conservation Significant Flora

Impacts to conservation significant flora have been avoided and minimised during the concept design phase, by preferentially locating the Development Footprint within previously cleared paddocks. Additionally, the concept alignment has sought to avoid known locations of conservation significant flora species. In particular, the Development Footprint was modified to avoid a historic record of *Drakaea elastica* identified from the DBCA database.

No flora species listed under the EPBC Act or BC Act have been recorded during surveys of the Development Envelope and surrounds, and as such no impacts are anticipated. Seven DBCA-listed Priority flora species have been recorded from within (*Drosera sewelliae*—P2, *Leucopogon squarrosus* subsp. *trigynus*—P2, *Verticordia rutilastra*—P3, *Anigozanthos humilis* subsp. *chrysanthus*—P4, *Verticordia paludosa*—P4), or within 20 m of (*Acacia drummondii* subsp. *affinis*—P3, *Hibbertia miniata*—P4), the Development Footprint. A 20 m distance from the Development Footprint was selected to identify locations that could be at risk from accidental damage or clearing, as this aligns with the buffers generally applied by DBCA for Priority flora species.

At a local scale, the clearing of four occurrences of *Drosera sewelliae* represents 9% of the records within a 5 km radius of the disturbance footprint. Three occurrences of *D. sewelliae* are part of a larger group of occurrences that are considered to represent a single population. This population crosses the Development Footprint and will be fragmented by the Proposal. This will lead to a reduction in transfer of genetic material between the two portions of the population and may lead to divergence in the genetic makeup of the two groups. At least 24 plants will remain to the west of the clearing and at least 35 plants to the east. The vegetation in these locations is in Good to Very Good condition indicating there are limited additional threats to the species in this location. As the other populations of this species in the local area consist of a smaller number of individuals than the two parts of the fragmented population, it is considered likely that these two parts will remain viable. Given this, the loss of four occurrences of *D. sewelliae* is unlikely to adversely impact the conservation status of the species at a local level.

In a regional context, the clearing of four occurrences of *Drosera sewelliae* represents 7% of the total occurrences (including those recorded by FVC (2018a; **Table 4-21**). Examination of the records available through DBCA's NatureMap indicates the species is abundant at many locations where it is known to occur. As *Drosera sewelliae* is a P2 listed species, the loss of any known or new occurrences may be significant. The new records of this species as reported by FVC (2018a) represent a substantial, almost 2.5-fold, increase in the number of known populations of the species.

Four occurrences of the P2 species *Leucopogon squarrosus* subsp. *trigynus* are within the development footprint. This represents 80% of the known occurrences within 5 km of the Bindoon Bypass. At a regional level, the clearing represents 14% of the known records of the species occurrences (including those recorded by FVC (2018a, 2019); **Table 4-21**). A large proportion of the occurrences of this species (70%) are on conservation

estate and/or DBCA managed lands, affording these occurrences a higher level of protection. As *Leucopogon squarrosus* subsp. *trigynus* is a P2 listed species, the loss of any known or new occurrences may be significant. The records by FVC (2019) may represent the eastern most extent of the species, based on the soils it typically is found growing in association with. The lack of records in the local area may be due to a lack of survey, beyond those surveys undertaken for the Proposal. Surveys of areas of suitable habitat during the flowering period (likely to be July to September) may find additional occurrences of this species. As a large proportion of the known records are located within the conservation estate, the clearing of four new occurrences of the species is unlikely to adversely impact the conservation status of the species as a whole.

Three occurrences of the P3 species *Verticordia rutilastra* are within 5 km of the Development Footprint. Two of these occurrences (recorded by FVC (2019)) will be cleared. This represents 67% of the known occurrences within the local area. This relative paucity of records may be due to a lack of survey undertaken in the local area, beyond those surveys undertaken for the Proposal. Surveys of areas of suitable habitat during the flowering period (September to November) may find additional occurrences of this species.

Regionally, there are 49 known occurrences of *Verticordia rutilastra* representing 42 populations. The clearing of two of these occurrences represents 4% of the known occurrences of the species occurrences (including those recorded by FVC (2018a, 2019); **Table 4-21**). A substantial proportion (36%) of the known occurrences are within DBCA managed lands, the majority being within Lesueur National Park. The clearing of two new occurrences of the species is unlikely to adversely impact the conservation status of the species as a whole.

At a local scale, the clearing of one occurrence of the P4 species *Anigozanthos humilis* subsp. *chrysanthus* represents 7% of the occurrences within 5 km of the Development Footprint. The single occurrence to be cleared is part of a larger population. The required clearing intersects the edge of this population and will not result in fragmentation. The remaining portion of the population is anticipated to remain viable and no adverse impacts are anticipated at a local scale.

Regionally, the clearing of a single occurrence of *Anigozanthos humilis* subsp. *chrysanthus* represents 0.7% of the known populations occurrences (including those recorded by FVC (2018a, 2019); **Table 4-21**). Many of the known occurrences (27%) are within DBCA managed lands. In 2006, the estimated number of mature individuals from the 15 populations known at the time was 6,200 (Threatened Species Scientific Committee, 2006). The number of known populations has since increased to 40 and it is expected that the number of mature individuals would have increased by a similar magnitude. Examination of the records available through DBCA's NatureMap indicates the species is abundant at several locations where it is known to occur. Given the species appears to be relatively common, there are no adverse impacts expected in relation to the conservation status of the species as a whole.

The clearing of 57 occurrences of *Verticordia paludosa* represents 29% of the total occurrences (including those recorded by FVC (2018a, 2019); **Table 4-21**). A number of occurrences are on conservation estate and/or DBCA managed lands, affording these occurrences a higher level of protection. Examination of the records available through DBCA's NatureMap indicates the species is abundant where it is known to occur. Given the high number recorded from the Development Envelope, it is expected that additional individuals and populations are likely to occur in other areas of suitable habitat in the region. Impacts on this species as a result of Proposal implementation are not considered significant, as the species is abundant where it is known to occur and a number of these occurrences are within the conservation estate, affording them a higher level of protection.

Four occurrences of the P4 species *Hibbertia miniata*, and two occurrences of the P3 species *Acacia drummondii* subsp. *affinis*, are within 20 m of the Development Footprint. With appropriate avoidance measures in place, no impacts are expected for either of these species.

The four occurrences of *Hibbertia miniata* represent the northern most extent of a large population of 1,353 individuals. These four occurrences are separated from the remainder of the population by a property fence line, which will be retained as the road reserve fence, and Head Road. There are no works planned for Head Road as part of this proposal. Should these four individuals be cleared unintentionally, the loss of a small number of plants from the edge of the population is unlikely to impact the viability of the population.

The two occurrences of *Acacia drummondii* subsp. *affinis* are located near to works associated with the intersection of Gray Road and the Bindoon Bypass. These occurrences are at least 400 m from the Bindoon Bypass and at least 12 m from the proposed road reserve fence for Gray Road, which also defines the construction site boundary. It is unlikely that these plants will be cleared, however accidental clearing of these three occurrences represents a reduction of less than 1% of the known occurrences and is considered unlikely to affect the ongoing viability of the species.

4.2.5.2 Impacts to the EPBC Act listed Banksia Woodlands TEC

Impacts to conservation significant vegetation have been avoided and minimised during the concept design phase wherever practicable, by preferentially locating the Development Footprint within previously cleared paddocks. Where conservation significant vegetation cannot be avoided, the concept design has steepened batters on cut and fill areas to minimise the clearing required.

Implementation of the Proposal will result in the clearing of 60 ha of vegetation associations that are representative of the EPBC Act listed Banksia Woodlands TEC. This clearing respectively represents 12% of the extent of the Banksia Woodlands TEC within the Development Envelope. Of the area of Banksia Woodlands TEC to be cleared, 34.8 ha (58%) was mapped as in Very Good to Excellent condition.

Desktop assessment of vegetation outside of, but contiguous with, the study area identified 18,142 ha of vegetation likely to be the Banksia Woodlands TEC (FVC 2018a) (**Figure 4-11**). The Development Footprint will directly impact on 60 ha, which equates to 0.3% of this area.

The conservation advice for the Banksia Woodlands TEC estimates that 336,489.9 ha of Banksia Woodlands of the Swan Coastal Plain exists across the bioregion (Threatened Species Scientific Committee 2016). The clearing required for this proposal represents 0.015% of this extent.

Clearing of 60 ha of the Banksia Woodlands TEC is considered significant. Main Roads will mitigate this impact through land acquisition offsets, as described in **Chapter 7**.

4.2.5.3 Impacts to Native Vegetation

Impacts to native vegetation have been avoided and minimised where practicable during the concept design phase, by preferentially locating the Development Footprint within previously cleared paddocks. This approach has resulted in 383 ha (76%) of the Development Footprint being located in areas of paddock or previously cleared areas, mapped as Completely Degraded to Degraded. Not all areas of native vegetation are able to be avoided. Where impacts to native vegetation are unavoidable, the extent of clearing has been minimised as far as practicable by the employment of road safety barriers, steepening batters of cut and fill areas and adjusting road levels to minimise the depth/height of cut and fill areas. Approximately 119.1 ha of native vegetation will be cleared for the Proposal. Of this, 107.9 ha is in good or better condition. It is expected that this amount will be reduced in the detailed design phase.

Vegetation association BmKgHg is locally restricted to two locations in the study area, separated by Mooliabeenee Road. This vegetation association is therefore considered to be locally significant. Implementation of the Proposal will result in the clearing of less than 1% of this vegetation association. As such, this impact is considered minor and not significant.

Table 4-21: Regional Impacts on Priority Flora

Species name	Status	IBRA Subregions [#]	Number of Occurrences						
			DBCA and WA Herbarium records ¹	Within DBCA Managed Lands	Recorded by FVC (2018a, 2019)	Recorded by Phoenix (2016)	Total (DBCA, FVC & Phoenix)	Within Proposal Footprint (% cleared)	Occurrences Remaining
Species within the Development Footprint									
<i>Drosera sewelliae</i> (with <i>Drosera ?sewelliae</i>)	P2	Dandaragan Plateau, Northern Jarrah Forest	10 (10 populations)	5* (50%)	46 (16 populations)	0	56 (26 populations)	4 (7.1%)	52 (26 ² populations)
<i>Leucopogon squarrosus</i> subsp. <i>trigynus</i>	P2	Dandaragan Plateau, Perth	23 (10 populations)	16* (70%)	5 (4 populations)	0	28 (14 populations)	4 (14.3%)	24 (11 populations)
<i>Verticordia rutilastra</i>	P3	Avon Wheatbelt, Dandaragan Plateau, Lesueur Sandplain	47 (41 populations)	17 (36%)	2 (1 population)	0	49 (42 populations)	2 (4.1%)	47 (41 populations)
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>	P4	Avon Wheatbelt, Dandaragan Plateau, Lesueur Sandplain, Northern Jarrah Forest, Perth	115 (40 populations)	31** (27%)	7 (5 populations)	26 (3 populations)	148 (50 populations)	1 (0.7%)	147 (50 ² populations)
<i>Verticordia paludosa</i> (with <i>Verticordia ?paludosa</i>)	P4	Dandaragan Plateau, Lesueur Sandplain, Northern Jarrah Forest, Perth	40 (25 populations)	16 (40%)	154 (3 populations)	0	194 (28 populations)	57 (29.4%)	151 (28 ² populations)

Species name	Status	IBRA Subregions [#]	Number of Occurrences						
			DBCA and WA Herbarium records ¹	Within DBCA Managed Lands	Recorded by FVC (2018a, 2019)	Recorded by Phoenix (2016)	Total (DBCA, FVC & Phoenix)	Within Proposal Footprint (% cleared)	Occurrences Remaining
Species Outside of but within 20 m of the Development Footprint									
<i>Acacia drummondii</i> subsp. <i>affinis</i>	P3	Avon Wheatbelt, Dandaragan Plateau, Northern Jarrah Forest, Perth	54 (38 populations)	13 ^{***} (24%)	92 [^] (8 populations)	326 (20 populations)	380 (66 populations)	0 3 occurrences within 20 m of the footprint	No Change
<i>Hibbertia miniata</i>	P4	Dandaragan Plateau, Northern Jarrah Forest	52 (27 populations)	7 ^{**} (13.5%)	853 (3 populations)	12 (2 populations)	917 (32 populations)	0 4 occurrences within 20 m of the footprint	No Change

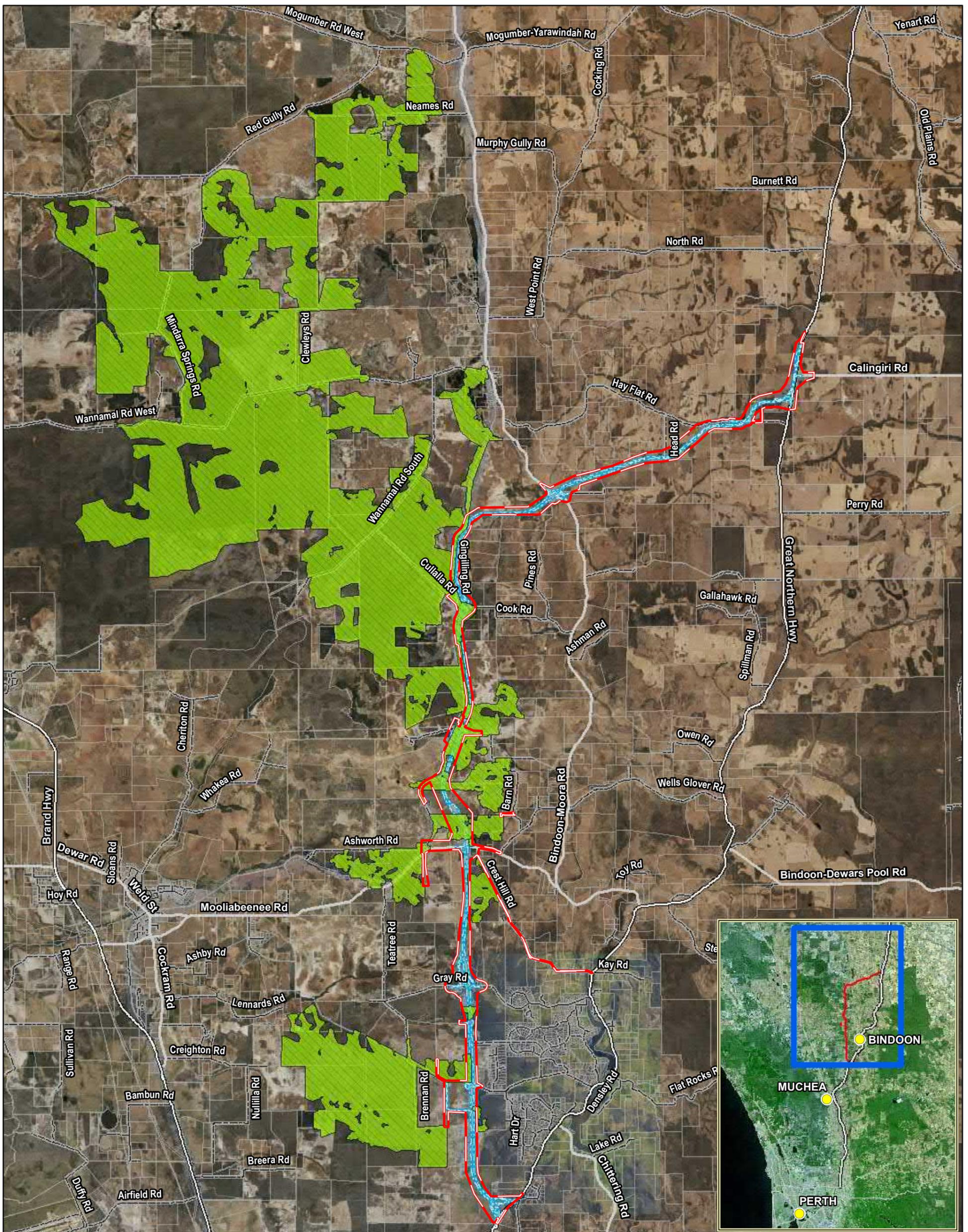
Number of populations has been determined using the DBCA Threatened and Priority Flora Report Form - Field Manual (Stack, 2017)

[#] Florabase Distribution. ¹ occurrences identified from NatureMap search

^{*} Two occurrences are within State Forest. ^{**} Four occurrences are within State Forest. ^{***} Six occurrences are within State Forest; two occurrences are within the Department of Defence Bindoon Training Area.

[^] 64 occurrences are within Udumung Nature Reserve

² Part of one population of *Drosera sewelliae*, two populations of *Verticordia paludosa*, and one population of *Anigozanthos humilis* subsp. *chrysanthus* will be cleared with the remaining part of these populations remaining intact



Legend

- Development Envelope
- Development Footprint
- Cadastral Boundary
- Highway
- Major Road
- Minor Road
- Banksia Woodlands mapping (FVC)
- Banksia Woodlands Patch

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© Main Roads Western Australia
 Scale at A3
1:141,521
 0 1,600 3,200
 Metres
 Coordinate System: GDA 1994 MGA Zone 50

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Main Roads Western Australia
 Client Project
Great Northern Highway Bindoon Bypass
 Environmental Review Document

Extent of Contiguous Areas of the Banksia Woodlands of the Swan Coastal Plain TEC
 Figure: 4-11

Drawing No GNH-CN12-EA-PER-00001		Issue 1	
Task No ERD	Drawing Status / Other Draft		
Date 22/08/2019	By BG	Chkd LB	Appd TJ

MXD Location: \\jacobson\PER\Projects\BIF\Projects\BIF\Technical\GIS\ArupMap\Environmental\CN12\ERD\Figures\GNH_CN12-EA-PER-0001-F4-11.mxd

The extent of the vegetation associations within the study area will not be significantly reduced as a result of the Proposal. The 119.1 ha of clearing required represents 18.5% of the vegetation, within the Development Envelope. Implementation of the proposal will not take any vegetation association within the Development Envelope below 30% of its pre-European extent. It should be noted that the Nooning complex is already below 30%.

Clearing of native vegetation will result in minor reductions to the extent of the South West Vegetation Complexes the FVC (2018a) mapped vegetation associations correspond to (**Table 4-7**). As the Nooning vegetation complex is below 30% remaining of the pre-European extent, clearing of this complex is considered significant. A total of 2.5 ha of vegetation corresponding to the Nooning complex will be cleared. As the remaining complexes (Coolakin, Cullula, Mogumber – south, Moondah and Yalanbee) are all above 30% of their pre-European extent remaining, clearing of these complexes is not considered significant.

The Bindoon area currently has a high level of vegetation fragmentation. The Proposal will result in fragmentation of additional areas of native vegetation, most notably at Barn Road and Cook Road. The presence of the railway at these locations has already fragmented the vegetation here and, as such, the implementation of the Proposal is unlikely to increase the level of fragmentation in these locations.

Clearing of the Development Footprint will also result in fragmentation of continuous patches of vegetation between Teatree Road and Gray Road, and to the north of Mooliabeenee Road, including two occurrences of the EPBC Act listed Banksia Woodlands TEC. This represents new fragmentation in these areas which may introduce new edge effects. A review of the potential edge effects due to the construction of new roads identified weeds to have the greatest potential for impact (van Etten 2014). This review determined that effects could be minimised provided appropriate management controls were in place, including ongoing control of invasive weeds and appropriate drainage design to capture road run-off. Main Roads requires that the road drainage network is capable of capturing surface water flows from rain events and discharging this run-off in a managed way, for example through infiltration in locations with sandy soils, or discharge to adjacent waterways, provided appropriate measures are in place to manage pollutants. This design requirement, together with the implementation of appropriate management actions, such as weed control, are considered sufficient to reduce impacts such that they are not considered significant.

4.2.5.4 Impacts to Wetlands, Groundwater Dependent and Riparian Vegetation

A total of 13.5 ha of native riparian or wetland vegetation will be cleared as a result of the Proposal. A further 15.5 ha of vegetation (consisting largely of native trees over cleared paddocks) in a Degraded or worse condition that is associated with waterways will also be cleared. This vegetation provides a number of ecosystem services in the form of habitat for fauna species (such as the Water-rat and fish species), assists in stabilising the banks of waterways and filtering surface water runoff from adjacent land. With appropriate mitigation controls in places (stabilisation of waterways and revegetation), impacts from the clearing of riparian vegetation are not expected to be significant.

Riparian and wetland vegetation contains flora species that are considered to be either fully (obligate) or partially (facultative) dependent on groundwater for survival. Changes in groundwater levels in wetland and riparian areas may impact the health of the vegetation, and result in changes to the structure or species compositions of these vegetation associations. The Proposal will not result in long-term changes to groundwater levels (**Chapter 4.4**). Temporary and localised impacts to groundwater levels will occur from abstraction of water for construction use and dewatering for bridge construction. With appropriate management measures and licencing through the RIWI Act, dewatering and water abstraction activities will not result in significant impacts to riparian, wetland and groundwater dependent vegetation.

Three CC wetlands will be impacted by the Proposal, with 1.1 ha of these wetlands intersected by the Development Footprint. Of this, 0.4 ha consists of vegetation in a Good or better condition. The total area of these CC wetlands is 91.5 ha. The CC wetland located at the Brockman River crossing has been mapped by FVC (2018b) as Completely Degraded to Degraded, and little native vegetation remains. Discussions with the DBCA confirmed that the impact is unlikely to be significant, given this degradation (R Huston 2018, pers. comm., 14 February 2018).

The remaining two CC wetlands are located adjacent to Teatree Road. Approximately 0.6 ha of the extent of these wetlands within the Development Envelope are covered by native vegetation in Good or Very Good to Excellent condition. The remainder of the area is either cleared (Teatree Road) or pasture. Given the presence of Good and Very Good to Excellent quality vegetation to the south of Teatree Road, impacts to this vegetation could be considered significant should appropriate management controls not be put in place.

4.2.5.5 Impacts due to Weeds, Fire and *Phytophthora Dieback*

Significant weeds are considered to be WoNS, Declared Plants under Section 22 of the BAM Act, Prohibited weeds under Section 12 of the BAM Act and invasive grasses (e.g. Veldt Grass and African Lovegrass). A single significant weed species (Skeleton Weed) was recorded in the Development Footprint. This weed is not considered an environmental weed and, while its impact on agricultural areas can be significant, it is not considered a major risk to native vegetation.

Agricultural weeds are known to occur throughout the Development Envelope. Introduced species used for pasture or cropping can establish in areas of native vegetation, gradually encroaching from the edges where native vegetation abuts agricultural land. The Proposal has the potential to introduce new weeds or spread existing weeds; however, as the majority of the Development Envelope is agricultural land, the Proposal is unlikely to increase the risk of weed encroachment into areas of native vegetation.

The majority of native vegetation areas within the Development Envelope have been mapped as dieback-free. Spread of dieback as a result of implementation of the Proposal has the potential to cause significant degradation to native vegetation—particularly Banksia woodlands and Jarrah/Marri woodlands, as these vegetation associations contain a high proportion of susceptible species. In particular, the EPBC Act listed Banksia Woodlands TEC contains a large number of species that are susceptible to dieback.

Temporary drainage during construction will be designed to avoid movement of water from areas identified as dieback-infested to dieback-free areas or areas that have not been assessed for the presence of dieback. Dieback management during construction is a standard practice in the southwest of WA, and will be implemented for this Proposal. Appropriate management and mitigation controls will be in place, and it is unlikely that implementation of the Proposal will result in the spread or introduction of dieback.

The risk of dieback spread from operational road drainage is considered to be extremely low as the compacted material used to construct the roadside drains provides a barrier between runoff captured from the road surface and the underlying soil or sub-soil. Movement of dieback infested soil/subsoil is therefore extremely unlikely.

4.2.6 Mitigation

It is important to recognise the decades of community and stakeholder consultation that frame the selection of the Development Envelope as the preferred corridor. Throughout the many option consideration and assessment processes, matters of environmental significance and values featured prominently (**Chapter 2.3**).

Within the selected Development Envelope, the mitigation hierarchy that has been applied to the Proposal is described as follows:

- **Avoid:** use route selection, alignment design and design modifications (e.g. steepening road batters, using barriers, etc.) to avoid environmental and/or social impacts.
- **Minimise:** reduce environmental and/or social impacts to as low as reasonably practicable.
- **Rehabilitate:** areas of cleared native vegetation will be revegetated and landscaped.
- **Offset:** residual impacts associated with native vegetation clearing will be offset through the provision of a suitable offset by Main Roads.

This mitigation hierarchy has been implemented throughout the concept design phase of the Proposal, and will continue to be implemented during detailed design and construction. Impacts to flora and vegetation have been avoided and minimised during the concept design phase by preferentially locating the Development Footprint

within previously cleared paddocks where practicable. Additionally, the concept alignment has sought to avoid known locations of conservation significant flora species and conservation significant ecological communities where practicable. In particular, the proposed alignment was modified to avoid a historic record of *Drakaea elastica* identified from the DBCA database. Where impacts to native vegetation were unavoidable, the extent of vegetation clearing has been minimised by steepening batters of cut and fill areas.

As discussed in this chapter, the following significant flora and vegetation values have been avoided by the Proposal:

- various conservation-significant flora species throughout the Development Envelope (**Table 4-13**)
- large areas of the EPBC Act listed Banksia Woodland TEC (**Table 4-8**), including most of the known contiguous areas and corridors (**Figure 4-11**).

To further minimise and mitigate potential impacts to terrestrial fauna, the following management measures, actions and controls are proposed:

- During the detailed design phase:
 - ▶ Clearing of native vegetation will be further reduced through engineering solutions, including but not limited to:
 - additional steepening of batters.
 - installation of barriers in areas of high conservation value (e.g. through Banksia Woodland TEC) to reduce clear zone requirements.
 - reduction of median widths or design of medians to reduce the clearing required between carriageways.
 - ▶ Drainage will be designed to avoid the movement of soils and/or water potentially carrying *Phytophthora* dieback into areas mapped as dieback-free.
- Vegetation clearing during construction will be minimised to as low as practicable. The alignment and width of the Development Envelope has been designed to identify a Development Footprint that minimises clearing, and this will be further refined during the detailed design phase.
- Where practicable, and in consideration of line-of-sight clearance requirements for highways, cleared areas will be revegetated. Revegetation will commence in the autumn following completion of construction works within designated revegetation areas and corridors to maintain ecological linkages.
- The area to be cleared will be accurately marked in the field, with pegs/flagging.
- A dieback and weed hygiene management plan will be developed for construction of the Proposal. The plan will include:
 - ▶ risk assessment of potential dieback and weed sources and activities with potential to spread said dieback and weeds.
 - ▶ identification of 'protectable' areas adjacent to the Development Footprint.
 - ▶ requirements for hygiene wash-down locations that consider risk to the surrounding landscape.
 - ▶ a program to monitor and report on compliance with wash-down requirements and corrective actions where non-compliance has occurred.
 - ▶ quarterly auditing of wash-down sites to identify weed incursions.
 - ▶ regular walk-overs at strategic locations along the Development Footprint (i.e. in association with native vegetation) to identify and ameliorate weed incursions.
 - ▶ development of an auditable hygiene inspection form to detail inspection results at the hygiene locations.

- ▶ certification of all machinery, plant and vehicles arriving on site as free of vegetative matter and soil, in order to avoid introducing weed species to the Development Envelope.
- Annual inspection of revegetation areas will be undertaken to assess revegetation success and weed presence/cover.
- Priority flora species not within the Development Footprint will be clearly marked as no-go zones, and access to these areas restricted. A 20 m buffer will be applied to Priority flora locations where practicable. Where this cannot be achieved, the no-go zone will start at the edge of the Development Footprint. The 20 m buffer will be maintained on all other sides at these locations.
- Areas of the EPBC Act listed Banksia Woodland TEC and vegetation association BmKgHg outside of the Development Footprint, will be clearly marked as no-go zones and access to these areas restricted.
- Educational and induction material about all relevant significant flora and ecological communities will be provided to contractors working on the Proposal, to reduce the risk of accidental clearing.

4.2.7 Predicted Outcome

The Proposal will result in the clearing of native vegetation, components of which are both locally and regionally significant and that support Priority flora species, State-listed TECs, State-listed PECs and Commonwealth-listed TECs. **Table 4-22** summarises the outcomes of the Proposal on Flora and Vegetation.

Table 4-22: Predicted Outcomes of the Proposal on Flora and Vegetation

Flora and Vegetation Aspect	Impact
Native vegetation	Clearing of no more than 107.9 ha of native vegetation in good or better condition
Banksia Woodland TEC (EPBC)	Clearing of no more than 60 ha of Banksia Woodland TEC
Vegetation associated with CC wetlands	Clearing of no more than 0.4 ha of vegetation in Good or better condition
Vegetation complexes less than 30% pre-European extent	Clearing of no more than 2.5 ha of vegetation associations corresponding to the Nooning complex.
P2 <i>Drosera sewelliae</i>	Loss of no more than 42 individuals as identified by FVC (2018a, 2019)
P2 <i>Leucopogon squarrosus</i> subsp. <i>trigynus</i>	Loss of no more than 4 individuals as identified by FVC (2018a, 2019)
P3 <i>Verticordia rutilastra</i>	Loss of no more than 2 individuals as identified by FVC (2018a, 2019)
P4 <i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>	Loss of no more than 1 individual as identified by FVC (2018a, 2019)
P4 <i>Verticordia paludosa</i>	Loss of no more than 108 individuals as identified by FVC (2018a, 2019)
Weeds	No introduction or spread of WONS or Declared Pests
Dieback	No introduction or spread of dieback to areas not previously infested

The Proposal will result in the clearing of 119.1 ha of native vegetation, of which 107.9 ha is in good or better condition, including:

- 60 ha of EPBC Act listed *Banksia Woodland* TEC
- 2.5 ha of vegetation associations corresponding to the Nooning complex
- 0.4 ha of vegetation in Good or better condition associated with CC wetlands.

The areas noted in the bullet points above overlap to some extent. These impacts are considered significant due to the conservation significance of the vegetation, high levels of biodiversity or due to being under-represented at a regional level. It should be noted that the relatively high biodiversity of the Development Envelope is representative of the linear nature of the Proposal, the variety of landforms traversed and its location on the boundary of two IBRA regions. Main Roads will further mitigate the impacts identified above through land acquisition offsets as detailed in **Chapter 7**.

No threatened flora species listed under the EPBC Act or BC Act have been recorded within the Development Envelope. Impacts to the P4 species *Verticordia paludosa* are not considered significant, as a number of known occurrences are located within conservation estate or DBCA-managed lands, affording these occurrences a higher level of protection. The species is also abundant where it is known to occur.

Impacts to the P3 species *Verticordia rutilastra* and the P4 species *Anigozanthos humilis* subsp. *chrysanthus* are not considered significant, due to the small number of occurrences, particularly in comparison to the total number of known occurrences, to be cleared, that a number of known occurrences are located within conservation estate or DBCA-managed lands, affording these occurrences a higher level of protection, and the relative abundance of *Anigozanthos humilis* subsp. *chrysanthus* in particular where it is known to occur.

Impacts on the P2 species *Drosera sewelliae* and *Leucopogon squarrosus* subsp. *trigynus* may be considered significant due to their conservation status. However, records from the FVC (2018a) surveys significantly add to the known occurrences for *Drosera sewelliae* and a large proportion of the known records of *Leucopogon squarrosus* subsp. *trigynus* are within lands managed by DBCA for conservation.

Up to 13.5 ha of riparian and wetland vegetation in good or better condition will be cleared. Outside of impacts to vegetation associated with CC wetlands, these impacts are not considered significant as construction works will be managed to maintain the integrity of waterways and revegetation will be undertaken. Water abstraction for construction use, and dewatering during bridge construction, will be managed such that these activities do not result in long-term changes to groundwater levels. Impacts to groundwater-dependent flora are therefore expected to be negligible.

The impacts to flora and vegetation can be managed to meet the EPA's objective. Residual impacts to conservation significant vegetation, CC wetland vegetation and under-represented vegetation are considered significant. However, with an ongoing commitment to further minimise the amount of clearing required during the detailed design phase, the implementation of appropriate management and mitigation controls and provision of offsets, the Proposal is likely to meet the EPA's objectives. An offset proposal for these impacts is provided in **Chapter 7**.