APPENDIX

I

Terrestrial and Aquatic Ecology Technical Report

Part 1 of 2

HELIDON TO CALVERT ENVIRONMENTAL IMPACT STATEMENT

IR_1381

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Inland Rail Helidon to Calvert EIS

Appendix I – Terrestrial and Aquatic Ecology Technical Report

Australian Rail Track Corporation

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Abbreviations

Abbreviation	Explanation
ANZECC	Australia and New Zealand Environment and Conservation Council
AoLA	Atlas of Living Australia
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARTC	Australian Rail Track Corporation Limited
AS	Australian standards
AUSRIVAS	Australian River Assessment System
BAMM	Biodiversity Assessment and Mapping Methodology
BD	biodiversity
Biosecurity Act	*Biosecurity Act 2014* (Qld)
BoM	Bureau of Meteorology
BPA	Biodiversity Planning Assessment
C2K	Calvert to Kagaru
CBD	Central Business District
CE	Critically Endangered
CEMP	Construction Environmental Management Plan
Ch	Chainage
Cr	Critical priority
Cth	Commonwealth
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DEHP	Department of Environment and Heritage Protection (former)
DERM	Department of Environment and Resources Management (former)
DES	Department of Environment and Science
DEWHA	Department of the Environment, Water, Heritage and the Arts (former)
DNRME	Department of Natural Resources, Mines and Energy (former)
DotEE	Department of the Environment and Energy (former)
DPI	Department of Primary Industries (former)
DRDMW	Department of Regional Development, Manufacturing and Water (formerly DNRME)
DTMR	Department of Transport and Main Roads
E	Endangered
EAP	Environmental Assessment Procedure
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994* (Qld)
EP Reg	Environmental Protection Regulation 2019 (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERA	Environmentally Relevant Activity
Es	Emergent stratum
EVNT	Endangered, Vulnerable and Near-threatened

Abbreviation	Explanation
EX	Extinct
FFJV	Future Freight Joint Venture
FHA	Fish Habitat Area
Fisheries Act	*Fisheries Act 1994* (Qld)
G	Ground stratum
GDE	groundwater dependent ecosystem
GIS	geographic information system
H	High Priority
H2C	Helidon to Calvert
ha	hectare
HES	High Ecological Significance
HVR	High Value Regrowth
ICBN	International Code of Botanical Nomenclature
ID	identification
Inland Rail	Melbourne to Brisbane Inland Rail
K2ARB	Kagaru to Acacia Ridge and Bromelton
kg/m	kilogram/metre
km	kilometre
Koala Plan	The Nature Conservation (Koala) Conservation Plan 2017
Land Act	Land Act 1994 (Qld)
LC	Least concern
LOR	Limit of reporting
m	metre
M	Migratory
Me	Medium Priority
MLES	Matters of Local Environmental Significance
mm	Millimetre
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
N	nitrogen
NC Act	*Nature Conservation Act 1992* (Qld)
NC Reg	Nature Conservation Regulation
NRM	Natural Resource Management
NSW	New South Wales
NT	Near-threatened
NTU	nephelometric turbidity unit
OC	Of concern
Offsets Act	*Environmental Offsets Act 2014* (Qld)
Outline EMP	Outline Environmental Management Plan
P	phosphorous
PAH	polycyclic aromatic hydrocarbons

Abbreviation	Explanation
Planning Act	*Planning Act 2016* (Qld)
PMST	Protected Matters Search Tool
Project	Helidon to Calvert Project
Public Health Act	*Public Health Act 2005*
QEOP	Queensland Environmental Offsets Policy (Qld)
QLD	Queensland
Qld	Queensland
QR	Queensland Rail
RBGFV	Royal Botanic Gardens Foundation Victoria
RCC	Redland City Council
RCP	reinforced concrete pipe
RE	Regional Ecosystem
S	Shrub stratum
SDA	State Development Area
SDPWO Act	*State Development and Public Works Organisation Act 1971* (Qld)
SEQ	South-east Queensland
SLC	Special least concern
sp.	Species
SPP	State Planning Policy 2017 (Qld)
spp.	Multiple species
T	Tree (canopy) stratum
ToR	Terms of Reference
V	Vulnerable
VM Act	*Vegetation Management Act 1999* (Qld)
Water Act	*Water Act 2000* (Qld)
Watercourse	Is a river, creek or other stream, including a stream in the form of an anabranch or a tributary, in which water flowers permanently of intermittently, regardless of the frequency of flows
WIM	Watercourse Identification Mapping
WoNS	Weeds of national significance
WPSQ	Wildlife Preservation Society Queensland
WQO	Water quality objective

Glossary

Term	Explanation
Adverse impact	Adverse impacts are defined as those impacts that result in an unwanted and/or unanticipated result of taking a particular action. In an environmental context, an adverse impact means any change in the physical or biological conditions of the natural environment that results in a detrimental effect upon flora, fauna, air, water, minerals or other natural characteristic of the area.
Back on Track species prioritisation framework (Qld)	An initiative of the Department of Environment and Science (DES), the Back on Track species prioritisation program ranks species as Critical, High, Medium or Low priority for the State and for the Natural Resource Management (NRM) region (irrespective of their *Nature Conservation Act 1992* (Qld) (NC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) classification). There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. While not legislated, Back on Track provides a useful framework for biodiversity assessment and species prioritisation when determining ecological values. Priority Back on Track species have been identified for each of the 14 NRM regions across Queensland. The Project disturbance footprint is located in South-east Queensland NRM.
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: ▪ Genetic diversity – the variety of genes (or units of heredity) in any population ▪ Species diversity – the variety of species ▪ Ecosystem diversity – the variety of communities or ecosystems.
Biodiversity Planning Assessments (Qld) (BPAs)	BPAs have been prepared for each of Queensland's bioregions based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (Queensland Government 2014). The BPAs draw upon the former Department of Environment and Heritage Protection (DEHP) (now DES) certified regional ecosystem (RE) mapping, database information, and expert panel reports and incorporate information about threatened ecosystems and/or species, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, as well as buffers to wetlands or other types of important areas for ecological processes. There are three biodiversity significance levels to which an area can be assigned: ▪ State significance – areas assessed as being significant for biodiversity at the bioregional or State scales ▪ Regional significance – areas assessed as being significant for biodiversity at the sub-bioregional scale ▪ Local significance and or other values – local values that are of significance at the local government scale All remnant vegetation will qualify into one of the above three categories.
Biodiversity status	For biodiversity planning purposes the DES classifies a RE as Endangered if: ▪ Less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss, or ▪ 10 to 30 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 ha; or it is a rare Regional Ecosystem subject to a threatening process For biodiversity planning purposes DES classifies a RE as Of concern if: ▪ 10 to 30 per cent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss For biodiversity planning purposes a RE is listed as Least concern at present if: ▪ The degradation criteria listed above for Endangered or Of concern REs are not met.
Bioregion	A bioregion as defined in An Interim Biographic Regionalisation of Australia (Thackway and Cresswell 1995). The region subject to this report is the South-east Queensland bioregion.

Term	Explanation
Biosecurity Act 2014 (Qld) *(*Biosecurity Act*)*	The Biosecurity Act seeks to provide a framework for an effective biosecurity system for Queensland that helps to manage and minimise State biosecurity risks, as well as facilitate the response to biosecurity issues and events in a timely and effective way, so as to align with national and international obligations. The Act introduces the general biosecurity obligation upon all persons to take all reasonable and practical measures to prevent or minimise biosecurity risks. There are seven categories for restricted matter defined in the Biosecurity Act: ▪ Categories 1 and 2 are restricted matters that have specific urgent reporting requirements. ▪ Categories 3, 4, 5, 6 and 7 relate to restricted matter that is in a person's possession, under their control and is also about not feeding restricted matter. Several restriction categories apply to some restricted matter. In such cases, you would need to follow the requirements of all restriction categories for these restricted matter listings.
Conservation significant	A collective term used with reference to species that are listed as Critically endangered, Endangered, Vulnerable or Near threatened under the provisions of the NC Act and/or EPBC Act (refer NC Act conservation significance and EPBC Act conservation significance for more details).
Critical habitat	The whole or any part or parts of an area or areas of land comprising the habitat of an Endangered species, an Endangered population or an Endangered ecological community that is critical to the survival of the species, population or ecological community. Critical habitat is listed under the EPBC Act.
Critically endangered	Designated as Critically endangered under the EPBC Act. Refer to definition of EPBC Act conservation status for meaning of Critically endangered under the Act.
Cumulative impacts	The impacts that result from the incremental impact of an activity when it is added to past, present, and reasonably foreseeable future activities. Cumulative impacts arise when several developments that may have insignificant effects but when taken together have a significant effect.
Direct impacts	Impacts that result from a direct interaction between integral Project activities and the receptor (e.g. land clearing resulting in vegetation and habitat loss).
Disturbance footprint	The disturbance footprint is the disturbance footprint (both temporary and permanent) associated with the project. The disturbance footprint is the areas surject to direct disturbance.
Ecological community	An assemblage of species occupying a particular area (e.g. Swamp Tea-tree (*Melaleuca irbyana*) Forest of South-east Queensland.
Ecology study area	This includes the permanent operational and temporary construction disturbance footprints plus a nominal 1 km buffer area.
Endangered	Designated as Endangered under the EPBC Act, NC Act, *Vegetation Management Act 1999* (Qld) (VM Act). Refer to definitions of EPBC Act conservation status, NC Act conservation status, VM Act and *Environmental Protection Act 1994* (Qld) (EP Act) conservation status for meaning of Endangered under each Act.
Environmentally Sensitive Area (ESA)	▪ As defined under the Environment Protection and Biodiversity Conservation Regulation 2000, a Category A ESA is any of the following: – National Parks – Conservation Parks – Forest Reserves – Wet Tropics World Heritage Area – Great Barrier Reef Marine Park Area – Marine Parks other than General Use Zones. ▪ A Category B ESA includes the following: – World Heritage Areas – Queensland Heritage Register Places – Ramsar Sites – Cultural Heritage Registered Areas and DLAs other than Stanbroke – Special Forestry Areas – Fish Habitat Areas – Coordinated Conservation Areas

Term	Explanation
	– Endangered Regional Ecosystems (remnant and mature regrowth (biodiversity status)) – Marine Parks other than General Use Zones – Marine Plants. ▪ A Category C ESA includes any of the following: – Essential Habitat – Referable Wetlands – Declared Catchment Areas – Nature Refuges – Resources Reserves – State Forests – Timber Reserves. Of concern REs (remnant and mature regrowth (biodiversity status)).
EPBC Act conservation status	Under the EPBC Act, listed species and threatened ecological communities are assigned a conservation status of Extinct in the wild, Critically endangered, Endangered or Vulnerable. Definitions of these terms under the Act are as follows: Extinct in the wild ▪ It is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range or, ▪ It has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a timeframe appropriate to its lifecycle and form Critically endangered ▪ It is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria Endangered ▪ It is not Critically Endangered, and ▪ It is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria Vulnerable ▪ It is not Critically Endangered or Endangered, and ▪ It is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria. Migratory Migratory species are those animals that migrate to Australia and its external territories, or, pass through or over Australian waters during their annual migrations. Examples of migratory species are species of birds (e.g. albatrosses and petrels), mammals (e.g. whales) or reptiles. Listed migratory species are those listed in the: ▪ Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) ▪ China-Australia Migratory Bird Agreement (CAMBA) ▪ Japan-Australia Migratory Bird Agreement (JAMBA) ▪ Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).
Essential Habitat (Non-VM Act)	Essential habitat consists of areas containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter) or areas that have been confirmed as containing suitable habitat as identified by a specimen backed record or indirect evidence of the species (i.e. scat, trace, track, fur/feather, distinctive vocalisation or other site based evidence).
Essential Habitat (Defined under the VM Act)	Essential habitat for threatened species as mapped under the VM Act. This is a legislative matter that is defined by Government datasets.
Habitat	An area or areas permanently, periodically or occasionally occupied by a species, population or ecological community, including any and all biotic and abiotic features of the area or areas occupied.
High constraint area	The environmental value is at risk from the Project activity. The activity will only be allowed when managed with a specific set of stringent mitigation measures.

Term	Explanation
High Value Regrowth	In accordance with the *Vegetation Management Act 1999*, vegetation located – (a) on freehold land, indigenous land, or land subject of a lease issued under the *Land Act 1994* for agriculture or grazing purposes or an occupation licence under that Act; and (b) in an area that has not been cleared (other than for relevant clearing activities) for at least 15 years, if the area is – i. an endangered regional ecosystem; or ii. an of concern regional ecosystem; or iii. a least concern regional ecosystem.
Indirect impacts	Impacts that are not a direct result of Project activities but are encouraged to occur away from the original impact area via a complex pathway (e.g. soil disturbance during construction promoting weed and/or pest invasion that reduces habitat quality). In accordance with the EPBC Act, indirect impacts include the following: ▪ Downstream or downwind impacts, such as impact on wetlands or ocean reefs from sediment, fertilisers or chemical which are washed or discharged into river systems ▪ Upstream impacts such as impacts associated with the extraction of raw materials and other inputs which are used to undertake the action ▪ Facilitated impacts which result from further actions (including actions by third parties) which are made possible or facilitated by the action.
Least concern	Designated as Least concern under the VM Act. Refer to definition of VM Act conservation status for meaning of Least concern under the Act.
Matters of national environmental significance	Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), actions that have, or are likely to have, a significant impact on a matter of national environmental significance require approval from the Australian Government Minister for the Environment (the Minister). The Minister will decide whether assessment and approval is required under the EPBC Act. The nine matters of national environmental significance protected under the EPBC Act are: ▪ World heritage properties ▪ National heritage places ▪ Wetlands of international importance (listed under the Ramsar convention) ▪ Listed threatened species and ecological communities ▪ Migratory species protected under international agreements ▪ Commonwealth marine areas ▪ The great barrier reef marine park ▪ Nuclear actions (including uranium mines) a water resource, in relation to coal seam gas development and large coal mining development
Microchiropteran bats	This report uses the term Microchiropteran bats to refer to small, mostly insectivorous bats that use echolocation to navigate and find food.
Migratory	Species listed as Migratory under the EPBC Act. Refer to definitions of EPBC Act conservation status, for meaning of migratory under the Act.
MSES wildlife habitat	As defined by DES, MSES Wildlife habitat is vegetation in which a species that is listed under the NC Act as Endangered, Vulnerable or Near Threatened has been known to occur. MSES wildlife habitat is identified on the approved DES RE mapping.
Naturalness and ecological condition	The apparent naturalness or health/condition of an ecological community, as assessed against the following criteria: ▪ Disturbance — described in terms of its cause (natural or human), its degree or severity, its extent and distribution within the community ▪ Weed content — description of species abundance, horizontal and vertical distribution of each species ▪ Ecological viability — measure of a community's ability to survive in the longer term ▪ Ecological health — measure of regeneration, size, structure and number of dead or dying plants within a community ▪ Ecological relationships — the sequential relationship of one community to another, such as diurnal systems.

Term	Explanation
NC Act conservation status	Under the NC Act, protected species are assigned a conservation status of Extinct in the wild, Endangered, Vulnerable, Near threatened, or Least concern. Definitions of these terms under the NC Act are as follows: Extinct in the wild ■ There have been thorough searches conducted for the wildlife, and ■ It has not been seen in the wild over a period that is appropriate for the lifecycle or form of the wildlife Endangered ■ There have not been thorough searches conducted for the wildlife and the wildlife has not been seen in the wild over a period that is appropriate for the lifecycle or form of the wildlife, or ■ The habitat or distribution of the wildlife has been reduced to an extent that the wildlife may be in danger of extinction, or ■ The population size of the wildlife has declined, or is likely to decline, to an extent that the wildlife may be in danger of extinction, or ■ The survival of the wildlife in the wild is unlikely if a threatening process continues Vulnerable ■ Its population is decreasing because of threatening processes, or ■ Its population has been seriously depleted, and its protection is not secured, or ■ Its population, while abundant, is at risk because of threatening processes, or ■ Its population is low or localised or depends on limited habitat that is at risk because of threatening processes Near threatened ■ The population size or distribution of the wildlife is small and may become smaller, or ■ The population size of the wildlife has declined, or is likely to decline, at a rate higher than the usual rate for population changes for the wildlife, or ■ The survival of the wildlife in the wild is affected to an extent that the wildlife is in danger of becoming vulnerable Least concern ■ The wildlife is common or abundant and is likely to survive in the wild Native wildlife may be prescribed as least concern wildlife even if: ■ The wildlife is the subject of a threatening process, or ■ The population size or distribution of the wildlife has declined, or ■ there is insufficient information about the wildlife to conclude whether the wildlife is common or abundant or likely to survive in the wild.
Near threatened	Designated as Near threatened under the NC Act. Refer to definition of NC Act conservation status for meaning of Near threatened under the NC Act. Capitalisation of the term Near threatened in this report refers to those species listed as such under the NC Act.
Negative impact	An impact that is considered to result in an unfavourable or adverse change to the receptor.
Non-remnant vegetation	Vegetation that is not mapped as remnant vegetation by DES and/or which fails to meet DESs criteria for remnant vegetation (see definition of remnant vegetation, below). This includes regrowth, heavily thinned or logged vegetation and significantly disturbed vegetation that fails to meet the structural and/or floristic characteristics of remnant vegetation. It also includes urban and cropping land. Non-remnant vegetation may retain significant biodiversity values (Neldner et al. 2017).
Of concern regional ecosystem	Designated as Of concern under the VM Act or Of concern under the EP Act. Refer to definition of VM Act status for meaning of 'Of concern' under the Act.
Permanent impact	The impact will last indefinitely (i.e. greater than 21 years duration).
Project cumulative impact area	The Inland Rail Program cumulative impact area encompasses the Inland Rail disturbance footprint and extends 50 km beyond the disturbance footprint boundary.
Regional Ecosystem (RE)	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil. REs may be classified under schedules 1 to 3 of the Vegetation Management Regulation as Endangered, Of concern or Least concern. Refer to VM Act conservation status for meaning of Endangered, Of concern and Least concern under the Act. These terms in reference to REs in this report refers to the RE status under the Act.

Term	Explanation
Regrowth vegetation	As defined under the VM Act, regrowth is any vegetation that is not 70 per cent of height of an equivalent community of undisturbed vegetation or 50 per cent of what would be undisturbed foliage cover and a mix of species represented in undisturbed communities. Areas identified as Category C on a regulated vegetation management Map.
Remnant vegetation	Remnant woody vegetation is defined as vegetation where the dominant canopy has >70 per cent of the height and >50 per cent of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy (Neldner et al. 2012). Areas identified as Category B on a regulated vegetation management map
Sensitive environmental receptor	A sensitive environmental receptor is a feature, area or structure or grouping that may be affected by direct or indirect changes to the environment. For the purposes of this assessment a sensitive environmental receptor are those that constitute MNES or MSES (e.g. regulated vegetation, threatened species as listed under the provisions of the EPBC Act and/or the NC Act).
Significant impact	A significant impact is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment, which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.
Spatial extent	Impacts are considered with respect to the biologically meaningful spatial extents of local, regional, State, and national/international.
VM Act conservation status	Under the VM Act, REs may be classified as either Endangered, Of concern or Least concern. Definitions of these terms under the Act are provided below Endangered ▪ Less than 10 per cent of pre-clearing extent of remnant vegetation (see following definition) exists in the bioregion, or 10 per cent to 30 per cent of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha Of concern ▪ 10 per cent to 30 per cent of pre-clearing extent of remnant vegetation exists in the bioregion, or more than 30 per cent of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha Least concern ▪ More than 30 per cent of pre-clearing extent of remnant vegetation exists in the bioregion, and it is greater than 10,000 ha In addition, for biodiversity planning purposes DEHP also classifies a RE as No concern at present if the degradation criteria listed above for Endangered or Of concern REs are not met.
Vulnerable	Designated as Vulnerable under the EPBC Act and/or NC Act. Refer to definitions of EPBC Act conservation status and NC Act conservation status for meaning of Vulnerable under these Acts.
Weeds of National Environmental Significance (WoNS)	Thirty-two (32) species of weeds are declared to be weeds of national significance, based on their invasiveness, potential for spread and environmental, social and economic impacts. The State Government is responsible for the legislation and administration of WoNS in Queensland and landholders are responsible for managing WoNS. The Australian Weeds Strategy provides a framework for establishing consistency between all stakeholders and identifies priorities for national weed management with the aim of minimising the environmental, social and economic impacts of weeds. A National Management Group has been established for each of the WoNS to manage the implementation of the respective National Strategic Plans.

Term	Explanation
Wetland	■ Areas shown on the *Map of Referable Wetlands* which is a document approved by the chief executive (Environment) on 4 November 2011 and published by the department, as amended from time to time by the chief executive under section 144D of the Environmental Protection Regulation 2019 (Qld); and ■ Are wetlands as defined under the Queensland Wetlands Program as areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m, and possess one or more of the following attributes: – At least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their lifecycle; or – The substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers; or – The substratum is not soil and is saturated with water or covered by water at some time.
Wetland of high ecological significance	Otherwise known as a high conservation value wetland, is a wetland that meets the definition of a wetland (above) and is shown as a wetland of high ecological significance or high conservation value wetland on the *Map of Referable Wetlands.*

Executive summary

This Terrestrial and Aquatic Ecology Technical Report has been prepared to address Sections 11.96 to 11.108 of the *Terms of Reference* for an environmental impact statement: Inland Rail – Helidon to Calvert Project. A separate 'stand-alone' document pertaining to matters of national environmental significance (MNES) that have been identified as controlling provisions (i.e. *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) threatened species and communities) has been provided as Environmental Impact Statement (EIS) Appendix J: Matters of National Environmental Significance Technical Report of the to address Sections 11.1 to 11.35 of the Terms of Reference (ToR). To avoid repetition, the EPBC Act controlling provisions of the Project have been excluded from this document. This technical report has been prepared for the purpose of supporting the EIS for the Project.

The Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the Helidon to Calvert (H2C) section of Inland Rail (the Project), which consists of 47 kilometre (km) long single-track dual gauge greenfield and brownfield corridor railway with four crossing loops to accommodate double stack freight trains up to 1,800 metres (m) long. It will also involve the construction of an approximately 850 m long tunnel through the Little Liverpool Range to facilitate the required gradient across the undulating topography. The Project is classed as a greenfield and brownfield development. The design response to key environmental features has been developed in line with engineering constraints for a feasible rail design. The rail design is based on meeting engineering design criteria while minimising environmental and social impacts and minimising disturbance to existing infrastructure.

The ecology study area (the focus area of this assessment) adopts the EIS investigation corridor, being an approximate 2 km wide study area, 1 km either side of the proposed rail alignment. It includes the disturbance footprint, which encompasses all areas where works are proposed, including both permanent and temporary works, and land within a 1 km radius either side of the proposed rail alignment.

The methodology involved in this assessment included desktop analysis, review of existing literature and previous studies, an assessment of the likelihood of occurrence of conservation significant species and predicted habitat modelling. Following this, an assessment of the significance of impacts was undertaken.

The ecology study area is situated within the south-east Queensland bioregion, which has experienced a long history of human disturbance as a result of agricultural practices urban development and resource development. At a regional level, large tracts of remnant vegetation are typically fragmented, occurring in the areas that are less attractive to development (i.e. rocky ranges, sloping topography) and roadside vegetation, or as relatively small isolated patches subject to edge related impacts. Furthermore, the temporary construction footprint travels through two catchment areas, including Lockyer Creek between Helidon and east of Laidley, and Bremer River between Grandchester and Calvert, within the Brisbane River basin. A number of waterways occur within the disturbance footprint, including; Sandy Creek, Lockyer Creek, Laidley Creek and Western Creek. Two high ecological significance wetlands are located at the eastern end of the disturbance footprint, adjacent to Western Creek.

The ecology study area provides suitable habitat for seven non-MNES (i.e. species listed under the EPBC Act), and *Nature Conservation Act 1992* (NC Act) listed conservation significant species (i.e. three plants and five animals) as well as potential habitat for 22 non-threatened, migratory species as listed under the EPBC Act. In addition, a number of endangered, of concern and least concern REs are also present within the ecology study area that are protected under the *Vegetation Management Act 1999* (VM Act). The ecology study area contains a suite of sensitive environmental receptors, including protected areas, HVR vegetation, conservation significant flora and fauna species regionally significant species as well as bioregional corridors (local, regional and State significant). For the purposes of the impact assessment a sensitive environmental receptor are those that constitute non-threatened MNES or Matters of State Environmental Significance (MSES) (e.g. regulated vegetation, threatened species as listed under the provisions of the NC Act).

Seventy-seven (77) sensitive environmental receptors were identified within the ecology study area for the purposes of this assessment. These varied from broad scale sensitive environmental receptors such as protected areas and bioregional corridors, down to finer species-scale sensitive environmental receptors, including conservation significant and migratory species. These sensitive environmental receptors were grouped into high, moderate and low sensitivity categories based on factors including conservation status, exposure to threatening processes, resilience and representation in the broader landscape.

The construction, operation and decommissioning of the Project has the potential to impact on environmental sensitive environmental receptors via the following mechanisms (predominantly associated with the construction phase):

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species by invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light impacts
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

The nature of each unmitigated potential impact was considered in relation to the identified sensitive environmental receptors to derive an initial assessment of impact significance for the Project.

This was determined by assigning sensitivity and magnitude ratings which were then allocated a significance rating through the significance assessment matrix. The potential impacts upon the sensitive environmental receptors were then assigned a major, high, moderate, low or negligible rating.

The proposed avoidance and mitigation measures for the Project were identified in order to reduce the significance of the potential impacts upon the sensitive environmental receptors. The mitigation strategies associated with the Project are presented in Section 5.2. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate), which included a range of mitigation measures and management plans, the impacts to the identified sensitive environmental receptors were generally reduced.

Following initial impact assessment and the application of mitigation measures, each sensitive environmental receptor (where applicable) as analysed to determine if the Project would result in significant residual impact in accordance with the relevant Commonwealth or State significant impact guideline.

In accordance with the outcomes of the MNES significant impact guideline (refer Section 5.3.3), there are **no significant impacts expected** for the following non-threatened EPBC Act listed migratory species:

- Common sandpiper (*Actitis hypoleucos*)
- Fork-tailed swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Pectoral sandpiper (*Calidris melanotos*)
- Red-necked stint (*Calidris ruficollis*)
- Oriental dotterel (*Charadrius veredus*)
- Oriental cuckoo (*Cuculus optatus*)
- Latham's snipe (*Gallinago hardwickii*)
- Gull-billed tern (*Gelochelidon nilotica*)
- Caspian tern (*Hydroprogne caspia*)
- Black-tailed godwit (*Limosa limosa*)
- Black-faced monarch (*Monarcha melanopsis*)
- Yellow wagtail (*Motacilla flava*)
- Satin flycatcher (*Myiagra cyanoleuca*)

- Eastern osprey (*Pandion haliaetus*)
- Red-necked phalarope (*Phalaropus lobatus*)
- Glossy ibis (*Plegadis falcinellus*)
- Pacific golden plover (*Pluvialis fu*lva)
- Rufous fantail (*Rhipidura rufifrons*)
- Spectacled monarch (*Symposiachrus trivirgatus*)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*)

Assessment of MSES prescribed has been undertaken in accordance with the MSES significant impact criteria (refer Section 5.3.4). Analysis indicates that the Project is likely to result in significant residual impacts to following sensitive environmental receptors, with all remaining sensitive environmental receptors unlikely to be subject to significant residual impacts in accordance with the MSES guidelines:

- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature): 0.77 ha
- Essential Habitat (EH): 95.66 ha
- High ecological value (HEV) waters: 6.44 ha
- Protected wildlife habitat for the following species:
  - Bailey's cypress (*Callitris baileyi*): 28.40 ha
  - Swamp tea-tree (*Melaleuca irbyana*) - 128.78 ha
  - Glossy-black cockatoo (*Calyptorhynchus lathami*): 45.11 ha
  - Powerful owl (*Ninox strenua*): 28.63 ha

Potential predicted cumulative impacts within 50 km of the Project were assessed incorporating the footprints of six other projects. Impacts include habitat loss from vegetation clearing/removal, fauna species injury or mortality, reduction in biological viability of soil to support growth due to soil compaction, displacement of flora and fauna species due to invasion of weeds and pest species, reduction in connectivity of biodiversity corridors, edge effects, habitat fragmentation, barrier effects, noise, dust, and light impacts and increase in litter (waste) and aquatic habitat degradation.

The significance of the predicted cumulative impact as a result of the Project added to the seven other similar projects that occur within 50 km of the Project boundary are likely to be higher on the following sensitive environmental receptors:

- EPBC Act listed, non-threatened migratory species:
  - Latham's snipe (*Gallinago hardwickii*) – Project impact makes a 7.44 per cent contribution to the clearing of approximately 1,799.41 ha (sum of cumulative impact) which constitutes 1.29 per cent of the available habitat within the cumulative impact study area
  - Pectoral sandpiper (*Calidris melanotos*), Red-necked stint (*Calidris ruficollis*), Black-tailed godwit (*Limosa limosa*), Yellow wagtail (*Motacilla flava*), Red-necked phalarope (*Phalarops lobatus*), Pacific golden plover (*Pluvialis fulva*), Common greenshank (*Tringa nebularia*) and Marsh sandpiper (*Tringa stagnatilis*) – Project impact makes a 5.70 per cent contribution to the clearing of approximately 1,413.32 ha (sum of cumulative impact) which constitutes 1.19 per cent of the available habitat within the cumulative impact study area
- Essential habitat – cumulative removal of 1,389.60 ha, of which the Project contributes up to 6.88 per cent of the available habitat within the cumulative impact study area
- Category C Regulated vegetation (High Value Regrowth) – cumulative removal of 922.04 ha to which the Project impact constitutes 7.29 per cent of the clearing. This constitutes 1.18 per cent of the available habitat within the cumulative impact study area.

The sensitive environmental identified through the EIS will be subject to further investigations and surveys during the detailed design phase to more accurately determine the magnitude of the significant residual impacts upon the identified MNES and MSES. The specific mitigation measures will then be applied to ensure that the significance ratings of any potential impacts are classified as low as is reasonably practicable. In order to mitigate the residual impacts to the sensitive environmental receptors identified above, environmental offsets will be required.

This report includes an Environmental Offsets Delivery Strategy as an Appendix.

1 Introduction

1.1 Project overview and objectives

The Australian Rail Track Corporation (ARTC) proposes to construct and operate the Helidon to Calvert (H2C) (the Project) section of the Inland Rail Program (Inland Rail).

The project consists of approximately 47 kilometres (km) of single track dual gauge railway with four crossing loops to accommodate double stack freight trains up to 1,800 metres (m) long. It will also involve the construction of an approximately 850 m long tunnel through the Little Liverpool Range to facilitate the required gradient across the undulating topography. The corridor will be of sufficient width to accommodate future possible upgrades of the track, including a future possible requirement to accommodate trains up to 3,600 m in length.

It is noted that although ARTC are applying for approval to build infrastructure to accommodate trains up to 1,800 m in length, infrastructure will be designed such that the future extension of some crossing loops to accommodate 3,600 m trains is not precluded. ARTC intend to acquire the land for the future 3,600 m crossing loop extension with the initial land acquisition, however, the approval for the construction of future 3,600 m crossing loops will be subject to separate approval applications in the future. This assessment is based on 1,800 m train lengths.

1.2 Scope and purpose

The Project was declared a 'coordinated project for which an EIS is required' by the Coordinator-General on the 16 March 2017 under section 26(1)(a) of the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act). The Terms of Reference (ToR) for the Project sets out the matters that the proponent must address in the Environmental Impact Statement (EIS).

On 17 March 2017, the Commonwealth Minister for Environment determined the Inland Rail – Helidon to Project is a 'controlled action' under the EPBC Act (reference number EPBC 2017/7883).

The SDPWO Act EIS process has been accredited under the bilateral agreement for the assessment of the Project under Section 45 of the EPBC Act. The EIS must state the controlling provision for the Project and describe the particular aspects of the environment that led to the controlled action decision. The controlling provisions are threatened species and communities.

This report has been prepared in consideration of Sections 11.96 to 11.108 of the *Terms of Reference for an environmental impact statement: Inland Rail - Helidon to Calvert Project* which was issued in October 2017 by the Coordinator-General (refer Section 1.3).

Matters associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) as identified by the ToR (i.e. Items 11.1 to 11.35) are addressed as a stand-alone document in EIS Appendix J: Matters of National Environmental Significance Technical Report and as such are not included within the scope of this technical report in order to avoid duplication. However, MNES that have not been identified as a controlling provision of the Project (e.g. migratory species) have been included within this technical document in accordance with item 11.96 of the ToR.

For the purposes of the Project and this technical report, the investigations and assessment were focussed on the Project disturbance footprint and the ecology study area presented in Figure 1.1 and Section 3.2.

This information was used to undertake impact assessment in accordance with the

- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (henceforth referred to as the MNES Guidelines) (Department of the Environment (DotE) 2013) for EPBC Act listed migratory species

- Queensland Environmental Offsets Policy Significant Residual Impact Guidelines (henceforth referred to as the MSES Guidelines) (Department of State Development, Infrastructure and Planning (DSDIP) 2014a)

Potential impacts to sensitive environmental receptors resulting from construction, operation and decommissioning of the Project were identified, with mitigation measures developed to avoid, minimise and manage environmental impacts resulting from the Project. An assessment of the impacts of the Project following the application of mitigation measures is provided, along with the significance of the anticipated impacts to each sensitive environmental receptor. This impact assessment determined which MNES/MSES (henceforth referred to as sensitive environmental receptors) were likely to be subject to significant residual impacts as a result of the Project.

1.3 Terms of reference

This report addresses the relevant flora and fauna ToR for the Project in relation to ecological issues (i.e. items 11.96 to 11.108), as summarised in Table 1.1. Compliance of the EIS against the full ToR is documented in EIS Appendix B: Terms of Reference compliance table.

Matters associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) as identified by the ToR (i.e. Items 11.1 to 11.35) are addressed in EIS Appendix J: Matters of National Environmental Significance Technical Report and as such are not included in Table 1.1. However, MNES that have not been identified as a controlling provision of the Project (e.g. migratory species) have been included within this technical document in accordance with item 11.96 of the ToR.

Table 1.1 Terms of Reference compliance table relevant to flora and fauna

Flora and fauna/Biosecurity Terms of Reference requirement		Report section
Flora and fauna		
Existing environment		
11.96	Identify and describe matters of State environmental significance (MSES), State and regionally significant biodiversity and natural environmental values of the terrestrial and aquatic ecology, including their seasonal variations, likely to be impacted by the project which have not been addressed in the section on MNES.	Description of environmental values - Section 4 Chapter 11, section 11.6
11.97	Describe the likely impacts on the biodiversity and natural environmental values of affected areas arising from the construction and operation of the project. The assessment should include, but not be limited to, the following key elements: (a) MSES, matters of local environmental significance, and designated State and regional biodiversity values and conservation corridors of conservation significance. Reference should be made to the Biodiversity Planning Assessment and BioCondition assessment tools where appropriate (b) terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interaction and areas surrounding watercourses and wetlands (c) biological diversity including listed flora and fauna species and regional ecosystems, connectivity and essential habitat (d) the existing integrity of ecological processes, including habitats of threatened, near-threatened or special least-concern species (e) the integrity of landscapes and places, including wilderness and similar natural places (f) actions of the project that require an authority under the NC Act and Water Act (for example, riverine protection permits) and/or could be assessable development for the purposes of the VMA, Fisheries Act and PA (g) any exposure to contaminants or the bio-accumulation of contaminants (h) impacts on native fauna due to proximity to the site and site impacts (e.g. lighting, noise, waste and fencing)	a) Sections 5.1, 5.3.1, 5.3.2 and 5.3.4 Chapter 11, Sections 11.8, 11.9.3 and 11.11.3 b) Section 5 Chapter 11, Sections 11.8 and 11.9.3 c) Section 5.1.2 and 5.3 Chapter 11, Sections 11.8 and 11.9.3 d) Sections 5.1.2 and 5.3 Chapter 11, Sections 11.8, 11.9.3 and 11.1 e) Sections 5.1.2 and 5.3 Chapter 11, Sections 11.8 and 11.9. f) Section 5 Chapter 11, Section 11.8 g) Section 5.1.2.11 Chapter 11, Section 11.8.2.11 h) Sections 5.1.2.9 and 5.1.2.10 Chapter 11, Sections 11.8.2.9 and 11.8.2.10 i) Section 5.1.2.8 Chapter 11, Section 11.8.2.8 j) Sections 5.1, 5.3.1, 5.3.2 and 5.3.4

Flora and fauna/Biosecurity Terms of Reference requirement		Report section
	(i) impacts to movement of native fauna due to barrier effect of linear infrastructure (j) impacts on vegetation category areas identified on the regulated vegetation management maps under Queensland's vegetation management framework.	Chapter 11, Sections 11.8, 11.9.3 and 11.11.3
Mitigation measures		
11.98	Describe any proposed measures to avoid, minimise or mitigate potential impacts on natural values, and enhance these values. Assess how the nominated quantitative indicators and standards may be achieved for nature conservation management. In particular, address measures to protect or preserve any threatened or near-threatened species.	Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9
11.99	Assess the need for buffer zones and the retention, rehabilitation, planting or construction of movement corridors across the railway and propose measures that would avoid the need for waterway barriers or propose measures to mitigate the impacts of their construction and operation.	Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9
11.100	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed	Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9
11.101	Where a significant residual impact will occur on a prescribed environmental matter as outlined in the Environmental Offsets Regulation 2014, the offset proposal(s) must be consistent with the requirements of Queensland's EO Act and the latest version of the Queensland Environmental Offsets Policy.	Biodiversity offsets - Section 5.4 Chapter 11, Section 11.1
11.102	Assess the need and suitability and provide objective commitments to the provision of fauna passage between habitat fragmented by the rail corridor, of suitable design and location for affected species and their habitat.	Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9
11.103	Demonstrate that actions of the project avoid and minimise impacts of clearing of vegetation regulated through the VMA/PA and how any clearing maintains connectivity of the remaining mapped category B area in the landscape. Provide details on the exemptions/assessment pathway for any clearing of vegetation regulated through the VMA/PA	Legislative, policy standards and guidelines - Section 2 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9
Biosecurity		
Existing environment		
11.104	Provide information on the current distribution of animal pests and weeds on the preferred alignment.	Invasive species biosecurity areas - Section 4.3.4 Weed species - Section 4.4.1.1 Invasive animals - Section 4.4.2.3 Chapter 11, Sections 11.6.2.4 and 11.6.3.2
11.105	Surveys of animal pests and weeds should be undertaken in those areas identified during the desktop assessment as containing listed flora, fauna or ecological communities of national or State environmental significance (MNES or MSES defined by the EPBC and NC Acts respectively	
Impact assessment		
11.106	Describe the impact the project's construction and operation will have on the spread of pest animals and weed species along the preferred alignment and into adjoining properties	Displacement of flora and fauna species by invasion of weed and pest species - Section 5.1.2.4 Chapter 11, Sections 11.8.2.4 and 11.9.3
Mitigation measures		
11.107	Propose detailed measures to control and limit the spread of pests and weeds on the preferred alignment and adjacent areas and any relevant local government area Biosecurity Plans. This includes restricted matters listed in the Biosecurity Act and Biosecurity Regulation 2016 and designated pests under the Public Health Act 2005	Proposed mitigation measures - Section 5.2.2 Chapter 11, Section 11.9

Flora and fauna/Biosecurity Terms of Reference requirement		Report section
11.108	All proposed measures must be in accordance with any relevant biosecurity surveillance or prevention program authorised under the Biosecurity Act and any requirements of the VMA/PA. Mitigation measures may be developed in consultation with relevant agencies and local government (e.g. baiting programs).	

1.4 Project location and existing land use

The location of the Project and the Ecology study area is shown on Figure 1.1. The Project is located within the Ipswich City and Lockyer Valley Local Government Areas (LGAs) in South-east Queensland (SEQ). The Project is the third most-northern package of Inland Rail. The Project is located within the Lockyer Creek and Bremer River catchments (of the Moreton hydrological basin) and, is expected to cross four main watercourses and several unnamed tributaries along the alignment.

The Project consists of both greenfield and brownfield rail corridors. The permanent operational disturbance footprint will utilise the existing West Moreton System rail corridor for approximately 50 percent of the alignment – this equates to approximately 18 per cent of the area required for this footprint. The permanent operational disturbance footprint will utilise the Gowrie to Grandchester future State transport corridor for approximately 17 per cent of area required for this footprint.

The Project starts within the existing West Moreton System rail corridor at Helidon, traversing east for approximately 1.3 km. The Project then deviates from the West Moreton System rail corridor and continues east for approximately 4 km. The Project aligns with the Gowrie to Grandchester future State Transport corridor west of Grantham, continuing within the gazetted future corridor for approximately 6.3 km. The Project then utilises the West Moreton System rail corridor north west of Placid Hills, continuing within the existing rail corridor for approximately 18.4 km whilst traversing through the localities of Gatton, Lawes and Forest Hill.

The Project deviates from the West Moreton System rail corridor at Laidley North, continuing south-east for approximately 4.9 km whilst predominately within the Gowrie to Grandchester future State transport corridor. Deviating from the Gowrie to Grandchester corridor, the Project enters the western tunnel portal at Laidley and passes beneath the Little Liverpool Range. The Project exits the tunnel at the eastern tunnel portal and traverses east for approximately 4.2 km. The Project re-joins the West Moreton System rail corridor east of Grantham, continuing within the existing corridor for approximately 5.9 km through to Calvert.

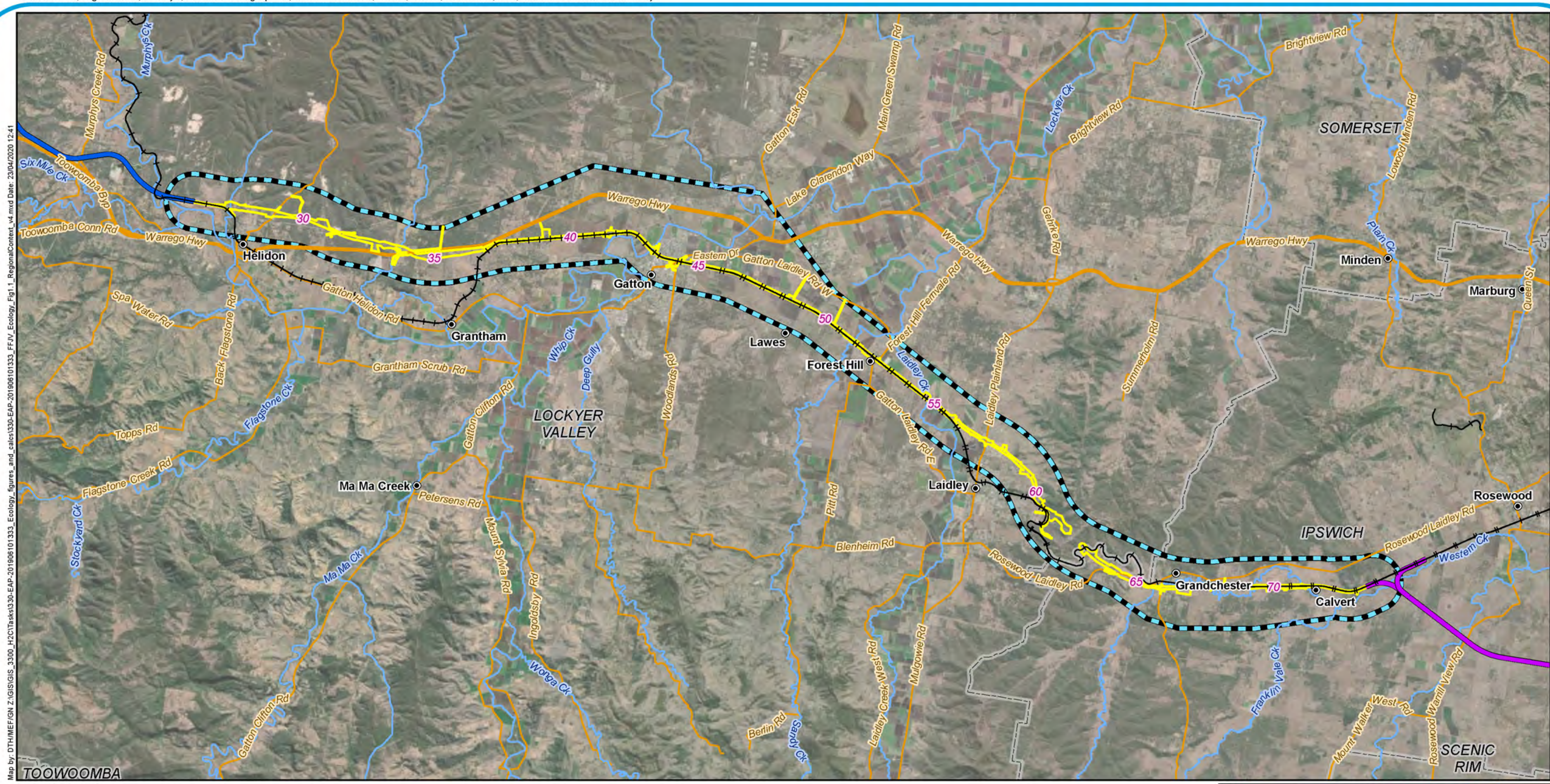
Grazing land is the predominant land use within the permanent operational and temporary construction disturbance footprints. The next most common land use is also generally of an agricultural nature, being land classified as irrigated seasonal horticulture. Other land uses include land classified as residential, services (which primarily includes commercial and recreational services located within the Gatton township) and land in transition (which includes land located to the north of Laidley currently being developed into a housing estate).

The intended land use for the Project is rail and associated infrastructure, including road realignments, grade separations and ancillary infrastructure. A new Energex powerline to power the tunnel will be incorporated into the intended land use.

1.5 Ecology study area

The ecology study area adopts the EIS investigation corridor, being an approximate 2 km wide study area, 1 km either side of the proposed rail alignment. It includes the disturbance footprint, which encompasses all areas where works are proposed, including both permanent and temporary works, and land within a 1 km radius either side of the proposed rail alignment. It should be noted that for the estimation of direct impacts, the disturbance footprint does not include the surface area associated with the rail tunnel (where the alignment intersects a portion of the Little Liverpool Range) as no surface disturbance is predicted (refer Figure 1.1).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

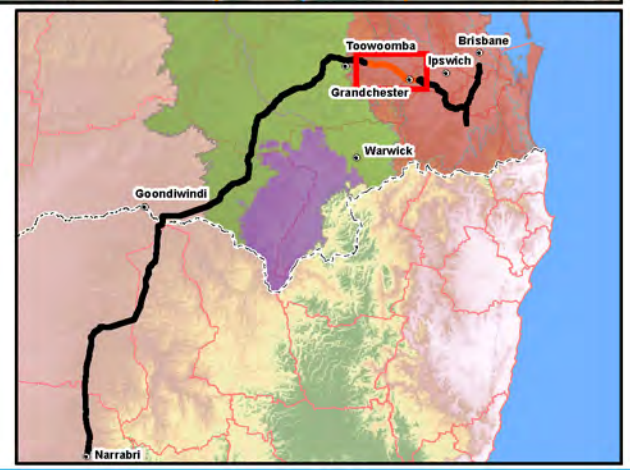


Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Bioregions

- Brigalow Belt South
- Nandewar
- South Eastern Queensland



A3 scale: 1:150,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 20/04/2020 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 1.1:
Location of Project and regional extent and ecology study area

The ecology study area was used to identify sensitive environmental receptors (excluding the MNES controlling provisions) that are located in proximity to the Project and therefore relevant to the assessment of potential impacts.

1.6 Project description

Key elements of the Project design have responded to environmental and engineering constraints to produce a feasible rail design. The Project design is based on minimising environmental and social impacts, minimising disturbance to existing infrastructure and meeting engineering design criteria.

Key components of the Project include:

- 47 km of single track dual gauge rail line with 4 crossing loops to accommodate 1,800 m long train sets
- The corridor identified for the Project will is expected to be a width of 40 m to 62.5 m and extending wider where earthworks, structures and other associated infrastructure are required. For the existing rail corridor, the existing width has been generally maintained (where possible), and locally widened to accommodate the proposed works.
- The approximately 850 m Little Liverpool Range tunnel, bridges and viaducts to accommodate topography and Project crossings of waterways, roads and other infrastructure
- Approximately 34 km of embankments (excluding structures) and approximately 3,600,000 m^3 of cuttings along the length of the alignment, spanning approximately 7.6 km
- Approximately 2,500,000 m^3 of fill along the length of the alignment
- 105 waterway crossings along the length of the alignment including 19 bridge structures and 86 drainage structures
- Defined watercourses under the *Water Act 2000* (Qld) intercepted by the proposed Project alignment (26 marked waterways for water barrier works waterways which are intersected 29 times by the Project).A total of 31 bridges proposed, including 13 rail-over-water, 6 rail-over-water-and-road (identified above), 6 rail-over-road, 4 road-over-rail, 1 rail-over-existing-rail, and 1 pedestrian-over-rail
- Tie-ins to the existing West Moreton System at the Project boundary and other potential intermediate locations to be confirmed by operational modelling (approximately 24 km of parallel length)
- The construction of associated rail infrastructure, including maintenance sidings, rail maintenance access roads and signalling infrastructure to support the train control system
- Construction laydowns, storage, workspace and temporary access roads.
- Environmental design matters including fauna sensitive design measures, landscaping and habitat rehabilitation requirements, and concept noise barriers.

Construction activities for the Project will likely include temporary roads, upgrades and/or alterations to existing roads. The construction of the Project may also require relocation of some services, depending on their proximity to the construction zone. These aspects will be further examined in future design stages.

Construction of the Project is planned to start in 2021 following detailed design and subject to required post-EIS approvals and relevant activities. With commencement in 2021, completion is targeted for 2026. The commencement of construction of the Project will also be subject to successful procurement of contractor. The completion date will also be influenced by a number of variables, including the impacts of ongoing design and development work.

2 Legislative, policy, standards and guidelines

2.1 Commonwealth and State legislation

This section describes the legislative, policy and management framework for the Project, including:

- Legislative framework which applies to the assessment of terrestrial and aquatic ecology applicable to the Project at the Commonwealth and State levels, and provides the statutory context for which the terrestrial and aquatic ecological assessment has been undertaken
- Statutory approvals and/or offset requirements that may be required as a result of potential impacts to terrestrial and aquatic ecology, based on consideration of the overall approvals pathway for the Project.

An overview of the Commonwealth and State legislation that is relevant to ecological aspects of the Project, outlining the intent of the legislation and applicability to the Project is presented in Table 2.1.

Table 2.1 Legislative approvals, licences, permits and authorities relevant to the Project

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Commonwealth			
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	Australia and its Territories. Specifically, projects that involve or have the potential to impact upon nationally and internationally important flora, fauna, ecological communities and heritage places – defined under the EPBC Act MNES.	The EPBC Act is the Australian Government's central piece of environmental legislation and provides the legal basis for the management and protection of nationally and internationally important flora, fauna, ecological communities and heritage places. Under Section 45 of the EPBC Act, the Australian Government and Queensland Government have a bilateral agreement relating to environmental assessment. This agreement allows the Commonwealth Minister for the Environment and Department of Agriculture, Water and the Environment (DAWE) to rely on specified environmental impact assessment processes of Queensland in assessing actions under the EPBC Act.	ARTC submitted an EPBC Act referral to the Department of the Environment and Energy (DotEE) (now DAWE) in February 2017 (EPBC 2017/7883) The Minister for the Environment declared the Project a 'controlled action' on 17 March 2017. The controlling provisions for the controlled action are: - Listed threatened species and communities. The EPBC Act controlled action will be assessed under the bilateral agreement with the Queensland Government. Note that EPBC Act controlling provisions have been assessed within EIS Appendix J: Matters of National Environmental Significance Technical Report. To avoid repetition between technical reports, this document discusses MNES that have not been identified as controlling provisions (i.e. EPBC Act listed migratory species only)
EPBC Act Environmental Offsets Policy (DSEWPC 2012) (EPBC Act Offsets Policy)	Areas subject to the EPBC Act.	The EPBC Act Offset Policy was developed to support the management and protection of MNES under the EPBC Act and outlines the Australian Government's approach to the use of environmental offsets for impacts to MNES. Eight principles for the use of environmental offset under the EPBC Act have been developed by DAWE. These principles are used to assess any proposed environmental offset for MNES to ensure consistency, transparency and equity under the Act. The Australian Government's position is that environmental offsets must: - Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action - Be built around direct offsets but may include other compensatory measures	The Project will implement a range of mitigation measures to avoid and minimise significant residual impacts on MNES. Offsets provided for under the policy include direct offsets, and other compensatory methods (or indirect offsets). It is likely that a combination of methods will be applicable to the Project, based on the extent of the significant residual impacts on MNES identified in EIS Appendix J: Matters of National Environmental Significance Assessment Technical Report. ARTC's Environmental Offset Delivery Strategy – Qld is contained in Appendix J of this report.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		■ Be in proportion to the level of statutory protection that applies to the protected matter ■ Be of a size and scale proportionate to the residual impacts on the protected matter ■ Effectively account for and manage the risks of the offset not succeeding ■ Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of State or territory offsets that may be suitable as offsets under the Act for the same action) ■ Be efficient, effective, timely, transparent, scientifically robust and reasonable ■ Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced (Australian Government 2013). The Australian Government defines offsets as measures that compensate for the residual adverse impacts of an action on the environment (DSEWPC 2012).	
Matters of National Environmental Significance: *Significant impact guidelines 1.1 – Environmental Protection and Biodiversity Conservation Act 1999*	MNES	The purpose of the guideline is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the DotEE for a decision by the Australian Government Minister for Environment (the Minister) on whether assessment and approval is required under the EPBC Act. These guidelines outline a 'self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required.	Assessment of MNES against these guidelines will facilitate the determination of a Significant residual impact. Matters associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) are addressed as a stand-alone document in EIS Appendix J: Matters of National Environmental Significance Technical Report and as such are not included within the scope of this technical report in order to avoid duplication. However, an assessment of MNES that have not been identified as controlling provisions for the Project (i.e. EPBC Act listed migratory species) has been included in Section 5.3.3.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Draft *Referral guidelines for 14 birds listed as migratory species under the EPBC Act* (DAWE 2020b)	MNES	The purpose of the guideline is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the DAWE for a decision by the Australian Government Environment Minister (the minister) on whether assessment and approval is required under the EPBC Act in relation to the 14 migratory birds. These guidelines outline a 'self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required.	Assessment of MNES (non-threatened migratory species) against the guidelines will facilitate the determination of a significant residual impact to migratory birds relevant to this guideline. Assessment been undertaken in Section 5.3.3 for EPBC Act migratory species.
State			
Planning Act 2016 (Qld) (Planning Act)	Queensland	The purpose of the Planning Act is to provide an efficient, effective, transparent, integrated, coordinated and accountable system of land use planning, development assessment and dispute resolution to facilitate the achievement of ecological sustainability. Together with a development assessment system, Chapter 1 of the Planning Act establishes a hierarchy of planning instruments which comprises: ▪ State planning policies (including temporary policies) ▪ Regional plans ▪ Planning schemes ▪ Temporary local planning instruments ▪ Planning scheme policies.	The Project may trigger the requirement to obtain approval for aspects of development that are assessable under Schedule 10 of the Planning Regulation 2017 (and integrated through other legislation as part of the Development Assessment Rules process) following completion of the EIS process.
Regional plans (Qld)	Queensland. Specifically, activities that are regulated through the Planning Act.	Regional plans are State planning instruments made under the Planning Act. Regional plans seek to provide strategic direction to achieve regional outcomes that align with the State interests in planning and development.	The Project is located within the South-east Queensland (SEQ) Regional Planning area. The regional plan, otherwise known as *Shaping SEQ*, provides the regional framework for collaboration with the regions' 12 local governments for the management of growth, planning directions, economic competitiveness and high-quality living. The *Shaping SEQ* plan identifies the need to plan strategically for the protection and enhancement of biodiversity values, koala habitat and landscape function and processes. Inland Rail has been identified in this plan.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
State Planning Policy 2017 (SPP)	Queensland	The SPP is a key component of the Queensland land use planning system which articulates the Queensland Government's 17 State interests in land use planning and development. The SPP is a statutory instrument and requires that the State interests be integrated into local government planning schemes. Some State interests in the SPP include assessment benchmarks that apply to certain types of development where a local government planning scheme does not appropriately integrate the relevant State interest. A number of the State interests set out in the SPP apply to the Project and to the Project impact areas.	The SPP is applicable to the Project across various aspects, including terrestrial and aquatic ecology which is represented by the *State interest guideline – biodiversity* (DSDIP 2014b). The biodiversity State interest requires development to be located in areas to avoid significant impacts to MNES, avoid and minimise impacts to matters of State environmental significance (MSES) and matters of local environmental significance (MLES), maintaining or enhancing ecological processes and connectivity by avoiding fragmentation and conserve and enhance koala habitat extent and condition. MLES are identified in relevant LGA planning schemes. The Project area is located within the Ipswich City Council and Lockyer Valley Regional Council areas. No MLES are identified within any current Planning Scheme applicable to the Project disturbance footprint.
Environmental Protection Act 1994 (Qld) (EP Act)	Queensland	The EP Act is the key legislative framework for environmental management and protection in Queensland. It regulates activities that will, or have the potential to, release contaminants into the environment which may cause environmental harm. These activities are defined as Environmentally Relevant Activities (ERAs). ERAs include both prescribed ERAs and resource activities. The EP Act regulates the application of Environmental Authorities (EAs) for ERAs, and employs a number of mechanisms to achieve its objectives relating to biodiversity, including the Environmental Protection Regulation 2019 (Qld) (EP Reg). The EP Reg identifies prescribed ERAs that require an approval and provides the mechanism for levels of protection for Environmentally Sensitive Areas, which are defined in Schedule 12 of the EP Reg. The EP Act also regulates wetlands in wetland management areas under the subordinate Environmental Protection Policy (EPPs) including the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water)). The EPP (Water and Wetland Biodiversity) establishes a process for identifying Environmental values to be protected and states standards for water quality in support of those values.	The identification of any prescribed ERAs that will require an EA has been identified in EIS chapter 3: Project approvals of the EIS. Confirmation of these ERAs will be undertaken as part of the post-EIS approvals process. The EP Act also lists obligations and duties to prevent environmental harm, nuisances and contamination. ARTC will comply with the general environmental duty through the implementation of the environmental management plans for the construction and operation of the Project.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Nature Conservation Act 1992 (Qld) (NC Act)	Queensland	The NC Act provides for the conservation of nature through protection of all native plants, birds, reptiles, mammals and amphibians in Queensland (along with a limited range of invertebrates and freshwater fish). The NC Act is based on principles aimed at conserving biological diversity, ecologically sustainable use of wildlife, ecologically sustainable development and international criteria developed by the International Union for the Conservation of Nature for establishing and managing protected areas. The NC Act has 14 subordinate regulatory instruments in the form of regulations, conservation plans and notices. Of particular relevance to the Project are three instruments that regulate disturbance to flora, fauna and habitat, including: ▪ Nature Conservation (Animals) Regulation 2020, which prohibits the taking or destruction, without authorisation, of protected animals and lists all fauna species that are considered to be extinct in the wild, endangered, vulnerable, near threatened, least concern and special least concern wildlife (refer Glossary and Abbreviations for definitions of these terms). Also listed is international wildlife and prohibited wildlife. ▪ Nature Conservation (Plants) Regulation 2020, which prohibits the taking or destruction, without authorisation, of protected plants and lists all flora species that are considered to be extinct in the wild, endangered, vulnerable, near threatened, least concern and special least concern wildlife (refer Glossary and Abbreviations for definitions of these terms). Also listed is international wildlife and prohibited wildlife. ▪ Nature Conservation (Protected Plants) Conservation Plan 2000 which provides protection for protected flora species. Currently all species of native Australian flora are listed as protected plants, including those species that are considered of Least concern. The NC Act also includes provisions for protected areas such as national parks, nature refuges, and world heritage management areas.	The following permits and management plans may be required for the Project: ▪ Wildlife Movement Permits (Sections 88 and 97 of the NC Act) - for wildlife protected under the NC Act, and those found in certain areas covered by conservation plans created and implemented under the NC Act ▪ Clearing Permit (Protected Plants) (Section 89 of the NC Act) – for the clearing of vegetation contained within High risk areas identified on the Department of Environment and Science (DES) flora survey trigger map, or where protected plants have been identified in a Project survey within a proposed clearing area ▪ Rehabilitation Permit (spotter catcher endorsement) (Part 14 of the Nature Conservation (Animals) Regulation 2020) ▪ Damage Mitigation Permit (removal and relocation) ((Part 10 of the Nature Conservation (Animals) Regulation 2020) ▪ Species management plan must be submitted to the DES for approval for tampering with some animal breeding places (Section 33 of the Nature Conservation (Animals) Regulation 2020). For the purposes of this document only species listed solely under the NC Act (i.e. MSES) and non-threatened EPBC Act listed species (i.e. Migratory birds), have been included. In instances where an NC Act listed species is also listed under the EPBC Act (i.e. identified as a controlling provision under the EPBC Act), this species has been included within EIS Appendix J: Matters of National Environmental Significance Technical Report and has subsequently been excluded from this document to avoid repetition

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Nature Conservation (Koala) Conservation Plan 2017 (Koala Plan)	Queensland	The Koala Plan requires any clearing in certain areas to be undertaken sequentially, and in the presence of a suitably qualified koala spotter. The Koala Plan also prescribes three mapped koala districts (A, B and C) and includes requirements relating to the release of rehabilitation, sick or injured koalas.	The Project will require clearing within District A as identified in the Koala Plan. Clearing works in Koala habitat within District A require 'sequential clearing' and the presence of Koala spotters. Refer Section 4.3.14.
Biosecurity Act 2014 (Qld) (Biosecurity Act)	Queensland	The Biosecurity Act seeks to provide a framework for an effective biosecurity system for Queensland that helps to manage and minimise State biosecurity risks, as well as facilitate the response to biosecurity issues and events in a timely and effective way, so as to align with national and international obligations. The Act introduces the general biosecurity obligation upon all persons to take all reasonable and practical measures to prevent or minimise biosecurity risks. Under the Biosecurity Act, Red imported fire ants (*Solenopsis invicta*) are a Category 1 'restricted matter' and must be reported if found and all reasonable steps taken to minimise the risk of them spreading. The Act establishes a Fire Ant Biosecurity Zone. Restrictions on the movement of carriers of fire ant within and out of the zone will be prescribed and will include 'risk items' such as soil or anything that has soil attached and material that is a product or by-product of quarrying or mining. Movement of carriers by anyone of land within the zone will be prohibited unless the person has a Biosecurity Instrument Permit or under a prescribed exemption (which include implementing risk-mitigation activities).	The Project will potentially involve interaction with restricted matters and prohibited matters (potentially including pests, diseases or contaminants) and will therefore require compliance with the Biosecurity Act. A Biosecurity Management Plan will ensure that the potential spread of invasive species as a result of Project activities are minimised and managed appropriately. The Biosecurity Management Plan will consider operational impacts associated with movement of stock and produce on trains as a vector for spread of pest animals, plants and pathogens. The Project will traverse areas contained within Red Imported Fire Ant Biosecurity Zone 2, therefore there will be restrictions around the movement of materials that could spread the Red imported fire ant. The Biosecurity Management Plan will also consider Red imported fire ants Refer Section 4.3.4.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Agricultural Chemicals Distribution Control Act 1966 (ACDC Act)	Queensland	The ACDC Act and Agricultural Chemicals Distribution Control Regulation 1988 aim to control the distribution of agricultural chemicals from aircraft and from ground equipment. A herbicide, a category of agricultural chemical, is defined as any material used or intended to be used for destroying or preventing the spread of weeds. Herbicides are registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). The misuse of herbicides has the potential to harm agriculture or livestock, the environment, trade, or human health, and the ACDC Act and Regulation are in place to ensure that commercial operators and their businesses distribute herbicides responsibly.	Large areas of the ecology study area have significant weed growth, particularly non-native grasses, which have been introduced as part of historic agricultural land use of the area (refer Chapter 11: Flora and Fauna). In addition, Project activities have the potential to increase the proliferation of weeds and pests. There is the requirement to appropriately manage weeds and pests as part of Project works. Any use of pesticides or herbicides to manage pests and weeds will need to be performed in accordance with the ACDC Act. Ground distribution of pesticides and herbicides may require both the operator of the equipment and the company or business employing or directing the operators to be licensed in accordance with the ACDC Act. For the purposes of the CEMP, the APVMA will regulate the lawful application of pesticides and herbicides for targeted pest and weed management activities.
Public Health Act 2005 (Qld) (Public Health Act)	Queensland	The objective of the Public Health Act is to is to protect and promote the health of the Queensland public by: ▪ Preventing, controlling and reducing risks to public health ▪ Providing for the identification of, and response to, notifiable conditions ▪ Imposing obligations on persons and particular health care facilities involved in the provision of declared health services to minimise infection risks ▪ Inquiring into serious public health matters ▪ Responding to public health emergencies ▪ Providing for compliance with this Act to be monitored and enforced.	The Project will traverse areas that potentially contain designated pests as defined under the *Public Health Act* (e.g. Fire ant Biosecurity zones). Measures to control and minimise the spread of these pests is required. Control measures for designated pests is provided in Section 4.3.4.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Vegetation Management Act 1999 (Qld) (VM Act)	Queensland. Specifically, activities that are regulated through the Planning Act	The VM Act regulates the conservation and management of vegetation communities and clearing of vegetation identified as "Regulated vegetation" identified as Category A, B, C and R. The VM Act provides a framework for identification, description, and mapping of remnant Regional Ecosystems (REs) certified by DES as Endangered, Of concern or Least concern (refer Glossary for definitions of these terms). It also provides a framework for the identification, description and mapping of High Value Regrowth (HVR) vegetation as Endangered, Of concern or Least concern.	The clearing of vegetation regulated under the VM Act (e.g. Category B and C regulated vegetation) will occur as a result of the Project. 'Clearing of any relevant remnant or regulated regrowth vegetation will constitute operational works under Schedule 10 of the Planning Regulation that will require development approval, unless an exemption applies. Under Schedule 21, Part 1, Item 14 of the Planning Regulation, the following clearing work is exempt clearing work for which a development permit is not required: (14) Clearing vegetation for the construction or maintenance of infrastructure stated in Schedule 5, if- (a) the clearing is on a designated premises; or (b) the infrastructure is government supported transport infrastructure'. The Project is considered to be Government Supported Infrastructure as per requirements of the Planning Regulation. Vegetation clearing for the Project is considered to be eligible for exemption under Schedule 21 of the Planning Regulation given the Project is for transport infrastructure (rail transport infrastructure) that is government supported transport infrastructure (for a public use and funded partly by the Commonwealth Government).
Environmental Offsets Act 2014 (Qld) (Offsets Act)	Queensland	The Offsets Act and associated Environmental Offsets Regulation 2014 (Qld) seeks to 'counterbalance the significant residual impacts of particular activities on prescribed environmental matters through the use of environmental offsets'. Introduced on 1 July 2014, the Act is administered by DES, and establishes a new framework to regulate the delivery of offsets in Queensland, integrating the previous multiple sets of policies in a manner which provides an outcome based approach and reducing duplication.	The Project will be required to deliver environmental offsets with regard to the Offsets Act. Environmental offsets for Significant residual impacts to a prescribed matter may be delivered through a proponent-driven offset (e.g. land-based offset), a financial offset calculated in accordance with the Financial Settlement Offset Calculation Methodology, or a combination of proponent driven and financial offsets.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		Under the Offsets Act, an environmental offset is defined as 'an activity undertaken to counterbalance a Significant residual impact of a prescribed activity on a prescribed environmental matter'. The Act defines the type of activities for which offsets may be imposed (i.e. 'prescribed activities') where these activities are determined to result in a 'Significant residual impact'. To achieve the purpose of the Offsets Act, the Queensland Environmental Offsets Policy (Version 1.9, August 2020) has been developed to provide further guidance on the requirements for the assessment of 'Significant residual impacts', and accepted methods for the delivery of offsets, where required.	Information related to the provisions of offsets are provided in Section 5.4. An Environmental Offset Delivery Strategy is provided in Appendix J.
Queensland Environmental Offsets Policy Significant Residual Impact (DSDIP 2014a) (MSES Guidelines)	Queensland	The purpose of this guideline is to assist in deciding whether or not a prescribed activity will or is likely to have a significant residual impact on a matter of State environmental significance (MSES). This guideline applies to any activity prescribed in the Environmental Offsets Regulation 2014 that requires an approval in relation to MSES, under any of the following: ▪ NC Act ▪ *Marine Parks Act 2004;* or ▪ EP ACT	The Project involve disturbance to features protected the EP Act and NC Act, and as such, assessment against the MSES guidelines is required to determine if a significant residual impact upon an MSES occurs. Assessment against the MSES guidelines is undertaken in Section 5.3.4
Water Act 2000 (Qld) (Water Act)	Queensland	The Water Act provides for the sustainable management of non-tidal waters and other resources, together with the establishment and operation of water authorities, and for other purposes. The Queensland Government maintains Watercourse Identification Mapping (WIM), which identifies defined watercourses under the Water Act, as well as drainage features (not regulated under the Water Act). Through the Planning Act, certain water related development under the Water Act is assessable. In addition to the approvals triggered under Planning Act, the Water Act regulates the undertaking of works that involve the excavating or placing fill in a watercourse, lake or spring.	The Project involves works within defined mapped watercourses and the provisions of the Water Act may apply. Other unmapped waterways will be required to be verified during the detailed design phase to determine their status under the Water Act. The Project involves the removal of vegetation, excavation or placing fill in a waterway, lake or spring. ARTC is an approved entity for the purposes of the riverine protection permit exemption requirements. Where works are proposed within a watercourse, these activities will be in accordance with the riverine protection permit exemption requirements. A riverine protection permit will be required in instances where the exemption requirements cannot be achieved.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
			ARTC or the construction contractor will obtain a water entitlement, water licences and/or development permits for watercourse diversion for the Project to enable the take of water for use during construction. Where works are proposed within a watercourse, these activities will be in accordance with the riverine protection permit exemption requirements. A riverine protection permit will be required in instances where the exemption requirements cannot be achieved.
Fisheries Act 1994 (Qld) (Fisheries Act)	Queensland	The Fisheries Act provides for the management, use, development and protection of fish habitats and resources, together with the management of aquaculture activities. Administered by the Department of Agriculture and Fisheries (DAF), the Fisheries Act applies to: ▪ Works in a declared Fish Habitat Area (FHA) ▪ Waterway barrier works resulting in the construction of instream structures inhibiting the free movement of fish along waterways. Under the provisions of the Fisheries Act and Planning Act, a Development Permit for Operational Works involving Waterway Barrier Works is required for works which pose a barrier to fish passage (including permanent, partial and temporary barriers) within a waterway which is mapped by DAF on the spatial data layer *'Queensland waterways for waterway barrier works'* unless: ▪ The works have a low impact to fisheries productivity and comply with DAF's requirements for 'works which are not waterway barrier works' which include (subject to specific design and construction requirements): ▪ New single or multi-span bridges ▪ Maintenance of existing bridge structures not subject to an existing permit ▪ Bank revetment ▪ Road resurfacing at waterway crossings ▪ Stormwater outlet construction. ▪ Works that occur within these waterways will be defined as waterway barrier works, unless the works comply with the *Accepted development requirements for operational work that is constructing or raising waterway barrier works (1 October 2018).*	The Project transverses mapped waterways for waterway barrier works and therefore will likely trigger the requirement to obtain a Development Permit for Operational Works that is constructing or raising waterway barrier works, unless an exemption applies, or where works can be shown to comply with the accepted development requirements. The Project does not require: ▪ The removal, destruction or damage of marine plants ▪ Works involving aquaculture ▪ Work that is completely or partly within a declared FHA.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Queensland Environmental Offsets Policy (Qld) (QEOP)	Queensland	The QEOP (DES 2020) aims to provide a framework for environmental offsets in Queensland, including principles and guidelines for using environmental offsets and guidance on when offsets should be used. The QEOP outlines seven principles that direct the way offsets must be used to contribute to environmentally sustainable development as follows: ▪ Offsets will not replace or undermine existing environmental standards or regulatory requirements, or be used to allow development in areas otherwise prohibited through legislation or policy ▪ Impacts must first be avoided, then minimised, before considering the use of offsets for any remaining impact ▪ Offsets must achieve a conservation outcome that achieves an equivalent environmental outcome ▪ Offsets must provide environmental values as similar as possible to those being lost ▪ Offset provision must minimise the time-lag between the impact and delivery of the offset ▪ Offsets must provide additional protection to environmental values at risk, or additional management actions to improve environmental values ▪ Where legal security is required, offsets must be legally secured for the duration of the impact on the prescribed environmental matter.	The biodiversity offsets package that may be required for the Project will consider the QEOP. Information related to the provisions of offsets are provided in Section 5.4
Back on Track species prioritisation framework	-	The Back on Track species prioritisation framework is an initiative of the DES, based on the method of Marsh et al, (2007) that ranks species (regardless of their NC Act or EPBC Act classification) as Critical, High, Medium, or Low priority for the State and for the Natural Resource Management (NRM) region. There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. Although it is not statutory, the Back on Track priority species provides a framework for biodiversity assessment and species prioritisation when determining ecological values.	Priority Back on Track species have been identified for each of the 14 NRM regions across Queensland. The Project is located in the SEQ NRM region. A total of 105 priority Back on Track species (56 flora species and 49 fauna species) are known to occur within the SEQ NRM region through the prioritisation framework (Department of Environment and Resource Management (DERM) 2010a). Sections 4.3.1.2 and 4.3.2.2 list the NRM State Back on Track species and their rank for the NRM.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Biodiversity Planning Assessments (BPAs)		BPAs for each of Queensland's bioregions have been prepared based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (Department of the Environment and Heritage Protection (DEHP), 2014a). The BPAs draw upon the DES certified RE mapping, database information, and expert panel reports and incorporate information about threatened ecosystems and/or species, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, as well as buffers to wetlands or other types of important areas for ecological processes. The BPA assigns areas to one of three biodiversity significance levels, including: ▪ State significance — areas assessed as being significant for biodiversity at the bioregional or State scales ▪ Regional significance — areas assessed as being significant for biodiversity at the sub-bioregional scale ▪ Local significance and or other values — local values that are of significance at the local government scale. All remnant vegetation will qualify into one of the above three categories. Although it is not legislated, the BPA provides a framework for biodiversity assessment when determining environmental values. In addition to terrestrial BPAs, aquatic BPAs utilises and assesses the conservation and ecological value of wetland systems based on a series of national and international criteria, including naturalness (aquatic and catchment), diversity and richness, threatened species/ecosystems, priority species/ecosystem, special features, connectivity and representativeness to provide aquatic conservation assessments for SEQ (DEHP 2015).	The Project is located within the SEQ BPA area, (Queensland Government 2016a). The following reports outline the BPAs conducted within the ecology study area: ▪ Biodiversity Planning Assessment for the south-east Queensland Bioregion: Fauna Expert Panel Report (Version 4.1) (DEHP 2016a) ▪ Biodiversity Planning Assessment for the south-east Queensland Bioregion: Flora Expert Panel Report (Version 4.1) (DEHP 2016b) ▪ Biodiversity Planning Assessment for the south-east Queensland Bioregion: Landscape Expert Panel Report (Version 4.1) (DEHP 2016c) ▪ The ecology study area is located within the Bremer and Logan Aquatic Conservation Assessment catchments (as part of the wider SEQ catchment) and outlined within the following report: ▪ Aquatic Conservation Assessment using AQUABAMM for the riverine and non-riverine wetland of SEQ (DEHP 2015).

3 Methodology of assessment

3.1 Overview

An overview of the stages involved in the assessment of sensitive environmental receptors (i.e. MNES (restricted to migratory species not listed as threatened under the EPBC Act) and MSES (not listed as threatened under the EPBC Act) is provided in Figure 3.1. Further information regarding the development of predictive habitat mapping to support the assessment process provided in Appendix A.

The initial step of the assessment was to identify the sensitive environmental receptors relevant to the Project. This was undertaken using a combination of desktop-based datasets and validation of predictive, species-specific mapping, which was supplemented by targeted field surveys at defined locations (refer Section 3.4.1). Ecological site investigations associated with pre-clearance work for geotechnical investigations (EPBC Referral 2018/8263) were also incorporated into the findings (refer Section 3.3.2).

It should be noted from the outset that detailed onsite surveys for threatened fauna have not necessarily been carried out as per the relevant Commonwealth and/or State survey guidelines for each species. Surveys for protected flora have been carried out following State guidelines (e.g. DEHP 2014b). Nevertheless, a range of survey methods carried out over a number of years and seasons are considered applicable to detecting the potential presence of conservation significant flora and fauna that may occur in the area. Section 3.3.2 outlines the methods used during Project-associated surveys as they apply to species that are the subject of this technical report.

Predictive habitat modelling for each flora and fauna species that constituted a sensitive environmental receptors (refer Sections 3.3.4.1and 3.3.4.2) and associated constraints mapping, was developed based on the desktop and field survey results. It should be noted from the outset that detailed onsite surveys for threatened fauna and flora have not necessarily been carried out as per the relevant Commonwealth and State survey guidelines for each species. As such, the threatened species habitat modelling was based on a conservative approach to mapping habitat. That is, unless there is sufficient and robust scientific information to support a species from being excluded from the area, it has been assumed to be present if habitat for the species is known or there are local records for the species. The approach is also conservative given the quality of habitat or the carrying capacity of the habitat has been excluded from the assessment. Although this information may be used to determine whether a significant impact is likely when assessed against the MNES Guidelines (migratory species) or MSES Guideline – refer Sections 5.3.3 and 5.3.4 respectively.

The predictive habitat modelling and constraints mapping, along with relevant scientific information was used to inform the significant impact assessment (direct and indirect) and where applicable measures to avoid, minimise and mitigate impacts. As part of this assessment the maximum potential area of disturbance was determined using the predictive habitat modelling (i.e. the total extent of habitat to be cleared irrespective of habitat type and quality).

A key outcome of the significant impact assessment is the determination as to whether the Project will have a significant residual impact on each sensitive environmental receptor.

The approach outlined in Figure 3.1 and documented in this report, is the initial step in the determination of the extent of impacts associated with the Project upon sensitive environmental receptors. That is, during the detailed design, the design and construction methodology will be refined (in particular the disturbance footprint) with due consideration to the Project's impacts and mitigation measures, approval conditions and additional information on the ecological values of the Project (e.g. additional ecological surveys in accordance with Commonwealth and State threatened species survey guidelines). As such the significance of the impacts on sensitive environmental receptors will also change. All of which will be done in consultation with relevant stakeholders (Commonwealth and State government) and where applicable the community.

The approach adopted for this assessment is designed to be dynamic and will evolve in response to changes to the design and footprint, along with additional ecological information gained from Project activities (e.g. pre-clearing surveys or protected plant surveys in accordance with the relevant flora survey guidelines (i.e. DEHP 2016d) and changes to species status. This flexibility also has benefits such that during the construction stage, it allows management and monitoring of compliance with disturbance limits and environmental offset requirements. That is, the predictive mapping models along with other Project inputs (e.g. fauna 'breeding places' identified during pre-clearing surveys) can be used to identify temporary and permanent no-go zones and track clearing extents against relevant disturbance limits and where applicable inform additional specific mitigation measures.

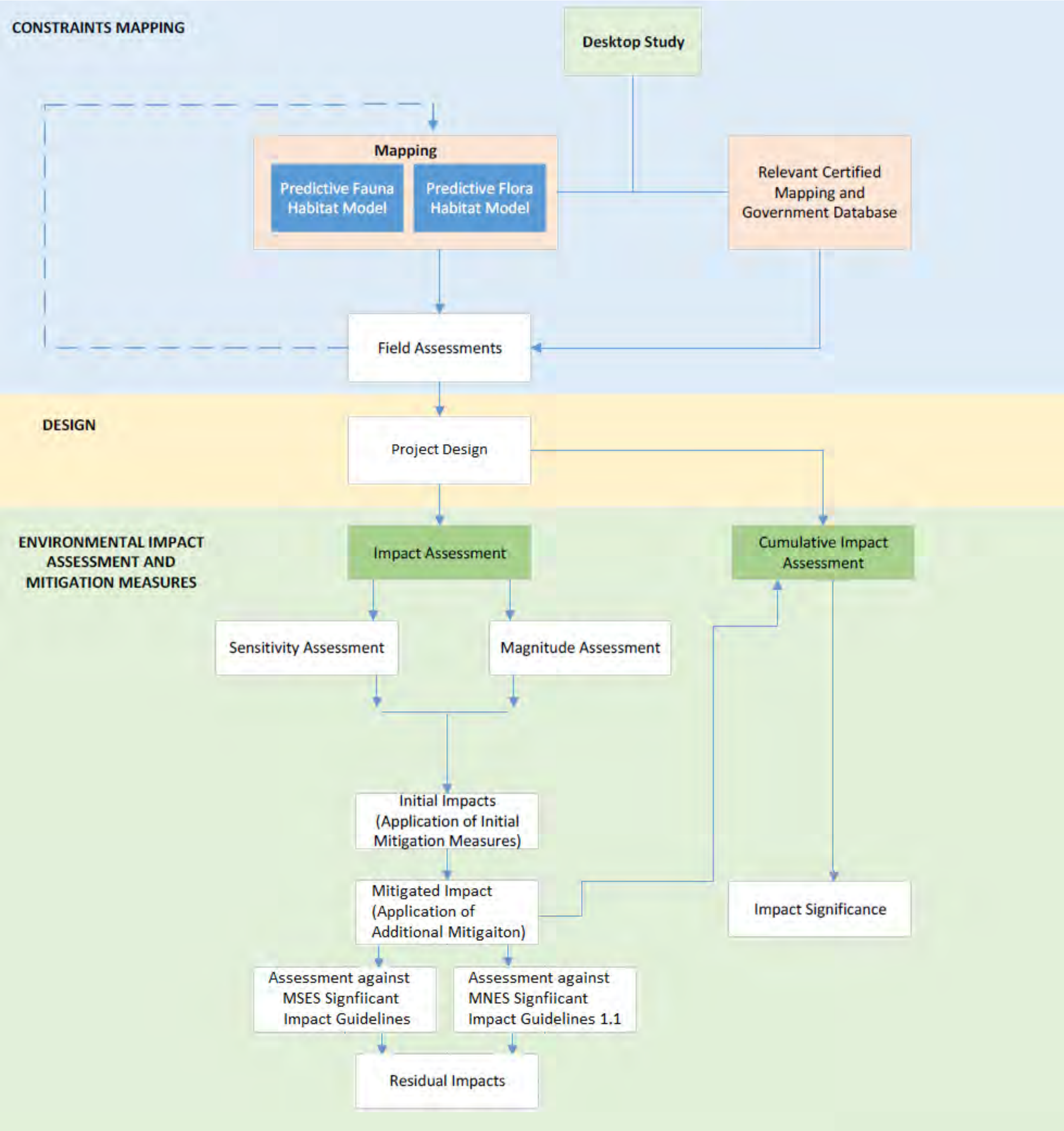


Figure 3.1 **Assessment methodology**

3.2 Stakeholder engagement

Flora, fauna and habitat matters have been raised regularly by stakeholders and the community in discussions, meetings and correspondence with the Project team. This included habitat for fauna and habitat connectivity across the corridor. The project team also held a workshop about how to provide species record information or data collected by community members to the Queensland government, so it can be recorded and recognized in the WildNet database from where it could be drawn to be used as part of the EIS investigations. The feedback provided by stakeholders and the community to the project team has continuously reinforced the importance of ecological values to the community and driven the project team to seek opportunities to avoid, minimise and manage impacts to species and their habitats wherever feasible in this stage of project development.

3.3 Desktop study

This section details the desktop analysis undertaken to identify existing terrestrial environmental and aquatic features and constraints related to flora and fauna and identify existing gaps in datasets. This analysis included a review of existing field data collected prior to the commencement of the Project EIS and field data collected during the EIS data collection phase. In addition, this section provides details related to the creation of predictive GIS models which specifically identify areas of habitat capable of supporting conservation significant flora and fauna species within the ecology study area. In accordance with the EIS Terms of Reference (ToR), the ecology study area was used to identify significant environmental receptors that are located in proximity to the Project.

3.3.1 Database review

A database review was undertaken in 2017 prior to field investigations to identify sensitive environmental receptors that were known or likely to be present within the ecology study area. However, to ensure that the most recent data was obtained, searches were re-run in 2020 to ensure that any relevant updates and species observations were incorporated into the assessment. Details of the relevant database sources, the most recent search dates, search area parameters and type of information considered for the desktop study are summarised in Table 3.1. It is acknowledged that the resolution currency of database information has its limitations, however these were minimised wherever possible by ensuring that the most recent datasets were used, datapoints with ambiguous metadata or of very low precision were excluded from analysis, and that any ground-truthed data (refer Sections 3.3.2 and 3.4) was prioritised over that of desktop based datasets. In addition, specimen backed records in excess of 30 years were excluded from analysis due to concerns related to currency and recent human induced disturbance to the broader area. Desktop searches can be found in Appendix D.

Table 3.1 Database review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (Atlas of Living Australia (AoLA) 2020)	29/03/2020	Ecology study area	Ongoing inspection of records of flora and fauna, including threatened species listed under the EPBC Act.
Flying Fox Monitoring Program (Queensland Government, 2020a)	24/03/2020	Ecology study area	Show the location of flying-fox roosts in Queensland recorded by the department and include monitoring data of continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Flying-fox roost monitoring and locations (DEHP 2016e)	04/03/2020	Ecology study area	Show the general location of flying-fox roosts in Queensland recorded by the department and include continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.

Database/data source name	Database search date	Database search areas	Data type
Birds Australia (2019)	29/03/2019	Ecology study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act.
BPA mapping (Queensland Government 2020b)	17/3/2020	Ecology study area	State, regional (MSES) and locally (MLES) significant biodiversity matters mapping. This mapping has been used to indicate the location of bioregional corridors (i.e. in the State, regional and local context). This mapping has also been used in the predictive modelling to identify core habitat areas (refer Appendix A). There are no MLES present in the ecology study area.
Back on Track species prioritisation framework (DEHP 2010a)	17/3/2020	SEQ NRM	The Back on Track species are categorised as Critical, High, Medium, or Low priority for the State and for each NRM region in Queensland. There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. Data is presented as a list of species (refer Sections 4.3.1.2 (flora) and 4.3.2.2 (fauna).
EPBC Act Protected Matters Search Tool (DAWE 2020a)	17/03/2020	Ecology study area	Provides a “predictive” account of MNES identified within a specific area. Includes: ▪ Threatened species as listed under the EPBC Act ▪ Migratory species listed under the EPBC Act ▪ TECs listed under the EPBC Act ▪ Critical habitats ▪ World Heritage Properties ▪ National Heritage Places ▪ Wetlands of International Importance (i.e. Ramsar) ▪ Great Barrier Reef Marine Park ▪ Commonwealth Marine Area Nuclear Areas
Groundwater Dependent Ecosystems Atlas (Bureau of Meteorology (BoM) 2020)	17/3/2020	Ecology study area	Provides information related to 3 types of groundwater dependant ecosystems (GDEs): aquatic, terrestrial and subterranean.
Regulated Vegetation Management Map (Queensland Government 2020c)	04/03/2020	Ecology study area	Mapping of regional ecosystems (REs) and High Value Regrowth that provide habitat for TECs and threatened species under the EPBC Act.
Register of critical habitat (Australian Government)	17/3/2020	Australian extent	Critical habitat listed under the EPBC Act.
Map of Referable Wetlands (Queensland Government 2020d)	17/3/2020	Regional extent	Includes State significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland REs.
Wildnet database (Queensland Government 2020e) incorporating WildNet and Herbrecs datasets	17/3/2020	Ecology study area	Records of flora and fauna, including conservation significant species listed under the EPBC Act and/or NC Act and MLES.
Wetland Info database (Queensland Government) 2020f)	04/03/2020	Ecology study area	Provides interactive maps, species records, case studies and legislation associated with Queensland wetlands.
Fish Habitat Areas (Queensland Government 2020g)	17/3/2020	Ecology study area	Boundaries of gazetted, declared fish habitat areas.

Database/data source name	Database search date	Database search areas	Data type
MSES Wildlife Habitat Map (Queensland Government 2020h)	17/03/2020	Ecology study area	Modelled habitat for threatened species listed under the EPBC Act.
Queensland waterways for waterway barrier works (Queensland Government 2020i)	17/3/2020	Ecology study area	Waterways where proposed waterway barrier works require assessment and approval under the Fisheries Act.
Watercourse Identification Mapping (Queensland Government 2020j)	17/3/2020	Ecology study area	Known extent of watercourses and drainage features that are managed under the *Water Act 2000.*
Queensland Springs Database (Queensland Government 2020k)	04/03/2020	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression groundwater dependent ecosystems (GDEs).
Matters of State Environmental Significance (Queensland Government 2020l)	17/3/2020	Ecology study area	Location of MSES including: ▪ Protected areas ▪ Marine parks ▪ Management A and Management B declared FHAs ▪ Threatened and special least concern wildlife listed under the NC Act ▪ Regulated vegetation under the VM Act ▪ Wetlands in a wetland protection area or wetlands of high ecological significance ▪ Wetlands and watercourses in high ecological value waters as defined in the Environmental Protection (Water) Policy 2009, Schedule 2 ▪ Legally secured offset areas.

3.3.2 Review of existing literature and previous studies

Ecological assessments have been undertaken by various parties to inform the preferred corridor and approval process. The assessments describe the ecological values contained within the ecology study area, including habitat, species diversity, abundance and seasonal distribution (refer Table 3.2). The assessments involved a range of survey techniques including methodologies that aligned with both the Commonwealth's and Queensland's threatened species survey guidelines.

In addition, seasonal variation was also captured in the modelling approach (refer Sections 3.3.4.1 and 3.3.4.2) which utilised government datasets and historic records that were developed across multiple seasons/years. The results of the modelling and subsequent mapping output provide a measure of the amount of suitable habitat that is present regardless of season as it collates essential habitat components required by the species (e.g. vegetation structure, geological feature, presence of specific hydrology regimes). In addition to the material identified in Table 3.2, site specific database queries as identified in Table 3.1, have been accessed to produce the predictive habitat mapping related to MSES flora and fauna to align with that prescribed by relevant conservation advice (refer Sections 3.3.4.1 and 3.3.4.2, Appendix A and Appendix B). Whilst it is acknowledged that each of the previous investigations were undertaken over a single season, the analysis of existing database records, additional survey work (refer Section 3.4) and the formulation of the predictive habitat models which are considered to adequately account for seasonal variation and detectability related to threatened species.

The findings of each of the studies were used to supplement gaps identified from database searches, particularly in relation to the MSES matters. Documents reviewed included those listed in Table 3.2. Information contained within these documents was incorporated into the predictive habitat mapping and relevant results sections of this report. This information was used to assess project related impacts in relation to MSES species.

Table 3.2 Project related assessments and reports

Document title	Reference	Summary of significant findings related to sensitive environmental receptors
Southern Freight Rail Corridor Study (March 2010) (C2K Project study area adjacent to east of Project)	AECOM (2010)	▪ Confirmation of the presence of the Swamp Tea-tree (*Melaleuca irbyana*) ▪ Observations of threatened species immediately east of ecology study area – anecdotally known to occur throughout the study area from community consultation feedback.
Australian Rail Track Corporation/Transport - Land/southwest of Ipswich/Queensland/Inland Rail Helidon to Calvert Project (EPBC referral 2017/7883)	ARTC (2017a)	▪ Provides initial details on how the project is likely to impact upon MNES (many of which are also MSES). This includes identification of potential habitat for 15 threatened species and five migratory species. ▪ Identified the likely presence of the following migratory species: – Fork-tailed Swift (*Apus pacificus*) – Marsh Sandpiper (*Tringa stagnatilis*)
Initial Advice Statement: Inland Rail, Helidon to Calvert – 15 February 2017.	ARTC (2017b)	▪ Provides initial details on how the project is likely to impact upon sensitive environmental receptors.
Inland Rail – Gowrie to Kagaru Geotechnical investigations. MNES assessment report – 23 July 2018 Biodiversity Management Plan – 31 October 2018	EMM Consulting (2018a, 2018b)	▪ Observations of threatened fauna throughout the alignment (scats and scratches) ▪ Confirmation of the presence of commonwealth related species (i.e. Lloyd's olive (*Notelaea lloydii*)) near Laidley
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2018 and 2019) Preclearance survey reports (2018 and 2019)	EMM (2018c, 2018d; 2019a, 2019b, 2019c)	▪ No MSES flora species observed
Inland Rail – Helidon to Calvert Geotechnical investigations. Protected plant survey report – 29 May 2019 Preclearance survey report (30 July 2019)	Eco logical (2019a, 2019b)	▪ Identification of a single Swamp Tea-tree (*Melaleuca irbyana*)

3.3.3 Assessment of the likelihood of occurrence of conservation significant species

The likelihood of occurrence of species of conservation significance, as an identifier of sensitive environmental receptors within the ecology study area, was determined based on the results of the desktop study and review of existing literature (refer Appendix B), which was later supplemented with data derived from field assessments (refer Section 3.4, Appendix D, Appendix E, Appendix H and Appendix I) and used to refine the predictive habitat mapping (refer Appendix A and Appendix F). The likelihood of occurrence assessment is central to determining which sensitive environmental features were identified for the Project and were subject to predictive habitat modelling (refer Section 3.3.4.1 and 3.3.4.2, Appendix A and Appendix G).

Species of conservation significance considered possible or likely to occur, or which were identified in the ecology study area during the field assessment, were assessed as sensitive environmental receptors applicable to the Project. Species of conservation significance which were considered unlikely to occur within the ecology study area, were not considered further as part of this assessment.

This process allowed for the identification of species that are most likely to be at risk from the Project impacts.

The likelihood of occurrence assessment was based on records collected during the Project EIS field assessments, historic datasets and consideration of a species current (known) distribution range and the presence and condition of suitable habitat in the ecology study area.

Species considered **unlikely** to occur include species that fit one or more of the following criteria:

- The ecology study area is beyond the current distributional limits
- Use specific habitat types or resources that are known not to be present in the ecology study area (e.g. altitudinal limits and intertidal saltmarshes and estuarine wetlands)
- Are considered locally extinct based on expert knowledge and/or literature.

Species considered to **possibly** occur include species that fit one or more of the following criteria:

- Have infrequently been recorded previously in the ecology study area (i.e. sporadic records with no recent sightings within the past 10 years within 20 km of the ecology study area)
- Use habitat types or resources that are present in the ecology study area, although generally in a poor or modified condition
- Are unlikely to maintain sedentary populations, however, may seasonally utilise resources within the ecology study area opportunistically during variable seasons or migration.

Species considered to **likely** occur include species that fit into one or more of the following criteria:

- Have been recently recorded in the ecology study area (i.e. sightings within the last 10 years within 20 km of the ecology study area)
- Use habitat types or resources that are present in the ecology study area, that are in good condition
- Are likely to maintain sedentary populations within the ecology study area.

Information related to ecology, habitat requirements and distribution for each of the species of conservation significance and communities identified from the desktop component is provided in Appendix B.

3.3.4 Predictive habitat modelling for conservation significant flora and fauna species

Predictive habitat modelling was undertaken to identify and map areas that were determined as having the potential to provide habitat for conservation significant species.

State-based GIS layer datasets were used as habitat delineators and were incorporated into the predictive habitat model where applicable for each species. For example, regional ecosystems associated with remnant and high value regrowth vegetation, geological datasets, drainage feature mapping and cadastral boundaries were used to identify road reserves (where grazing pressures would be excluded) that may provide important habitat for species.

In addition, to adequately capture known records of conservation species (e.g. historic records and those identified during field assessment), all areas (regardless of existing vegetation communities) within a 1 km radius of the record were “automatically” assigned as providing habitat for the specific species to which the record belonged. This distance adequately accounts for the potential movement and dispersal for the relevant species and would also mitigate potential issues associated with record precision. If the record occurred on the outside edge of the ecology study area, the 1 km buffer area for the record would still be integrated into the predictive habitat mapping where it intersected the ecology study area. In some instances, the mapped habitat contained areas of agricultural land, grassland (i.e. general habitat) and open woodland and habitat (i.e. considered essential habitat). The model was designed to recognise specific requirements of each threatened species, which were identified through the broader desktop analysis. This approach to habitat mapping represents a highly conservative methodology (i.e. where doubt exists, habitat is included rather than excluded in addition to the inclusion of some areas of habitat that are not considered essential to the survival of the species) so as not to underestimate potential habitat for conservation species.

Databases and other information that were used to feed into the predictive GIS based model are identified in Table 3.1 (refer Sections 3.3.1 and 3.3.2) and Appendix A. In addition to database information, data collected during field-based assessments (refer Section 3.4) was used to verify and ‘fine-tune’ model outputs (refer Appendix F).

3.3.4.1 Habitat mapping for species listed under the NC Act

The habitat in the predictive threatened species habitat model was for NC Act listed species was categorised as core, essential, general and unlikely using current scientific knowledge and pre-existing data derived from historic surveys, State based mapping, scientific publications and advice from industry recognised experts. The specific habitat assumptions for each species are provided in Appendix A.

The predictive habitat modelling provides greater certainty in predicting the likelihood of a species of conservation significance (NC Act listed species) occurring with the ecology study area, when compared to limited and or sporadic field investigations.

The species-specific assumptions allowed the following areas to be identified for each conservation significant species:

- Core habitat
- Essential habitat
- General habitat
- Unlikely habitat.

An overview of each of these categories is provided in the sections below.

Core habitat

Core habitat consists of essential habitat in which the species is known, and the habitat is recognised under relevant recovery plans or other relevant plans/policies/regulations. Where essential habitat intersects with areas identified as important within the relevant bioregion specific BPA, these areas have been elevated to the core habitat category. Species specific assumptions associated with the mapping of core habitat areas are detailed in Appendix A.

Aquatic fauna values were excluded from predictive core habitat modelling, with the highest tier of habitat modelling capped at essential habitat (as per Appendix A). There are currently no GIS datasets that are tractable to facilitate analysis of habitat to elevate essential habitat (i.e. known to support a species) to core habitat (i.e. areas of essential habitat contained within a protected area (e.g. BPA). However, any core terrestrial habitat in proximity to the aquatic ecosystem (i.e. watercourse), will flag significance of the aquatic values (as associated core habitat) due to the scaling of core terrestrial habitat mapping. As such, standalone aquatic core habitat is not possible (in the absence of any observation of species) in regard to core habitat predictive modelling.

Essential habitat

Essential habitat consists of areas containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter) or areas that have been confirmed as containing suitable habitat as identified by a specimen backed record or indirect evidence of the species (i.e. scat, trace, track, fur/feather, distinctive vocalisation or other site based evidence). Essential habitat has been defined from known location-specific records (i.e. low location error information and from within the last 30 years), with a 1 km buffer or site-based observation of the species during site investigations. In addition, if the 1 km buffer from the known record intersects an area identified as general habitat, the general habitat rating was elevated to essential habitat. Species specific assumptions associated with the mapping of essential habitat, and instances that deviate from the above criteria are detailed in Appendix A.

General habitat

General habitat consisted of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information to assess the area as essential/core habitat (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). General habitat also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records. General habitat may include areas of suboptimal habitat for a species. Species specific assumptions that define the general habitat category are identified in Appendix A.

Unlikely habitat

Unlikely habitat consisted of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species.

3.3.4.2 Habitat mapping for EPBC Act listed migratory species

The habitat in the predictive species habitat model for EPBC Act listed migratory species was categorised as Important habitat and Potential habitat using current scientific knowledge and pre-existing data derived from historic surveys, State based mapping and scientific publications and industry recognised experts. The specific habitat assumptions for each species are provided in Appendix A.

The predictive habitat modelling provides greater certainty in predicting the migratory species habitat occurring with the ecology study area, when compared to limited and or sporadic field investigations.

The species-specific assumptions allowed the following areas to be identified for each migratory species:

- Unlikely habitat
- Potential habitat
- Important habitat.

The use of these habitat categories aligns with DAWE's habitat definitions for species protected under the EPBC Act as identified in the *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DAWE 2020b).

An overview of each of these categories is provided in the sections below.

Important habitat

In line with the DAWE guidelines, important habitat has been identified for migratory species under the *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DAWE 2020b).

Species specific assumptions that define the Important habitat category for the abovementioned species is provided in Appendix A.

Potential habitat

Potential habitat consists of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information to assess the area as Important habitat or Habitat critical to the survival of the species (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). Potential habitat also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records. Potential habitat may include areas of suboptimal habitat for species. As Potential habitat for many species may include most of the mature vegetation communities of the specific bioregion, the potential habitat category restricts the habitat to a more limited and realistic set of environmental parameters which are supported by literature and field-based observations. Species specific assumptions that define the Potential habitat category are identified in Appendix A.

Unlikely habitat

Unlikely habitat consists of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species. However, it is acknowledged that these areas may provide temporary habitat for species during exceptional circumstances. It is considered that occurrences of the subject species within these areas is an anomaly as these areas are not likely to support the species in the long term.

3.4 Field assessments

This section outlines the field assessment methodologies adopted in recognition of relevant departmental guidelines or policies (i.e. survey guidelines, species recovery plans and the EPBC Act Significant Impact Guidelines). Field surveys were undertaken with reference to the following survey guidelines:

- Commonwealth published guidelines for threatened species where applicable (refer: http://www.environment.gov.au/epbc/policy-statements)
- Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland (Neldner et al 2017)
- Terrestrial vertebrate fauna guidelines for Queensland (Eyre et al 2018)
- Flora Survey Guidelines - Protected Plants, Nature Conservation Act 1992 (DEHP 2016d).

As noted previously detailed onsite surveys for threatened fauna and flora have not necessarily been carried out as per the relevant Commonwealth and State survey guidelines. For example, under the Survey guidelines for threatened birds (Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010) area searches for Red goshawk (*Erythrotriorchis radiatus*) should comprise 80 hrs of search effort spread across 10 days. A comparison of the Project survey effort with the required survey effort for each species as per the relevant survey guidelines is not presented within this report. The information within this document is based on desktop information and targeted field-based information from several surveys over a number of years. The approach to assessing threatened species presence and habitat modelling for threatened species has adopted a conservative approach in order to avoid underestimating the available habitat potentially present within the disturbance footprint. As such, it is considered this maintains the intent of the various guidelines. During the secondary Project approvals phase, detailed site-based surveys for threatened species will be required as the Project progresses, and the Project disturbance footprint is finalised.

The extent of fieldwork and predictive flora and fauna modelling undertaken for the Project, when used in conjunction with existing information (refer Table 3.3), are considered sufficient to provide confidence in predictions of potential impacts to sensitive environmental receptors.

The location of terrestrial and aquatic survey sites was dictated by land access agreements with landholders which was provided on a voluntary basis. This significantly reduced the areas that were accessible to ecological investigations.

Whist not specifically detailed within this document, results of previous field work conducted by Jacobs – Jacobs - GHD (2016) and findings associated with ecological investigations to support approval processes for Gowrie to Kagaru geotechnical program (i.e. undertaken by EMM and ELA) which occurred concurrently with the EIS investigations reported in this document, have been incorporated within the EIS reporting where relevant. Refer to Figure 3.2 for the locations of areas undertaken as part of these surveys. Surveys undertaken to support the geotechnical program were undertaken in accordance with the Flora survey guidelines - protected plants, *Nature Conservation Act 1992* (DEHP 2016d) and in addition, habitat assessments (including breeding and foraging habitat for threatened species), focussing on those listed as threatened (e.g. Glossy-black cockatoo and Powerful owl). This data has been used to assist in the predictive habitat mapping within the ecology study area.

3.4.1 Field assessment locations and timing

A representative sampling approach was employed as part of the Project EIS field sampling methodology. Seasonal sampling (i.e. Spring (mid-September to mid-December) and Autumn (late February to April)) are recommended for the SEQ bioregion (Eyre et al. 2015). Targeted surveys were undertaken by the Project EIS team during Spring 2017, with opportunistic surveys extending from February 2018 to October 2018. Additionally, the use of publicly available datasets, surveys undertaken by Jacobs - GHD 2016 (i.e. Autumn 2016) fulfil the seasonal requirements. The survey timings are considered adequate to measure taxa diversity and their repetition throughout the ecology study area. In addition, when combined with the predictive habitat modelling (refer Section 3.3.4) which has been supplemented with field-based datasets, a highly conservative approach has been adopted to the assessment of threatened species.

3.4.1.1 Previous and concurrent ecological surveys for Project

Table 3.3 presents the survey timing and survey activities associated with previous Project associated ecological investigations, including the Arup/SMEC works in 2016, and geotechnical field investigations undertaken by Eco Logical Australia (2019a, 2019b) and EMM Consulting (2018 and 2019). Figure 3.2 present the survey location points. Note, there is substantial overlap in the location of surveys undertaken during programs presented in Figure 3.2 with those undertaken as part of targeted surveys associated with the EIS in 2017 (refer Figure 3.3), allowing for seasonal assessments of the same areas. The targeted surveys for the EIS have also captured areas within the alignment not subject to assessment elsewhere such that the majority of the disturbance footprint has been subject to ecological assessment.

Table 3.3 Timing of field investigations undertaken associated with the Project used to supplement the results of the current study

Study/investigation	Consultant / year	Timing of investigations	Season	Methodologies and notes
Initial ecological assessment to support EPBC referral 2017-7883	Arup/SMEC (2016)	30 March to 1 April and 1 June 2016	Autumn, Winter (2016)	▪ Targeted threatened fauna species searches at 8 sites ▪ Protected plant surveys ▪ Fauna habitat assessments - 16 sites
Protected plant surveys associated with geotechnical investigations to support EPBC Referral 2018-8263 and inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM Consulting (2019a, 2019b)	16 May 2018 - 28 June 2018	Autumn, Winter (2018)	▪ Protected plant surveys within/adjacent to the Project disturbance footprint (meander surveys – minimum 30 minutes) at 15 sites throughout H2C the Project disturbance footprint

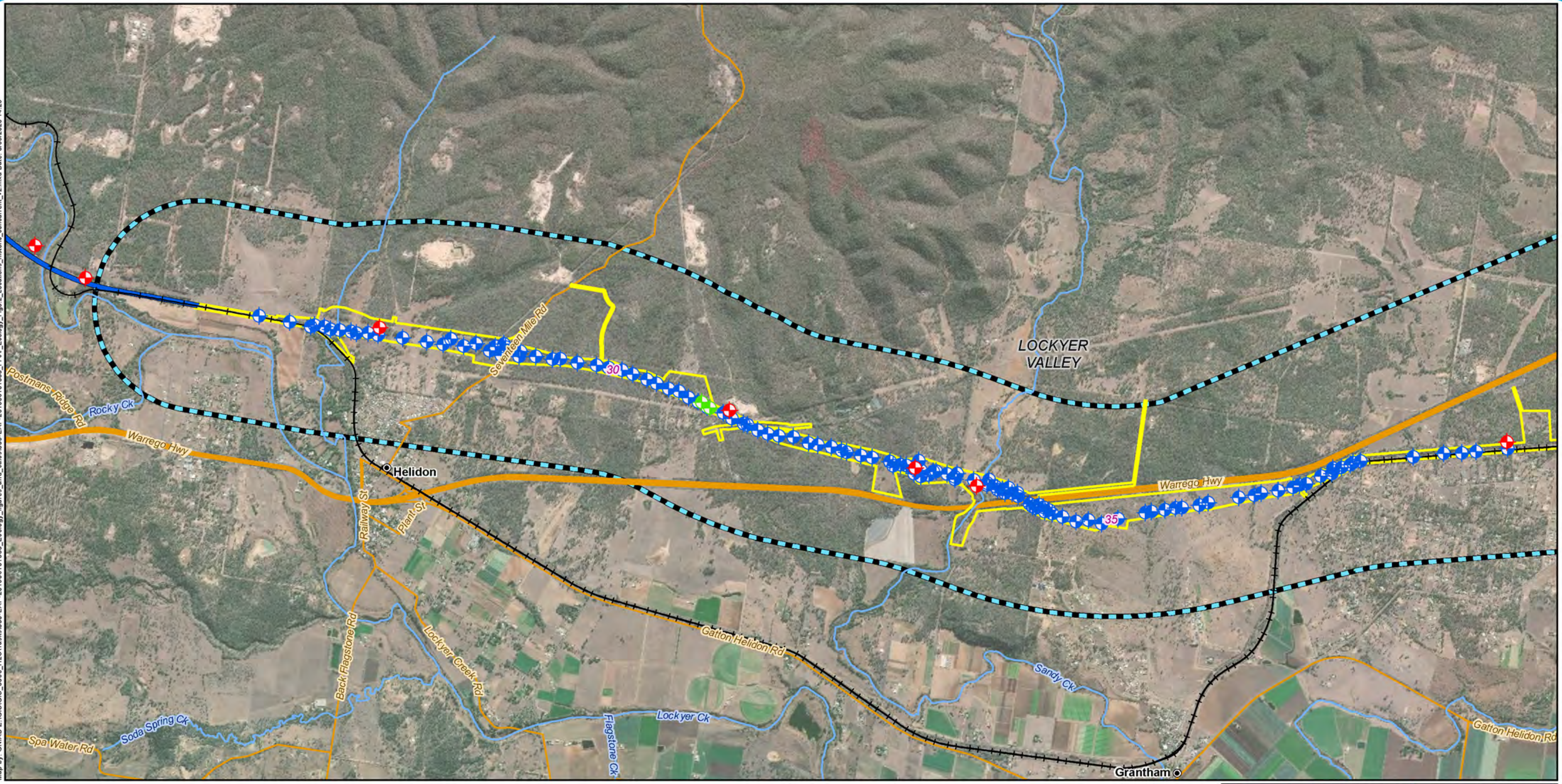
Study/investigation	Consultant / year	Timing of investigations	Season	Methodologies and notes
Pre-clearing surveys associated with geotechnical investigations to support EPBC Referral 2018-8263 and inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM Consulting (2018c, 2018d)	4-14 September 2018 26-28 November 2018	Spring (2018)	▪ Threatened fauna habitat assessments within/adjacent to the Project disturbance footprint ▪ Searches for fauna breeding places ▪ Vegetation community confirmation ▪ Fauna observations ▪ Assessment of 137 sites throughout H2C Project disturbance footprint
Protected plant surveys associated with geotechnical investigations for H2C alignment	Eco Logical Australia (2019a)	December 2018 and February 2019	Summer/ Autumn (2018/2019)	▪ Protected plant surveys within/adjacent to alignment (meander surveys – minimum 30 minutes) at 11 sites throughout the Project disturbance footprint (covering 24.72 ha)
Pre-clearing surveys associated with geotechnical investigations for H2C alignment	Eco Logical Australia (2019b)	December 2018 and April 2019	Summer/ Autumn (2018/2019)	▪ Threatened fauna habitat surveys within/adjacent to the Project disturbance footprint ▪ Searches for fauna breeding places ▪ Fauna observations ▪ Vegetation community confirmation ▪ Carried out at 2 sites throughout the Project disturbance footprint

Following the desktop component, sites were selected which were specifically identified as containing features of interest. Specifically, areas:

- Containing a representative example of a distinct vegetation community (i.e. areas contained within mapped remnant vegetation, regrowth vegetation, and non-remnant vegetation areas)
- Containing landscape features that were considered likely to support conservation significant species when viewed from aerial photography (i.e. Gilgai areas, wetlands and escarpments)
- Known or predicted to support conservation significant species
- With waterways which may be potentially impacted by the Project
- That have not been subject to previous ecological investigations.

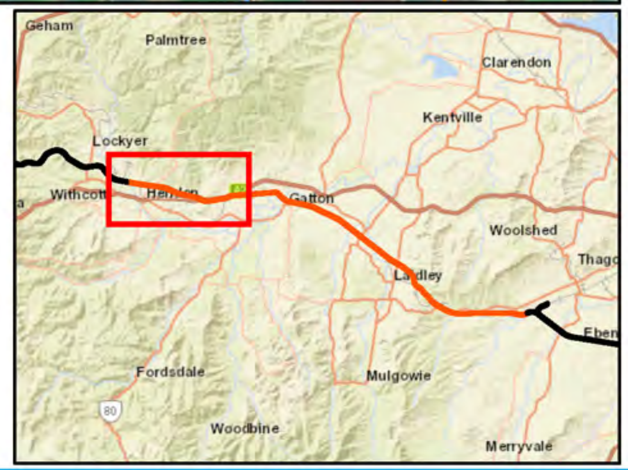
At each terrestrial sampling location, a vegetation survey, a fauna habitat assessment, active searches for cryptic fauna and opportunistic observations were undertaken as a minimum. In instances where wetland indicators were present (e.g. macrophytes, topography consistent with wetlands or areas mapped as a wetland), an assessment of the potential of the area to be a wetland was undertaken, recording site-based attributes as required.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Supplementary fauna survey point (ELA)
- Supplementary flora survey point (ELA/EMM)
- Supplementary terrestrial ecology survey point (Arup)
- Existing rail
- G2H project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas



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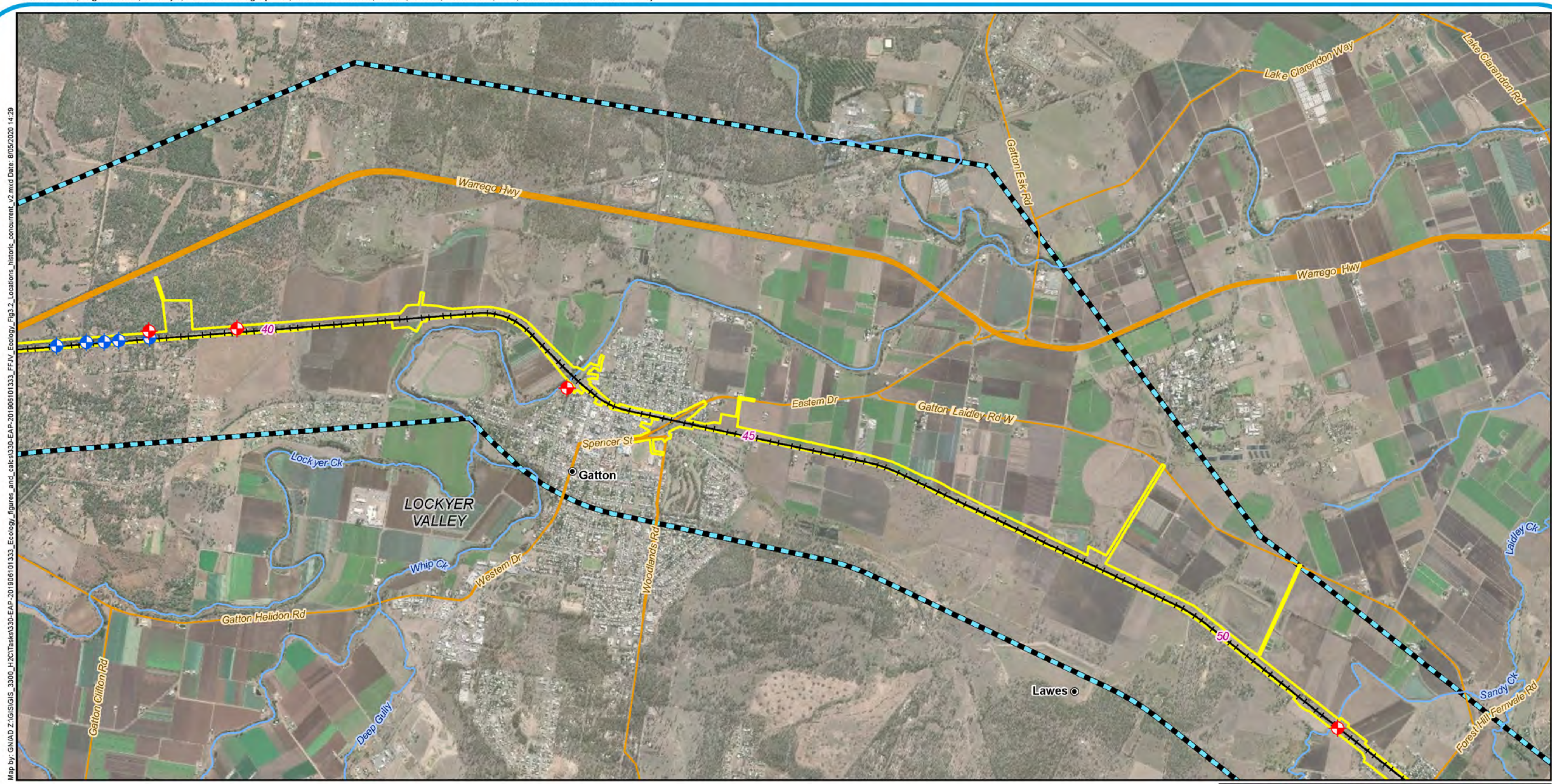
Helidon to Calvert

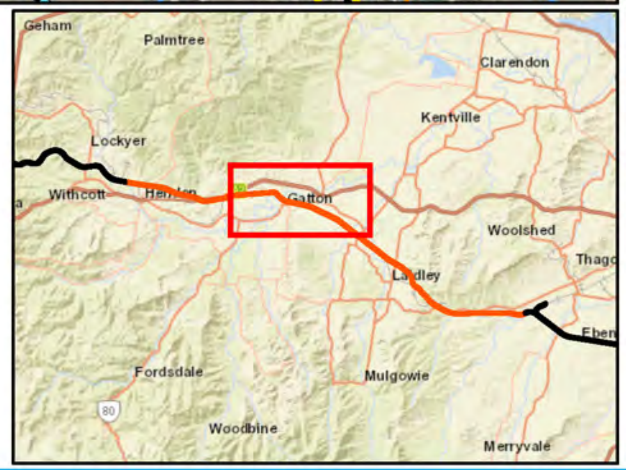
Figure 3.2a: Location of areas sampled as part of historic and concurrent works

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Supplementary fauna survey point (ELA)
- Supplementary terrestrial ecology survey point (Arup)
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas



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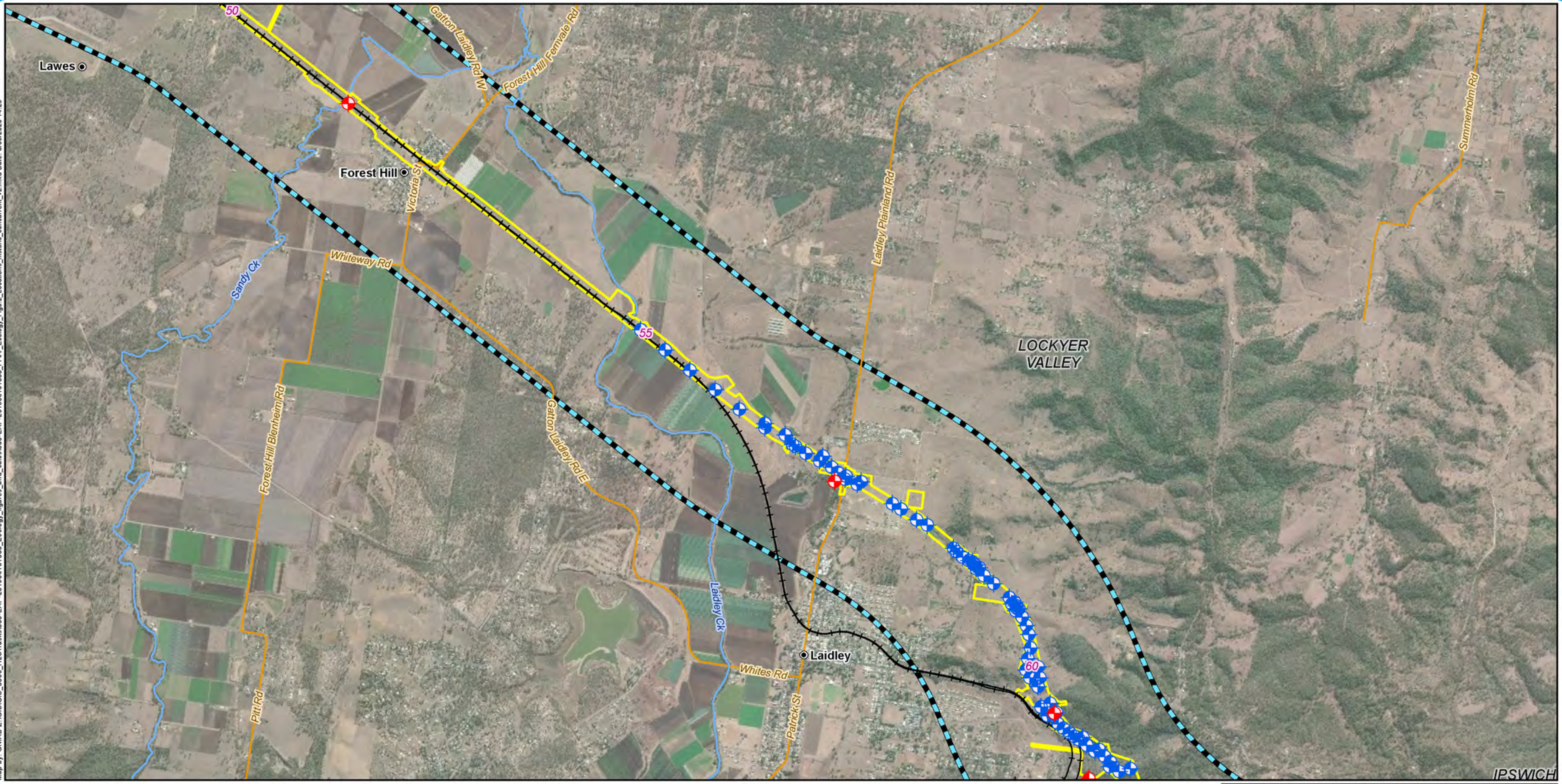
Helidon to Calvert

Figure 3.2b: Location of areas sampled as part of historic and concurrent works

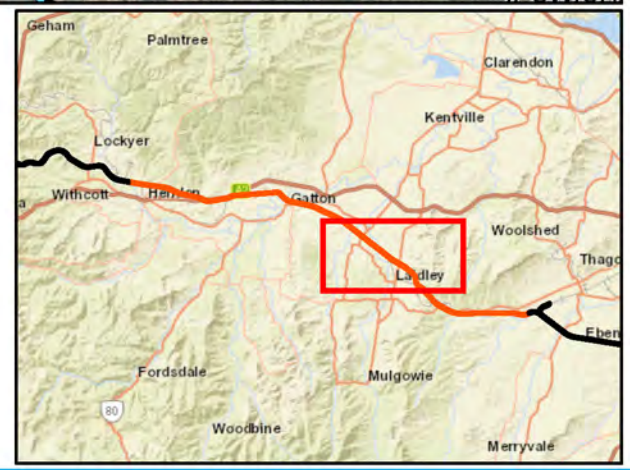
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: GN/AD Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig3.2_Locations_historic_concurrent_v2.mxd Date: 8/05/2020 14:29



Legend

- 5 Chainage (km)
- Localities
- Supplementary fauna survey point (ELA)
- Supplementary terrestrial ecology survey point (Arup)
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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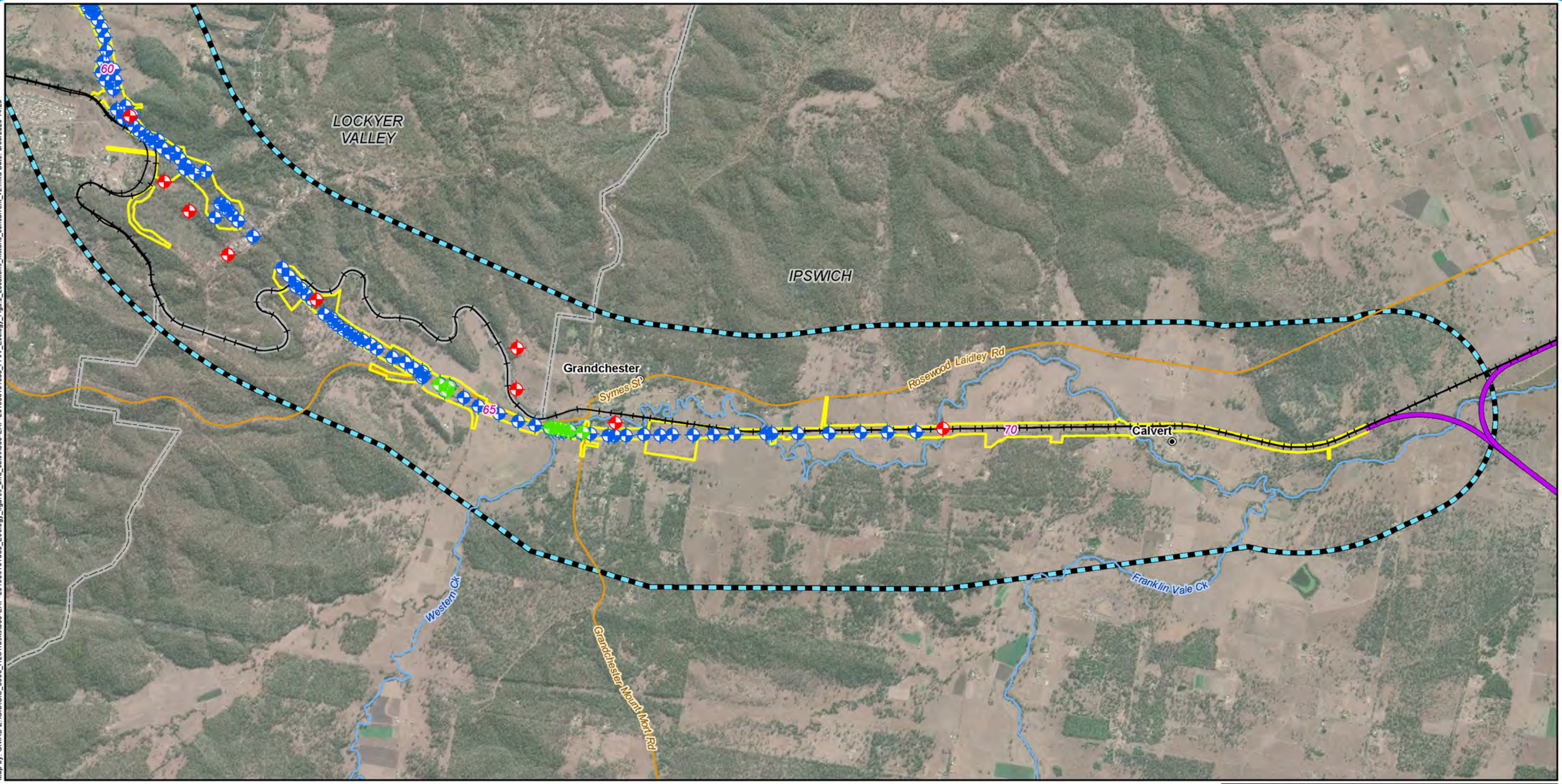
Helidon to Calvert

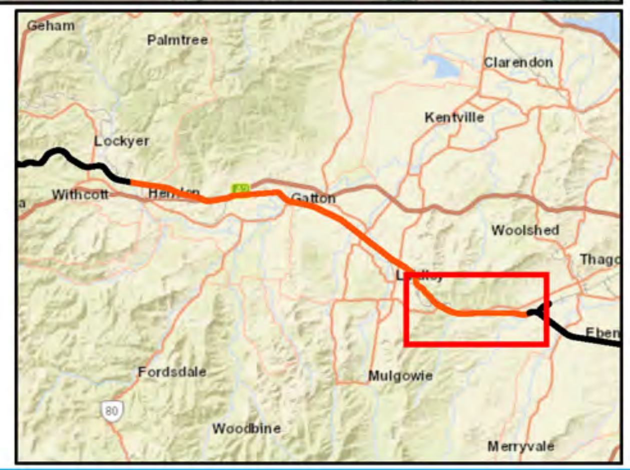
Figure 3.2c: Location of areas sampled as part of historic and concurrent works

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Supplementary fauna survey point (ELA)
- Supplementary flora survey point (ELA/EMM)
- Supplementary terrestrial ecology survey point (Arup)
- Existing rail
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

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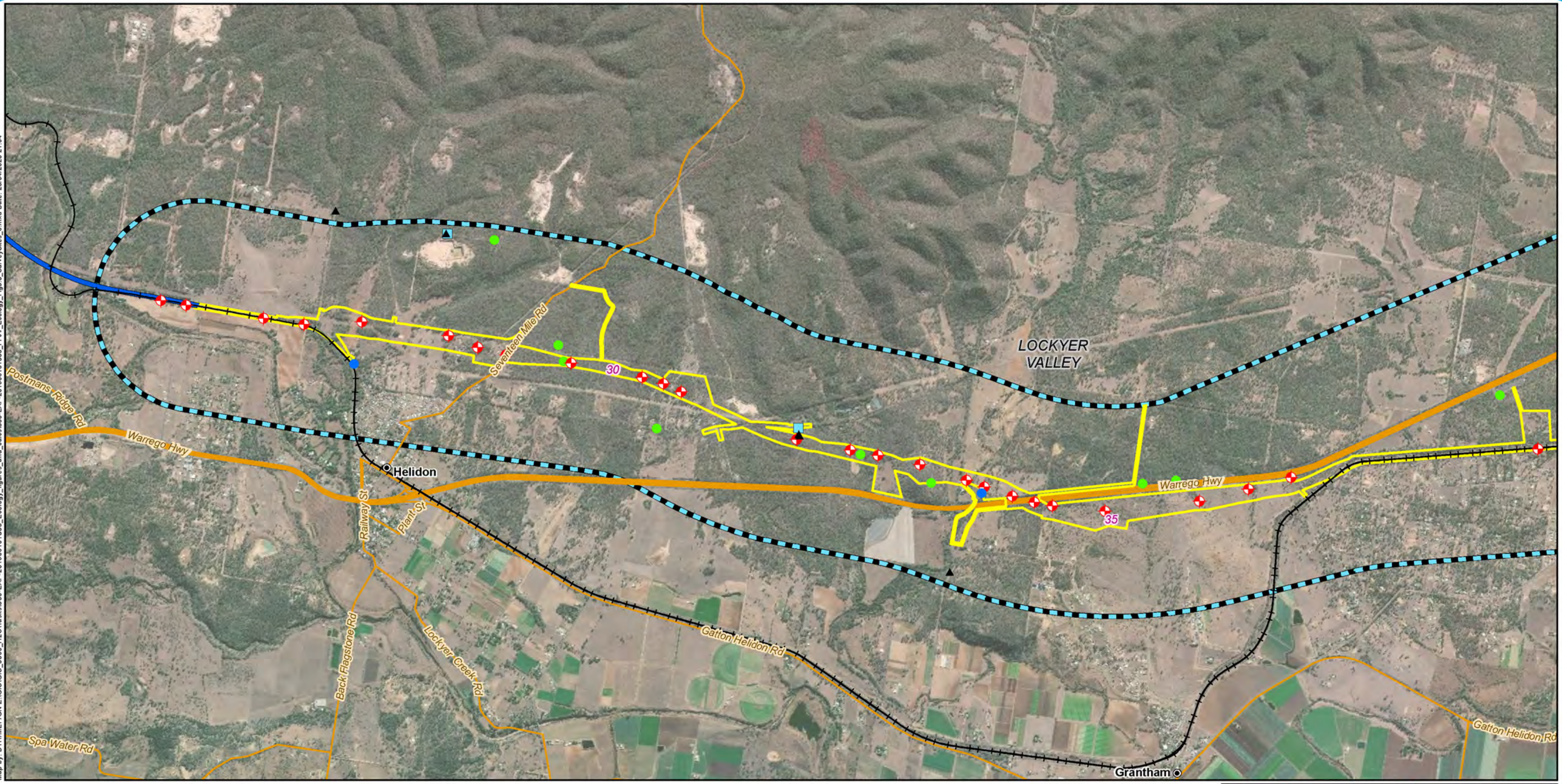
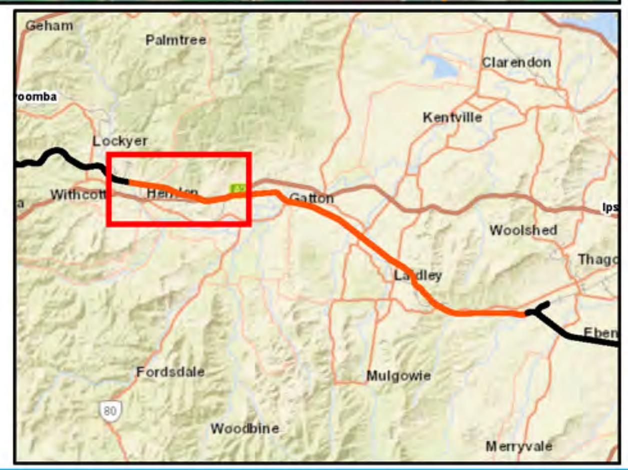
Helidon to Calvert

Figure 3.2d: Location of areas sampled as part of historic and concurrent works

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig3.3_SurveySites_6.mxd Date: 23/04/2020 21:04



Legend

- 5 Chainage (km)
- Localities
- Aquatic sampling sites
- Terrestrial sampling sites
- Opportunistic surveys
- Camera sites
- Anabat sites
- Existing rail
- G2H project alignment
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5 km

Future Freight
Integrating Community, Environment and Engineering

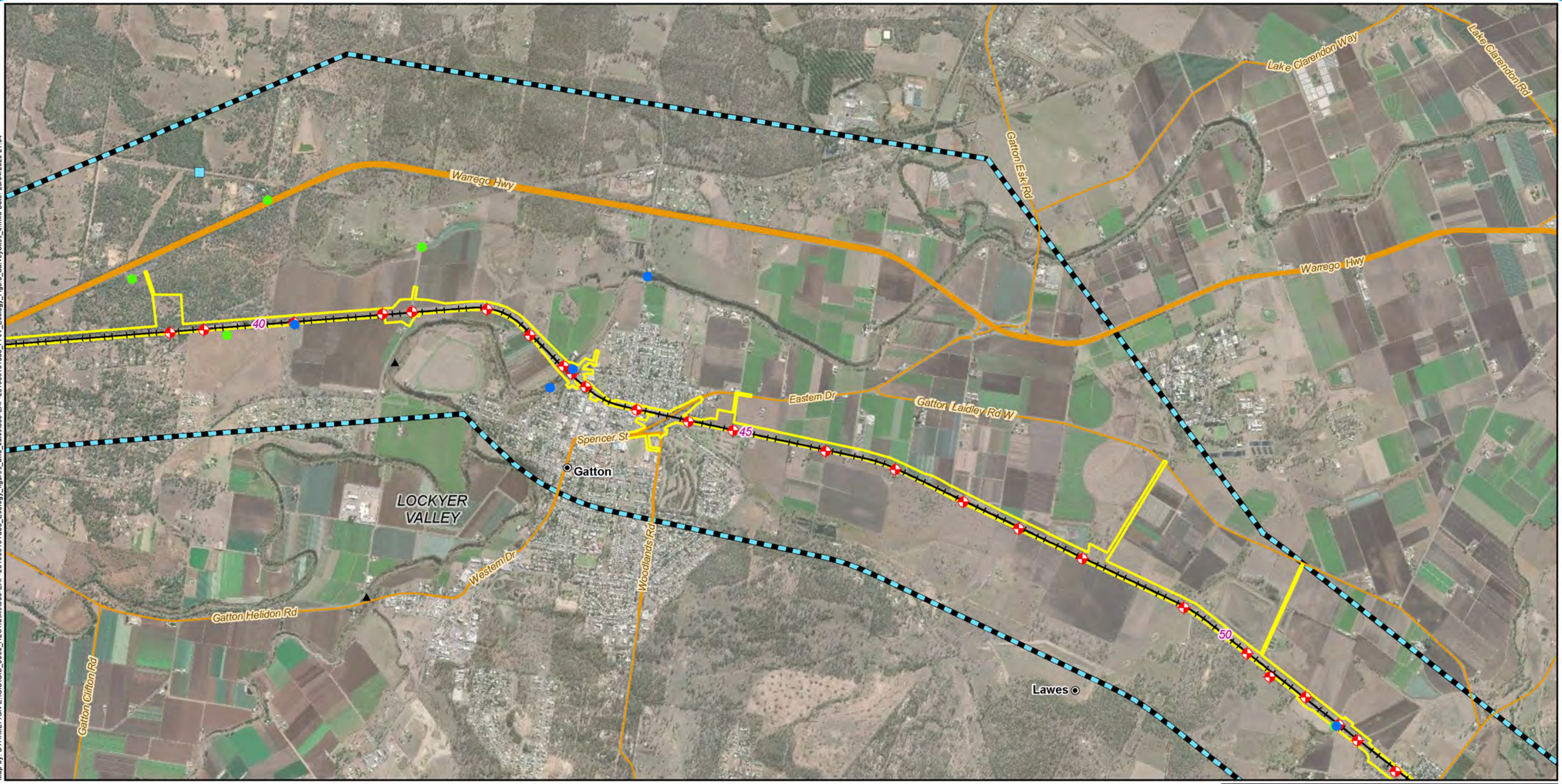
Issue date: 21/04/2020 Version: 6
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

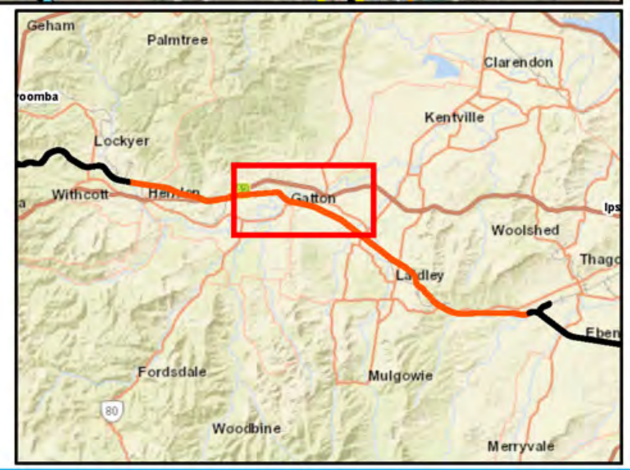
Figure 3.3a:

Location of sampling locations within the Ecology study area

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_cales\330-EAP-201906101333_FFJV_Ecology_Fig3.3_SurveySites_6.mxd Date: 23/04/2020 21:04



Legend

- 5 Chainage (km)
- Localities
- Aquatic sampling sites
- Terrestrial sampling sites
- Opportunistic surveys
- Camera sites
- Anabat sites
- Existing rail
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5 km

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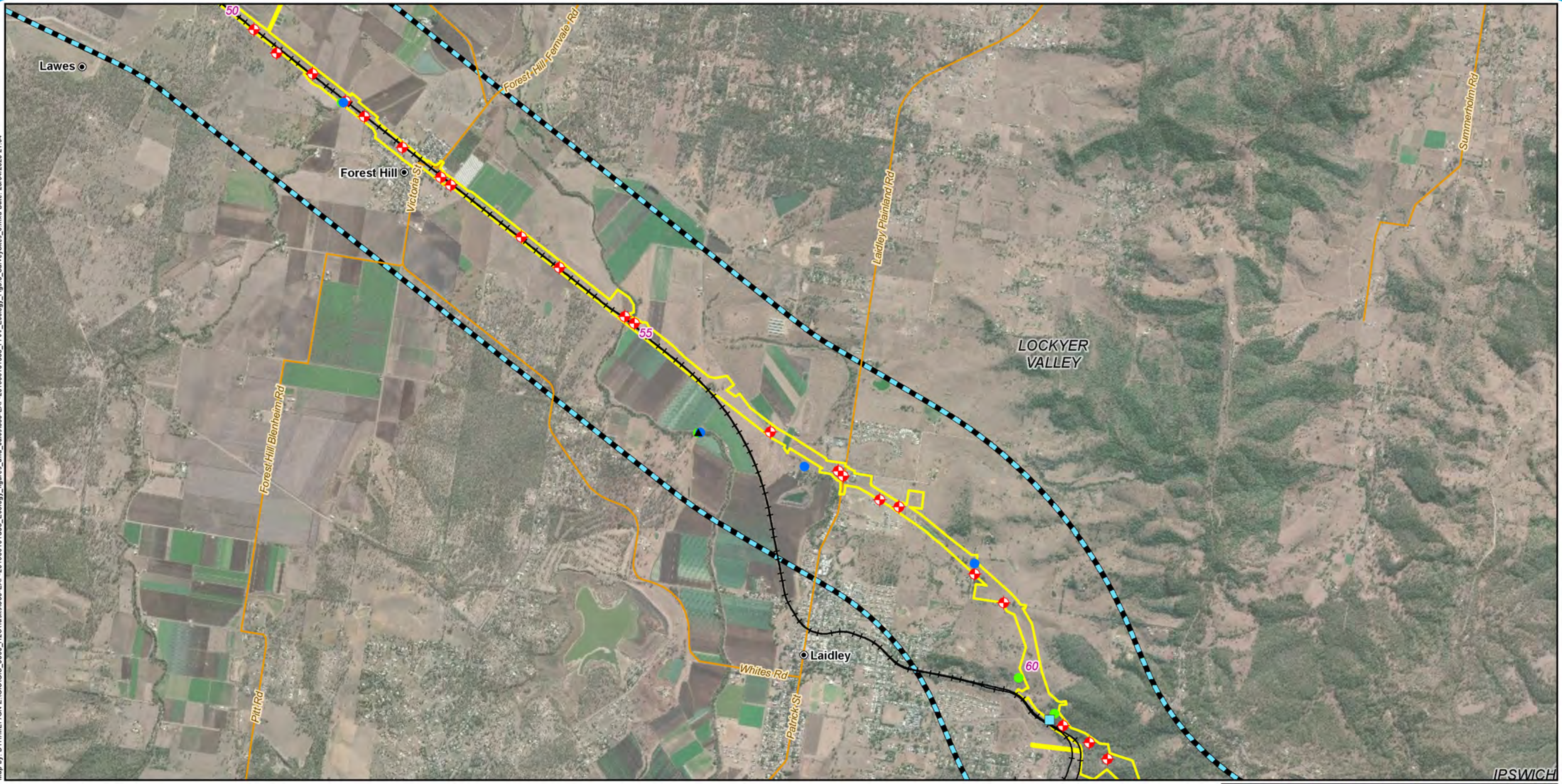
Helidon to Calvert

Figure 3.3b:

Location of sampling locations within the Ecology study area

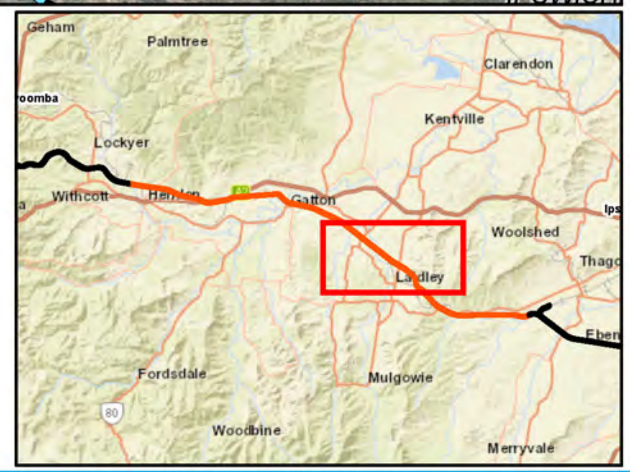
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_cales\330-EAP-201906101333_FFJV_Ecology_Fig3.3_SurveySites_6.mxd Date: 23/04/2020 21:04

Legend

- 5 Chainage (km)
- Localities
- Aquatic sampling sites
- Terrestrial sampling sites
- Opportunistic surveys
- Camera sites
- Anabat sites
- Existing rail
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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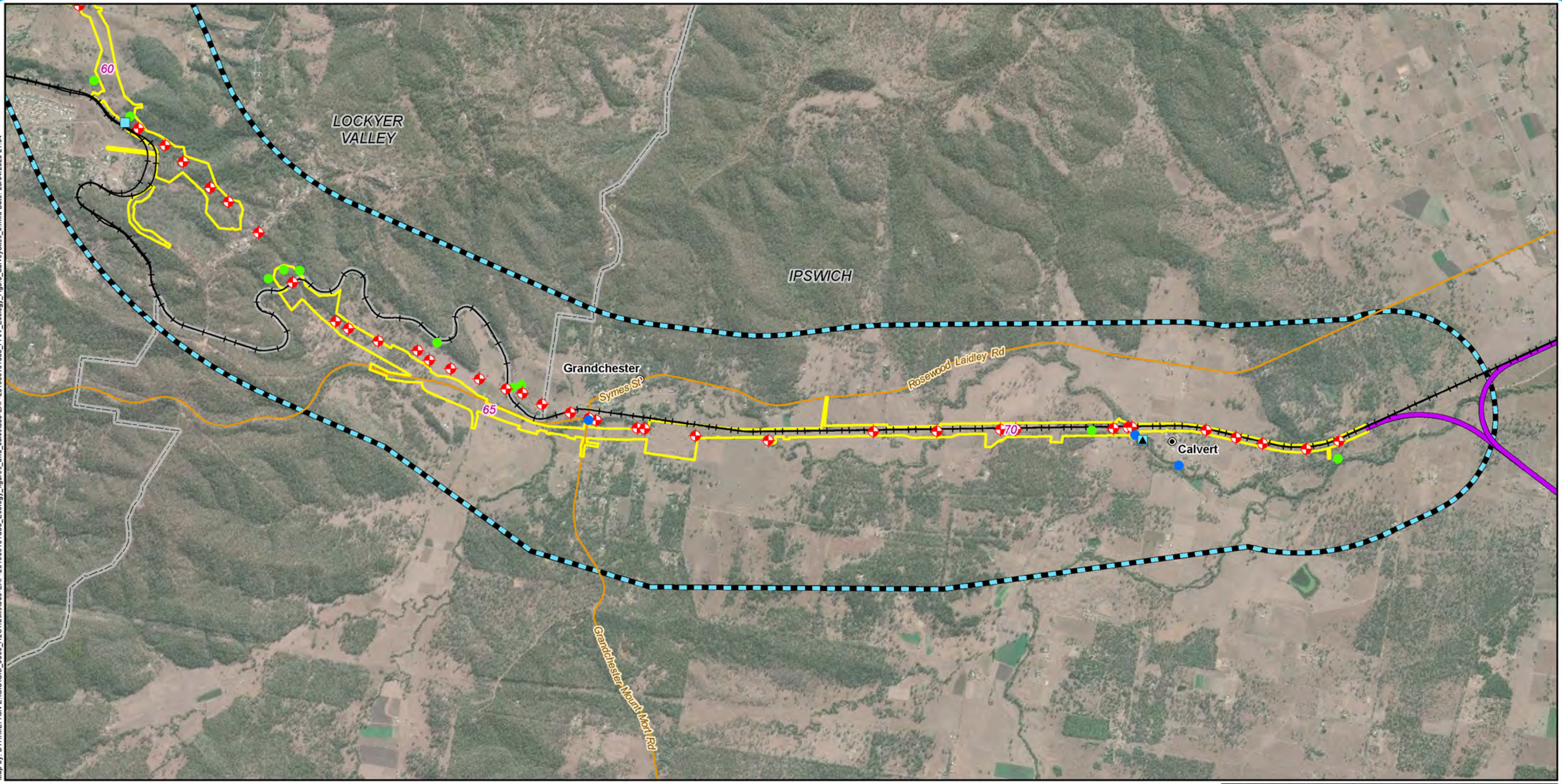
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

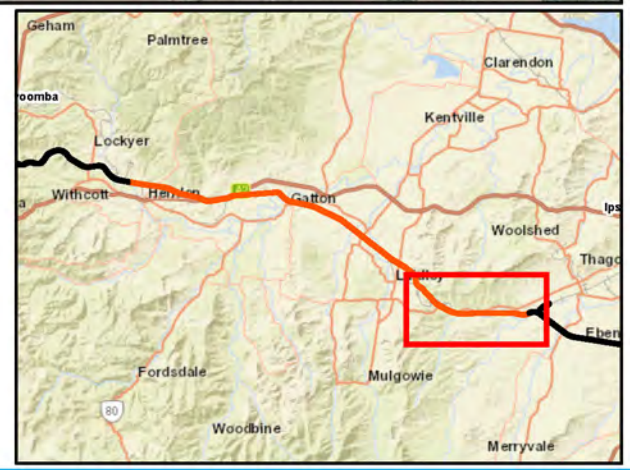
Figure 3.3c:

Location of sampling locations within the Ecology study area

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig3.3_SurveySites_6.mxd Date: 23/04/2020 21:04



Legend

- 5 Chainage (km)
- Localities
- Aquatic sampling sites
- Terrestrial sampling sites
- Opportunistic surveys
- Camera sites
- Anabat sites
- Existing rail
- C2K project alignment
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 21/04/2020 Version: 6
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 3.3d:
Location of sampling locations within the Ecology study area

3.4.1.2 Project ecological studies

Following the desktop study, sites were selected which were specifically identified as containing features of interest. Terrestrial ecology surveys were undertaken at 26 sites and aquatic ecology surveys were undertaken at 17 sites. Specifically, the following features were used to target areas:

- Containing a representative example of a distinct vegetation community (i.e. areas contained within mapped remnant vegetation, regrowth vegetation, and non-remnant vegetation areas)
- Containing landscape features that were considered likely to support threatened species when viewed from aerial photography (i.e. gilgai areas, wetlands and escarpments)
- Known or predicted to support threatened species
- With waterways which will be potentially impacted by the Project
- That have not been subject to previous ecological investigations.

At each terrestrial sampling location, a vegetation survey, a fauna habitat assessment, active searches for cryptic fauna and opportunistic observations were undertaken as a minimum (refer Appendix I and Appendix J). Wetland assessments were undertaken in instances where wetland indicators were present (e.g. macrophytes, topography consistent with wetlands or areas mapped as a wetland). At each aquatic ecology sampling location, an AUSRIVAS physical assessment protocol was completed to assess the existing physical habitat values of the waterway. All aquatic field assessments were completed during October 2017. The location of the terrestrial and aquatic assessment survey sites within the ecology study area, and the date of assessment, are presented in Table 3.4 and shown in Figure 3.3. In addition, opportunistic fauna sampling locations are provided in Figure 3.3.

Table 3.4 Targeted field survey sites and date of assessment

Site ID	Site location (GDA94)		Date assessed
	Latitude	Longitude	
Terrestrial ecology survey sites			
T2	-27.542124	152.261631	22 September 2017
T3	-27.5398618	152.142731	26 September 2017
T4	-27.5412823	152.143247	26 September 2017
T5	-27.5471236	152.152185	26 September 2017
T6	-27.5494628	152.171836	25 September 2017
T7	-27.5519496	152.178633	18 September 2017
T8	-27.5521229	152.199051	24 September 2017
T9	-27.5518616	152.202274	24 September 2017
T10	-27.5446987	152.233621	24 September 2017
T11	-27.5379911	152.246792	24 September 2017
T12	-27.5496055	152.242742	22 September 2017
T14	-27.5837466	152.349497	22 September 2017
T15	-27.6123215	152.383754	22 September 2017
T16	-27.6334983	152.414612	23 September 2017
T17	-27.6366002	152.418062	23 September 2017
T19	-27.650621	152.43138	21 September 2017
T20	-27.6499563	152.434404	21 September 2017
T21	-27.6498777	152.432833	21 September 2017
T23	-27.6562025	152.447643	19 September 2017
T24	-27.660068	152.454903	25 September 2017

Site ID	Site location (GDA94)		Date assessed
	Latitude	Longitude	
T25	-27.6598818	152.455766	25 September 2017
T26	-27.6890756	152.462416	19 September 2017
T27	-27.6640052	152.510872	19 September 2017
T28	-27.6648618	152.515745	19 September 2017
T29	-27.6665154	152.534648	19 September 2017
New E	-27.5307878	152.136645	25 September 2017
Aquatic ecology survey sites			
H2C 1A	-27.5528474	152.183508	10 October 2017
H2C 2A	-27.5487085	152.249294	12 October 2017
H2C 3A	-27.5542918	152.273942	12 October 2017
H2C 4A	-27.5527001	152.276136	9 October 2017
H2C 5A	-27.5837446	152.349692	10 October 2017
H2C 7A	-27.6152834	152.394006	11 October 2017
H2C 8A	-27.623664	152.410394	11 October 2017
H2C 9A	-27.6629196	152.462253	11 October 2017
H2C 10A	-27.664389	152.515044	11 October 2017
H2C 11A	-27.5507779	152.120564	9 October 2017
H2C 12A	-27.5447612	152.283386	10 October 2017
H2C 13A	-27.5814724	152.367306	10 October 2017
H2C 14A	-27.6123168	152.384017	12 October 2017
H2C 15A	-27.541364	152.123031	12 October 2017
H2C 16A	-27.5960112	152.343383	13 October 2017
H2C 17A	-27.6321585	152.386594	13 October 2017
H2C 18A	-27.6670612	152.519272	13 October 2017

3.4.2 Terrestrial flora field assessment

At each terrestrial survey site targeted for the FFJV EIS studies, a list of all flora species encountered, were recorded and documented. In addition, opportunistic observations across the ecology study area were used to supplement site specific datasets. Significant flora species that were not previously encountered, or species that were unidentifiable in the field (when sampling occurred), were collected and lodged at the Queensland Herbarium for formal identification. As per Aurecon's current Scientific Purposes Permit requirements, no more than two samples per species were taken at each survey location when sampling was required for identification purposes.

Verification via ecological assessment of a representation of distinctly different vegetation communities identified during the desktop component was undertaken in the field (refer Section 4.4). The following approach to sampling was applied:

- Within a representative of each different type of vegetation determined from aerial imagery, an intensive survey occurred, which included an assessment of the relative species density and diversity within the emergent stratum (Es), canopy (T1, T2, T3), shrub (S1, S2, S3) and ground strata (G) layers when they were present. Methodologies used were consistent with the Tertiary level as described by Neldner et al. (2012, 2017). Survey transects approximated 100 m in length and 20 m in width.
- Once a full vegetation survey was complete for each representative of the specific vegetation community, verification of the remaining map units of the same type was undertaken at the Quaternary level as described by Neldner *et al* (2012, 2017) (refer Appendix H for site vegetation assessment datasheets).

A representation of the predictive flora habitat modelling for sensitive environmental receptors (i.e. MNES flora) (refer Section 3.3.4) was verified where applicable during site field investigations throughout the ecology study area. In addition, where present wetland and spring vegetation was verified, this information fed back into the GIS system and was used to refine the predictive habitat modelling, wetlands and springs mapping as appropriate (refer Figure 3.1), noting where wetlands and water courses were dry during the surveys.

Field verification and refinement of predictive flora habitat mapping was undertaken by comparing the species-specific habitat assumptions derived from the desktop phase (refer Appendix A), to characteristics observed in the field. Where site-based field observations significantly deviate from the desktop derived habitat assumptions, these areas were amended within the predictive habitat mapping. Alternatively, where a conservation significant species was observed, these areas were elevated in status to either general habitat (for areas that were not currently mapped as general habitat for the species), or essential habitat (for locations that were already included within the general habitat mapping layer) (refer Section 3.3.4 and Appendix A for further detailed information).

3.4.2.1 Protected plant surveys

In addition to the methodologies presented above, a random meander survey was undertaken at each target and each opportunistic site (regardless of their inclusion/exclusion from 'High Risk' areas identified in the QLD Government Protected Plants flora survey trigger map) to specifically target threatened species. At each site, the random meander survey was undertaken (as per the QLD Protected plants survey guidelines (DEHP 2016d)) until no new flora species were identified for 30 minutes following the recording of the last identified flora species. As such, surveys were carried out for a minimum of 30 minutes at each site but may have extended well beyond this search timeframe where new species were encountered. Samples of all EPBC Act listed flora species encountered, were submitted with the Queensland Herbarium for incorporation into the HERBRECS database, and all flora survey records were submitted to the DES as part of FFJV's scientific purposes licencing commitments.

The random meander survey method was also employed at sites within and adjacent to the Project disturbance footprint associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) (EMM Consulting 2018a, 2018c, 2018d; EMM Consulting 2019a, 2019b; Eco Logical Australia 2019a, 2019b). As per the QLD protected plant survey guidelines (DEHP 2016d), surveys were carried out within the targeted clearing area with an additional 100 m buffer area applied (providing a substantial survey area at each site).

3.4.3 Terrestrial fauna field assessments

Assessments for conservation significant fauna species were conducted for the EIS studies (FFJV) with the following objectives:

- Validation of the predictive habitat mapping where applicable
- Use of specific techniques to identify conservation significant species and their habitat where present.

In addition to the techniques identified above, the use of existing datasets, historic records and the formulation of the predictive habitat models for conservation significant species provided a comprehensive assessment of the conservation significant fauna habitat contained within the ecology study area, that is considered to incorporate seasonal (i.e. temporal) variation and takes a precautionary approach to conservation significant species contained within the ecology study area.

Terrestrial fauna and habitat assessments were conducted using the following methodologies:

- A general habitat assessment and a record of all fauna encountered (i.e. observed/heard) was undertaken at every vegetation assessment survey site (Eyre et al 2018)
- Validation of the predictive habitat mapping was undertaken where applicable
- Use of specific techniques to identify conservation significant species (e.g. identification of scats, specific scratch marks and diggings).

Field based methodologies are further described in the sections below. A list of species encountered at each site was recorded.

3.4.3.1 Fauna habitat assessment

At each vegetation assessment location (refer 'terrestrial sampling sites' in Figure 3.3), an assessment of fauna habitat features, and a record of all fauna species encountered was undertaken (a total of 26 sites). Fauna habitat assessments were also undertaken within the ecology study area by Arup-Smec (2016) (a total of 16 sites). Fauna habitat features recorded included, but was not limited to:

- Level of disturbance (scale of 0 to nil and 3 to severe) relating to the following:
  - Fire
  - Grazing
  - Clearing
  - Erosion
- List of Endangered, Vulnerable and Near-threatened (EVNT) fauna species that are likely to utilise the area based on available habitat types (based on database search results and predictive habitat mapping)
- Availability of tree hollows present in the following categories:
  - > 30 cm diameter
  - > 15 cm but < 30 cm diameter
  - > 10 cm but < 15 cm diameter
  - > 5 cm but < 10 cm diameter
  - < 5 cm diameter
- Amount of fallen logs (> 10 cm diameter)
- Amount of coarse woody debris (< 10 cm diameter)
- Quantity of trees with decorticating bark
- Percentage of groundcover containing the following:
  - Leaf litter
  - Bare ground
  - Grasses
  - Soil cracks
  - Surface rocks
  - Non-native flora species (e.g. weeds)
- Presence/quantity of:
  - Soil banks (e.g. river beds/road cuttings)
  - Boulders
  - Wetlands/drainage features
- Relative abundance of the following:
  - Flowers
  - Fruit.

All species of fauna observed were identified to the species level where possible.

3.4.3.2 Targeted fauna survey methods

When areas were identified as containing habitat considered likely to support threatened species (i.e. both within vegetation assessment areas and at opportunistic locations), specific techniques were employed to increase the likelihood of detecting these species. Location selection was optimised to maximise fauna detection by selecting sites along drainage lines and fauna pathways within bushland.

Specific techniques adopted as part of the ecological assessments (including survey effort where applicable) and their relevance to MNES and MSES fauna include the following:

- Anabat devices (Microchiropteran bats) were deployed at five sites (overnight) for a total survey effort of five detector nights (refer Figure 3.3 for locations)
- Area searches for nests of birds of prey in suitable riparian areas during the EIS studies and by EMM Consulting (2018c, 2018d) and Eco Logical Australia (2019b) during targeted pre-clearance surveys (refer Figure 3.2 for locations)
- Active searches for feeding platelets of the Button quail (*Turnix* sp) within suitable habitat for the EIS studies and by Arup/SMEC (2016)
- Standardised surveys for all birds which is suitable for all conservation significant at all EIS assessment sites comprising recording birds by observation or calls for 20 minutes over a 2 ha survey area. These used the Birds Australia census technique described by Loyn (1986) for the EIS studies (refer Figure 3.3 for locations).
- Active searches for arboreal mammals at all EIS assessment sites (refer 'fauna ecology survey site in Figure 3.3 for locations), their pellets and scratches were undertaken for the EIS studies and across Project-associated studies by Arup/SMEC (2016) and Eco Logical Australia (2019b) (refer Figure 3.2 for locations)
- Active search for latrine sites and dens for the species such as Spotted-tail quoll (*Dasyurus maculatus*) within suitable rocky habitat for the EIS studies and Arup/SMEC (2016)
- Active searches for Macropods and their pellets which were validated by experts at Queensland Museum for confirmation. Searches for signs and habitat resources are considered an adequate form of survey method for detecting this species, as long as all suitable rocky habitat including mid-level ledges and holes are inspected for signs of activity (Department of Sustainability, Environment, Water, Populations and Community 2011). Carried out for the EIS studies, Arup/Smec (2016) and Eco Logical Australia (2019b).
- Active searches for reptiles at all EIS assessment sites. This involved 20 minutes of searching by two people over 1 ha within suitable microhabitats. This involved searching within suitable microhabitats, particularly beneath rocks and fallen logs and amongst leaf litter and woody debris. Carried out for the EIS studies (refer Figure 3.3 for locations).
- Spotlighting and night driving for amphibians, reptiles, birds and mammals – outside of formalised survey locations. Carried out for the EIS studies.

Other species encountered during these works were recorded, along with opportunistic observations (all fauna species), refer Appendix E for more details. Remote sensing techniques were used to ensure maximum chances of detecting threatened species, without increasing the species risk of harm or placing stress upon the animal (i.e. animals sampled ethically and humanely). This included:

- Infra-red remote motion-sensing cameras at watering points and/or at baited feeding stations (mammals and birds) – nine sites (overnight) (refer Figure 3.3 for locations).

Whilst the use of non-invasive techniques such as remote sensing data and habitat assessments in lieu of trapping deviates from the techniques recommended by the state and commonwealth governments, the use of such techniques, when combined with the predictive habitat mapping assists in providing information to suitably inform the impact assessment process in instances of site inaccessibility or deficiencies of existing information. The methodology employed is scientifically robust, defendable and repeatable.

3.4.3.3 Pre-clearance habitat surveys

In addition to the fauna survey methods employed for the EIS studies identified above (i.e. FFJV and Arup (2016)) a large number of 'preclearance surveys' associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) have been carried out during 2018 and 2019. These surveys were assessed to further inform the Project EIS studies and as part of requirements under QLD legislation. Surveys were carried out at 137 locations (EMM 2018c, 2018d) and 296 locations (Eco Logical Australia 2019b) throughout the Project disturbance footprint.

The surveys included the following methods:

- Searches for potential breeding habitat for threatened species such as:
  - Recording of all burrows/dens, logs, rocks, caves and suitable leaf litter that may contain breeding habitat for threatened species
  - Recording of hollow bearing trees noting hollow attributes such as size, angle, height in the tree and orientation it was facing
  - Recording of bird nests and potential for active nesting
- Habitat suitability assessments for threatened species with key habitat types recorded
- Assessment of Koala microhabitat incorporating evidence of koalas in the area (e.g. sightings, scratches and scats), food tree abundance, tree species and habitat context (Eco Logical Australia survey locations only)
- Incidental fauna observations recorded.

3.4.4 Aquatic field assessments

The aquatic ecology field assessment described the environmental values of targeted watercourses (to assess existing environmental condition adjacent to, and where the Project alignment intersects watercourses) within the ecology study area. The AUSRIVAS Physical Assessment Protocol (as per the original USEPA habitat assessment) was used in the field assessment of the watercourses. The AUSRIVAS Physical Assessment Protocol is a standardised rapid method for the collection of geomorphological, physical habitat and riparian data and was used to maintain consistency with the sampling approach which has been employed on other Inland Rail packages (i.e. the Calvert to Kagaru, Gowrie to Helidon, Border to Gowrie and North Star to Border alignments).

The key geomorphological, physical habitat and riparian data which was collected at each assessment site included:

- Valley characteristics, including valley shape and channel slope
- Land use, including catchment land use and local land use
- Physical morphology and bedform of the watercourse, including channel shape and extent and type of bars
- Cross sectional dimensions of the watercourse, including bankfull channel width and depth, bank width and height and baseflow stream width and depth
- Substrate characteristics, including bed compaction, sediment angularity, bed stability rating, sediment matrix and substrate composition
- Floodplain characteristics, including floodplain width and features
- Bank characteristics, including bank shape and slope, bank material, bedrock outcrops, factors affecting bank stability and artificial bank protection measures
- Instream vegetation and organic matter, including extent of large woody debris, macrophyte cover and species composition
- Physical condition indicators and habitat assessment

- Riparian vegetation characteristics, including shading of channel, extent of trailing bank vegetation, species compositions, riparian zone width and extent of disturbance.

The habitat value of each aquatic ecology assessment site was assessed to predict the nature of faunal assemblages utilising the watercourse. Due to the locality of the disturbance footprint, the habitat assessment was conducted for low gradient flow watercourses. Habitat scores were produced as a sum of the scores for each of the assessment parameters and were then broadly associated with category thresholds of poor (0-25 per cent), fair (25-50 per cent), good (50-75 per cent), and, excellent (75-100 per cent).

Recordings of incidental fauna species observed during the aquatic field survey were taken at each aquatic ecology assessment site. A sample of aquatic fauna species present at the time of the aquatic sampling was undertaken using two baited traps and dip netting, specifically targeting vertebrate species such as fish and turtles where adequate water was present. Capture and release trapping and netting works associated with fish and turtle assessments was conducted to collect incidental species occurrence data and supplement existing data sets. These works and did not exceed two hours at any site to reduce risk of harm to species and minimise field survey effort, whilst dip netting was completed on an incidental basis to address size-specific constraints associated with baited traps.

Adequate habitat assessment and field data was collected to inform a likelihood of occurrence assessment for threatened aquatic species within the ecology study area. The assessment approach discussed included the use of predictive habitat mapping and the use of field surveys at defined locations to bolster desktop-based datasets and validate predictive, species specific mapping for key target species within each ecology study area.

During the aquatic ecology field investigations, data was collected with respect to any aquatic invasive species and other disturbances present within or affecting the aquatic environments.

Macroinvertebrate sampling was excluded from the aquatic ecology field survey methodology due to the highly ephemeral nature of watercourses in the ecology study area and ability to determine overall watercourse ecological values from morphological assessments to a level required for an EIS.

The aquatic ecology field investigations were conducted at the same locations and at the same time as the first round of the Project surface water quality monitoring (refer Table 3.4).

In addition to the techniques identified above, the use of existing datasets, historic records and predictive habitat models provided a comprehensive assessment of the aquatic significant environmental receptors contained within the ecology study area. As such, a single aquatic value assessment was considered adequate to identification of potential sensitive receptors, considering the assessment follows a precautionary approach to conservation significant species contained within the ecology study area.

3.4.4.1 In-situ analysis of surface water quality

A fully serviced and calibrated YSI Professional Plus water quality meter and a TPS WP-88 Turbidity Meter were employed to record the following in situ water quality parameters at each surface water quality monitoring site:

- pH
- Temperature
- Electrical conductivity (actual and specific)
- Salinity
- Dissolved oxygen (dissolved and saturated)
- Turbidity.

Additionally, the following qualitative data was recorded:

- Time
- Water flow (none/low/mod/high/flood/dry)

- Turbidity (optical turbidity) (clear/slight/turbid/opaque/other)
- Odour (normal/sewage/hydrocarbon/chemical)
- Surface condition (none/dust/oily/leafy/algae)
- Algae cover (none/some/lots)
- Other visual observations and comments (e.g. colour, fish, presence of litter)
- A photograph and GPS point was collected from each sampling site.

3.4.4.2 Laboratory analysis of surface water quality

Surface water quality samples were collected at each surface water quality monitoring site in accordance with DES's Monitoring and Sampling Manual (DES 2018a).

Where practical, surface water quality samples were collected from the centre of the watercourse, where the velocity was the highest. The mouth of the sampling container was held above the base of the channel to avoid disturbing or collect any settled solids or materials.

The surface water quality samples were collected directly into the appropriate sampling bottles provided by the laboratory to avoid potential contamination associated with the use of intermediate containers. Where a sampling pole was required to be used to enable safe sample collection, the sampling bottle was placed on the pole and the sample was collected directly into the sampling bottle. Syringes and filters where flushed with water from the sampling site prior to use.

The surface water samples were placed directly into a clean, insulated box and kept cool via the use of ice and freezer blocks.

One duplicate sample was collected per sampling visit for quality assurance/quality control purposes.

The surface water quality samples were submitted to a National Association of Testing Authorities accredited laboratory (Eurofins) for analysis of the following water quality parameters:

- pH
- Suspended solids
- Turbidity
- Total phosphate
- Reactive phosphorus
- Speciated nitrogen (ammonia, nitrate, nitrite, organic nitrogen, total kjeldahl nitrogen, total nitrogen
- Dissolved metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc
- Salinity
- Electrical conductivity
- Chlorophyll a
- Polycyclic aromatic hydrocarbons.
- Field and laboratory results were compared against Bremer River WQOs and Logan Catchment WQOs and trigger values as well as the ANZECC/ARMCANZ guidelines.
- Further information regarding the assessment of surface water quality against water quality objectives is provided in EIS Appendix L: Surface Water Quality Technical Report.

3.4.5 Survey effort

In addition to the targeted EIS study survey locations identified in Table 3.2 (26 sites within the ecology study area) and initial flora studies carried out by Arup-Smec in 2016 (16 sites within the ecology study area) 100 opportunistic surveys associated with geotechnical investigations were undertaken by FFJV personnel, specifically targeting areas largely within the disturbance footprint. The location of opportunistic surveys is shown Figure 3.3. With regard to survey effort, a total area of approximately 365 ha was assessed (i.e. 79 ha associated with targeted surveys and 286 ha associated with opportunistic investigations). This represents approximately 3.3 per cent of the ecology study area and more than 50% of the Project disturbance footprint.

Protected plant surveys were also carried out during 2018 and 2019 (refer Table 3.2) by EMM Consulting (2018b, 2018c) and Eco Logical Australia (2019a). This includes surveys at an additional 26 sites within and adjacent to the Project disturbance footprint. The methods employed are considered to provide an acceptable level of survey effort to sufficiently inform an assessment against the state based assessment guidelines.

3.4.6 Permits to conduct works

The ecological field surveys reported in this document were conducted by FFJV under the provisions of Aurecon's Scientific Purposes Permit (WISP14453114), General fisheries permit (182654) and Animal ethics approval for General Fish Surveys (CA 2015/01/833) and General Terrestrial Surveys (CA 2015/03/846) and AECOM's Scientific Purposes Permit (WISP16615015) and Animal ethics approval for Fauna Surveys in Queensland (CA 2015/01/834).

3.4.7 Quality assurance/quality control

QA/QC in relation to field results occurred through the following processes:

- At least one suitably qualified person in accordance with Section 4.2.1 of the Flora Survey Guidelines (DEHP 2016d) was present within each survey team
- A portion of any potential MNES flora species encountered, or species that could not be confidently identified during field reconnaissance, was submitted to the Queensland Herbarium for verification/identification
- All flora samples to be submitted to the Queensland Herbarium were stored in a field press to ensure their integrity. Samples were stored in a cool/dry environment and were submitted to the Queensland Herbarium within 9 days of collection.
- A portion of any potential threatened flora species encountered, or species that could not be confidently identified during field recognisance, was submitted to the Queensland Herbarium for verification/identification
- Scats that were collected in the field were taken to the Queensland Museum for species confirmation
- Any threatened fauna species had to be sighted/confirmed by both member of the field team to produce a confirmed record. Where applicable/possible, proof (e.g. photograph, scat or other evidence) was collected.
- Surface water quality sampling was conducted in accordance with industry-accepted standards and quality assured procedures. Field quality control included rigorous sample collection, decontamination procedures (where appropriate), and sample documentation. As each sample was collected it was labelled with a unique sample identifier, the initials of the sampler, the date and the project number. All sample jars were filled leaving no headspace and placed immediately into ice-filled cooler boxes. All samples were transported in ice-filled coolers to prevent degradation of organic compounds. Chain of Custody (CoC) documentation was completed, with data including sample identification, date sampled, matrix type, preservation method, analyses required and name of sampler. Field data monitoring equipment was fully serviced and calibrated prior to use.

3.4.8 Nomenclature

3.4.8.1 Flora

The source of nomenclature for the flora sections of this report is the Census of the Queensland Flora (Queensland Government 2016b). The botanical names comply with the rules of the current International Code of Botanical Nomenclature (ICBN) (McNeill et al. 2006) and the International Code of Nomenclature for Cultivated Plants (Brickell et al. 2004). Author abbreviations follow Brummitt and Powell (1992).

3.4.8.2 Fauna

The sources of nomenclature for the fauna sections of this report are as follows:

- Ingram, McDonald and Nattrass (2002) for frogs
- Wilson and Swan (2017) for reptiles
- Pizzey and Knight (2012) for birds
- Menkhorst and Knight (2011) for mammals
- Action Plan for Australian Bats (Duncan et al. 1999)
- Pusey, Kennard and Arthington (2004) for freshwater fish.

3.5 Impact assessment methodology

The impact assessment of the Project uses a significance-based impact assessment framework to identify and assess potential Project related impacts in relation to sensitive environmental receptors. Initial impact assessment was undertaken to identify where sensitive environmental receptors may be subject to significant impacts (refer Section 3.5.3). Where impacts were identified as potentially significant, these were subject to assessment against the MNES and MSES significant impact assessment guidelines (refer Sections 3.5.4, 5.3.3 (MNES) and 5.3.4 (MSES).

For the purpose of assessment, the terrestrial and aquatic ecology was assessed both quantitatively and qualitatively. A significant impact depends upon the sensitivity of a sensitive environmental receptor, the quality of the environment which is impacted, and upon the magnitude of the potential impact. Determination of the sensitivity or vulnerability of the sensitive environmental receptor and the magnitude of the potential impacts facilitate the assessment of the significance of potential environmental impacts. The sections below discuss and define impact magnitudes, sensitive environmental receptor sensitivity and impact significance.

3.5.1 Magnitude of impacts

The magnitude of a potential impact is essential to the determination of its level of significance on sensitive values/sensitive environmental receptors. For the purposes of this assessment, impact magnitude is defined as being comprised of the nature and extent of the potential impacts, including direct and indirect impacts. The impact magnitude is divided into five categories (refer Table 3.5). The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the extent, duration (refer Table 3.6) and frequency of the impacts.

Table 3.5 Criteria for magnitude

Magnitude	Description
Major	An impact that is widespread, permanent and results in substantial irreversible change to the sensitive environmental receptor. Avoidance through appropriate design responses or the implementation of environmental management controls are required to address the impact. (e.g. greater than 50 per cent of the habitat within the greater area disturbed).
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the sensitive environmental receptor. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact. (e.g. between 13-50 per cent of the habitat within the greater area disturbed).
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the Project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls. (e.g. between 2-13 per cent of the habitat within the greater area disturbed).
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls. (e.g. between 1-2 per cent of the habitat within the greater area disturbed).
Negligible	An extremely localised impact that is barely discernible and is effectively mitigated through standard environmental management controls. (e.g. less than 1 per cent of the habitat within the greater area disturbed).

Table note:

* Greater area disturbed' refers to the wider area within which the proposed impact is situated and compared against (e.g. the ecology study area)

Table 3.6 Timeframes for duration terms

Duration term*	Timeframe – to be defined for each activity type (refer Table 5.1)
Temporary	Days to months (e.g. 1 to 2 seasons; 3 to 6 months)
Short term	Up to 2 year (i.e. 6 to 24 months)
Medium term	From 2 to 10 years[1]
Long term/long lasting	From 10 to 21 years[2]
Permanent or irreversible	More than 21 years[3]

Table notes:

* Duration terms are applicable project activities, and not specific to species and their associated habitats
1 Derived from the term 'moderate' EAM Risk Management Framework 2009 (Great Barrier Marine Park Authority 2009)
2 Derived from the term 'major' EAM Risk Management Framework 2009 (Great Barrier Marine Park Authority 2009)
3 Derived from the term 'catastrophic' EAM Risk Management Framework 2009 (Great Barrier Marine Park Authority 2009)

3.5.2 Sensitivity

To assess the significance of potential impacts on sensitive environmental receptors, sensitivity categories are applied to each of the features. The sensitivity categories are split into five discrete groups as described in Table 3.7. These groupings are based on qualitative assessments utilising information related to the sensitivity of the sensitive environmental receptor, in addition to the potential of a sensitive environmental receptor's occurrence within the receiving environment.

Through the determination of sensitivity categories for each of the sensitive environmental receptors, the features are then able to be assessed through a matrix against the magnitude of the potential Project impact type to indicate the level of significance for each of the impact types on the sensitive environmental receptors.

Each particular sensitive environmental receptors are treated individually. In the case where there are conflicting classes, the highest sensitivity (i.e. the "worst-case") is selected.

Table 3.7 Sensitivity criteria for sensitive significant environmental receptors within the ecology study area

Sensitivity	Description
Major	▪ The sensitive environmental receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive environmental receptor is entirely intact and wholly retains its intrinsic value ▪ The sensitive environmental receptor is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region, state, country or the world ▪ It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. ▪ Project activities would have an adverse effect on the value.
High	▪ The sensitive environmental receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive environmental receptor is relatively intact and largely retains its intrinsic value ▪ The sensitive environmental receptor is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region ▪ The sensitive environmental receptor has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the sensitive value. ▪ Project activities would have an adverse effect on the sensitive value.
Moderate	▪ The sensitive environmental receptor is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers ▪ The sensitive environmental receptor is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements ▪ The sensitive environmental receptor is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are exposed to threatening processes ▪ Threatening processes have reduced the sensitive environmental receptor‘s resilience to change. Consequently, changes resulting from Project activities may lead to degradation of the prescribed value ▪ Replacement of unavoidable losses is possible due to its abundance and distribution.
Low	▪ The sensitive environmental receptor is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations (e.g. historical societies) ▪ The sensitive environmental receptor is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value ▪ It is not unique or uncommon and numerous representative examples exist throughout the system/area ▪ It is abundant and widely distributed throughout the host systems/areas ▪ There is no detectable response to change or change does not result in further degradation of the environmental value ▪ The abundance and wide distribution of the sensitive value ensures replacement of unavoidable losses is achievable.
Negligible	▪ The sensitive environmental receptor is not listed on any recognised or statutory register and is not recognised locally by relevant suitably qualified experts or organisations ▪ The sensitive environmental receptor is not unique or uncommon and numerous representative examples exist throughout the system/area ▪ There is no detectable response to change or change does not result in further degradation of the sensitive value.

3.5.3 Significance of impact

The significance of a potential impact is a function of the significance of the Sensitive environmental receptor and the sensitivity of the Sensitive environmental receptor and the magnitude of the potential impact. Although the sensitivity of the Sensitive environmental receptor will not change (i.e. is generally determined qualitatively by the interaction of the Sensitive environmental receptor’s condition, adaptive capacity and resilience), the magnitude of the potential impact is variable and may be categorised quantitatively to facilitate the prediction of the significance of the potential impact.

Once the Sensitive environmental receptor has been identified, and the sensitivity of the Sensitive environmental receptor and the magnitude of the potential impact have been determined, this will facilitate the assessment of the significance of the potential impact through use of a five by five matrix (refer Table 3.8).

Table 3.8 Significance assessment matrix

Magnitude of impact	Sensitivity				
	Major	**High**	**Moderate**	**Low**	**Negligible**
Major	Major	Major	High	Moderate	Low
High	Major	Major	High	Moderate	Low
Moderate	High	High	Moderate	Low	Low
Low	Moderate	Moderate	Low	Negligible	Negligible
Negligible	Moderate	Low	Low	Negligible	Negligible

Table note:

Significance categories as identified in Table 3.8 are defined Table 3.9. Magnitude categories are defined in Table 3.5.

Table 3.9 Significance classifications

Significance rating	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to a sensitive environmental receptor that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
High	Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the sensitive environmental receptor. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
Moderate	Results in degradation of the sensitive environmental receptor due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable.
Low	Occurs where a sensitive environmental receptor is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
Negligible	Does not result in any noticeable change and hence the proposed activities will have negligible effect on a sensitive environmental receptor. This typically occurs where the activities are located in already disturbed areas.

Significance ratings of Low, Moderate, High and Major constitute a potential significant residual impact to an MNES (migratory species) or MSES, and were subsequently assessed against the MNES significant impact guidelines (for migratory species) or MSES significant impact to confirm the initial impact assessment results (refer Section 5.3.3 and Section 5.3.4).

Following the identification of the level of significance using initial impact mitigation measures, project mitigation measures were then applied to the potential impacts to identify the residual (mitigated) impacts in a tabular form.

Initial assessment of the significance of impacts was undertaken for the following project phases:

- Construction
- Commissioning and reinstatement
- Operation.

Given the uncertainty associated with timeframe for decommissioning, this phase was not considered in the initial impact assessment.

3.5.4 Assessment of the significance of impact against MNES (migratory species) and MSES guidelines

Following the initial assessment of significance (refer Section 5.3.2, Table 5.6), assessment of impacts to MNES (migratory species) or MSES that returned a mitigated initial significance rating of Major, High, Moderate or Low was undertaken. Those that returned a rating of Negligible, or for which habitat had not been identified within the ecology study area, were omitted from assessment against the MNES Guidelines. Relevant MNES/MSES were assessed against the following guidelines as applicable:

- Significant impact guidelines 1.1 – Matters of National Environmental Significance: *Environment Protection and Biodiversity Conservation Act 1999* (DotE 2013) (MNES Guidelines)
- Queensland Environmental Offsets Policy Significant Residual Impact Guideline (*Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004*) (DSDIP 2014a) (MSES Guidelines).

Assessment against the relevant criteria in the above guidelines is presented in the following sections:

- EPBC Act Migratory species – Section 5.3.3
- MSES – Section 5.3.4.

Following the identification of the level of significance using initial impact mitigation measures, proposed mitigation measures were then applied to the potential impacts to identify the residual (mitigated) impacts in a tabular form. Assessment of significant residual impacts to MNES (migratory species) and MSES was undertaken using the MNES and MSES significant impact guidelines respectively.

3.6 Cumulative impact assessment

When numerous projects occur in a region they result in cumulative impacts, which differ from those of an individual Project when considered in isolation. Cumulative impacts may be positive or negative, and their severity and duration will depend on the Project disturbance footprint and construction program overlap with other projects in close proximity.

The sections below outline the selected projects to be used in the cumulative impact assessment and the methodology to be applied in undertaking the assessment.

3.6.1 Project selection

Projects for inclusion in the cumulative impact assessment are all those within the Project region meet the following criteria:

- Have been declared a 'coordinated project' by the Coordinator-General under the QLD SDPWO Act) and an EIS is currently being prepared or is complete, or an Initial Advice Statement is available on the Queensland Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) website.
- Are currently being assessed under Part 1 of the Chapter 3 of the EP Act or, as a minimum, has an Initial Advice Statement available on the DES website.
- May use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the Project.
- Could potentially compound residual impacts that the Project may have on environmental or social values.

Table 3.10 indicates the projects that have been included in the cumulative impact assessment, and their associated selection criteria. The approximate location of these projects in relation to the Project is shown in Figure 3.4. The projects listed in Table 3.10 include infrastructure development projects located in proximity to the Project. It is noted that the Remondis Waste-To-Energy Power Station project (Remondis) located at Swanbank Industrial Estate has not been included as part of the cumulative impact assess as the project is located in a highly disturbed environment and initial investigations indicate that this project will not contribute towards impacts to sensitive environmental receptors as identified within this document.

It is important to note that projects that fall into the following categories have been excluded from the cumulative impact assessment:

- Existing or historic projects within the Project cumulative impact area that are considered to constitute part of the baseline environment
- Projects that have not been developed to the point that their environmental assessment process has been made public.

Table 3.10 Projects to be included in cumulative assessment

Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
Gowrie to Helidon (ARTC)	Rail alignment from Gowrie to Helidon	26 km single-track dual-gauge freight railway as part of Inland Rail	Draft EIS being prepared by ARTC	2021 – 2026 Jobs: Peak of 596 FTE, average of 264 FTE	>50 years Jobs: 20	b) & c)	Overlap of construction with H2C and G2H resulting in conflict in demand for construction resources and additional traffic on arterial roads Operational impacts associated with the road network from the operation of Inland Rail
Calvert to Kagaru (ARTC)	Rail alignment from Calvert to Kagaru	53 km single-track dual-gauge freight railway as part of Inland Rail	Draft EIS being prepared by ARTC	2021 – 2026 Jobs: Peak of 620 FTE, average of 271 FTE	>50 years Jobs: 20	b) & c)	Overlap of construction with H2C and C2K resulting in conflict in demand for construction resources and additional traffic on arterial roads Operational impacts associated with the road network from the operation of Inland Rail
Bromelton State Development Area (SDA) (Queensland Government)	Bromelton	Delivery of critical infrastructure within the Bromelton SDA will support future development and economic growth. This includes a trunk water main and the Beaudesert Town Centre Bypass. This infrastructure provides opportunities to build on the momentum of current development activities by major landowners in the SDA.	The current version of the Bromelton SDA Development Scheme was approved by Governor in Council, December 2017	2016 – 2031	-	c) & d)	Ongoing development at the Bromelton SDA could require deconfliction of construction resources. There may also be an increase of heavy vehicles using the surrounding highways during both construction and operation, resulting in road network impacts.

Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
Ipswich Motorway Upgrade Rocklea to Darra (Stage 1 and remaining sections) (Department of Transport and Main Roads (DTMR))	Western Brisbane	Addressing congestion and extensive delays in the Ipswich Motorway corridor by a range of road upgrades along 7km of Ipswich Motorway between Rocklea and Darra	Project listed on Queensland Infrastructure Initiative List – Proponent to complete business case development (Stage 3 of Infrastructure Australia's Assessment Framework)	2016/17 to 2020-2021 Jobs: Yet to be publicly announced	TBA Jobs: Yet to be publicly announced	c)	Construction periods may overlap resulting in conflict in demand for construction resources and additional traffic on arterial roads
RAAF Base Amberley future works (Department of Defence)	RAAF Base Amberley	White paper dedicated future upgrades to RAAF Base Amberley at a cost of $1B	N/A	2016 – 2022 Jobs: 7,000	- Jobs: Yet to be publicly announced	c)	Ongoing development at RAAF Base Amberley may see increase in road traffic with heavy vehicles and further increase as the H2C construction occurs
Gatton West Industrial Zone (GWIZ) (Lockyer Valley Regional Council)	3 km north west Gatton	Industrial development including a transport and logistics hub on the Warrego Highway	N/A	2019 – 2024 Jobs: 13.5FTE	- Jobs: Approximately 37	c)	May increase road traffic and increase need for rail resources during both construction and operation
InterLinkSQ (InterLinkSQ)	13 km west of Toowoomba	200 ha of new transport, logistics and business hubs. Located on the narrow-gauge regional rail network and interstate network. Located at the junction of the Gore, Warrego and New England Highways.	N/A	2017 –2037	- Jobs: 1,500	c)	Ongoing development could require deconfliction of construction resources. There may also be an increase in heavy vehicles using the surrounding road networks

Table notes:

Selection criteria based on the criteria outlined in the EIS Chapter 22: Cumulative impacts (Section 22.2):

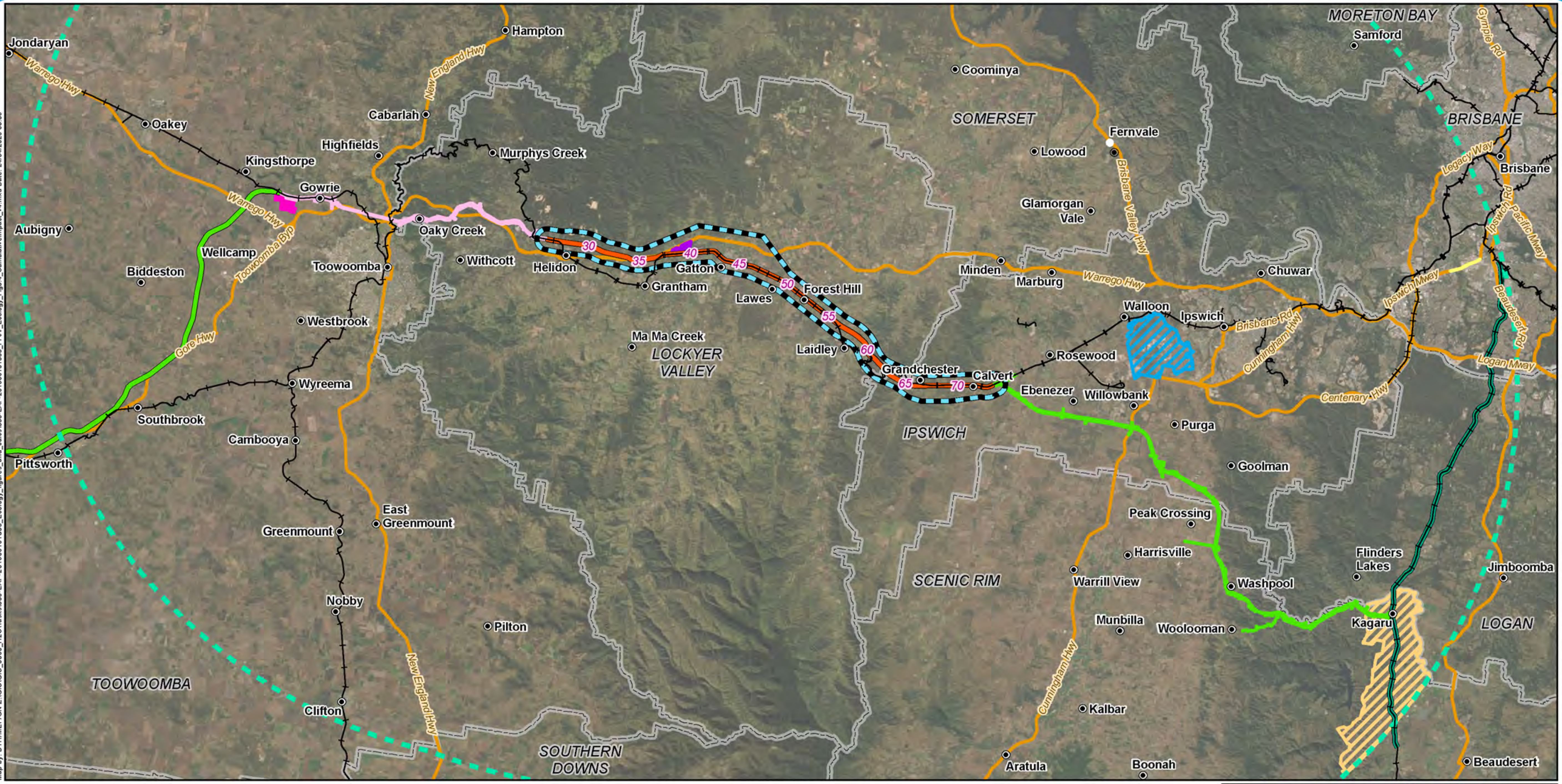
b) Have been declared a 'coordinated project' by the Coordinator-General under the SDPWO Act and an EIS is currently being prepared or is complete, or an Initial Advice Statement is available on the DSDMIP website.

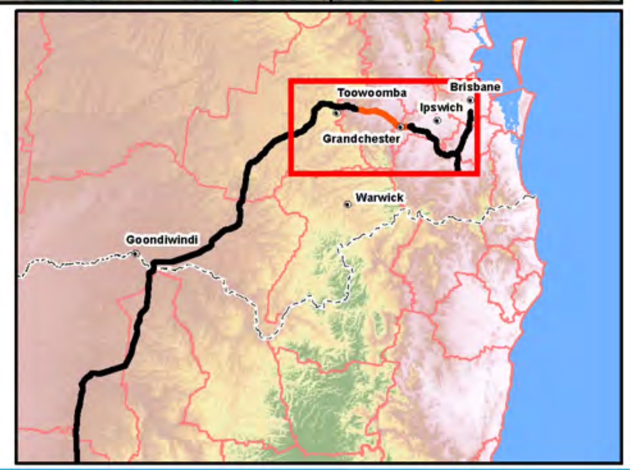
c) May use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the ARTC Inland Rail Project.

d) Could potentially compound residual impacts that Inland Rail may have on environmental or social values

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_FFJV_Ecology_figures_and_calcs\330-EAP-201906101333_Ecology_Fig3.4_CumulativeImpact_v4.mxd Date: 24/04/2020 08:35





Legend

- 5 Chainage (km)
- Localities
- Existing rail
- B2G project alignment
- H2C project alignment
- K2ARB project alignment
- Major roads
- Ecology study area
- Cumulative impact study area
- Local Government Areas

Cumulative Projects

- Bromelton State Development Area
- Calvert to Kagaru
- Gatton West Industrial Zone (GWIZ)
- Gowrie to Helidon
- Interlink SQ - Global Logistics Centre
- Ipswich Motorway Upgrade
- RAAF Amberley

A3 scale: 1:400,000

0 6 12 18 24 30km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 21/04/2020 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 3.4: Location of projects that have been included in the cumulative impacts assessment

3.6.2 Approach

The approach used to identify and assess potential cumulative impacts of this Project provided within this technical report is summarised below.

- A review of the potential impacts identified within the EIS assessments
  - The environment at the time of the Project EIS ToR is the baseline, prior impacts from past land use were not considered
- A register of assessable projects has been collated with timelines to demonstrate the temporal relationship between projects. This has included:
  - Identification of projects outside of Inland Rail
  - Only 'State significant' or 'strategic' projects that are in the public domain as being planned, constructed or operated at the time of the EIS ToR have been considered
  - Where additional projects worthy of consideration have arisen after the finalisation of the EIS ToR, the Coordinator-General has been consulted to determine if assessment is required.
  - The Inland Rail projects immediately adjacent to the Project within the assessment. For this Project, the Gowrie to Helidon and the Calvert to Kagaru Inland Rail projects have been considered
- Identification and mapping of the assessable projects and the areas of influence of the aspect being considered
  - Current operational projects and commercial or agricultural operations that are in the areas of influence around the Project are accounted for in the corresponding technical baseline studies for flora and fauna
- Where there is a potential overlap in impacts (either spatially or temporally), a cumulative impact assessment has been undertaken to determine the nature of the cumulative impact. This includes:
  - Where possible the assessment method has been quantitative in nature (e.g. calculation of impact areas which inform magnitudes) but qualitative assessment has also been undertaken
  - Where quantitative assessment is possible, the significance of impact has been assessed in comparison to the same criteria or guidelines as adopted by the relevant technical impact assessments
  - Where the impacts are expressed qualitatively, the probability, duration, and magnitude/intensity of the impacts should be considered as well as the sensitivity and value of the receiving environmental conditions
- An assessment matrix method (further detailed within Section 3.6.3) has been used to determine the significance of cumulative impacts with respect to detrimental effects
- Where cumulative impacts are deemed to be of 'medium' or 'high' significance, additional mitigation measures are proposed, beyond those already proposed by the relevant technical impact assessments.

3.6.3 Assessment matrix

Following the identification of each potential cumulative impact, a relevance factor score of Low, Medium and High has been determined in consideration of the impacts, in accordance with the assessment matrix given in Table 3.11.

The significance of the impact has been determined by using professional judgement to select the most appropriate relevance factor for each aspect in Table 3.11 and summing the relevance factors. The sum of the relevance factors determines the impact significance and consequence which are summarised in Table 3.12. For example, if a Sensitive environmental receptor such as groundwater was considered to have a probability of impact of 2, duration of impact of 3, magnitude /intensity of impact of 1 and a sensitivity of receiving environment of 1 the significance of impact would be (2+3+1+1 = 7) = Medium.

Table 3.11 Assessment matrix

Aspect	Relevance factor		
	Low	Medium	High
Probability of impact	1	2	3
Duration of impact	1	2	3
Magnitude/Intensity of impact	1	2	3
Sensitivity of receiving environment	1	2	3

Table 3.12 Impact significance

Impact significance	Sum of relevant factors	Consequence
Low	1 to 6	Negative impacts need to be managed by standard environmental management practices. Special approval conditions unlikely to be necessary. Monitoring to be part of general Project monitoring program.
Medium	7 to 9	Mitigation measures likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required, where appropriate.
High	10 to 12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary, where appropriate.

4 Description of environmental values

4.1 Content of this section

This section describes the sensitive environmental receptors of the ecology study area including the results of the desktop analysis, field surveys results and predictive habitat mapping. This section then defines the sensitive environmental receptors of the ecology study area which will be the scope of the impact assessment presented in Section 5.

The following sections present the environmental values associated with the regional setting in which the Project occurs in order to provide a broader context for the observed values within the ecology study area.

4.2 Regional and local context

4.2.1 Overview

The Project is located within the Moreton Basin subregion, one of the 12 subregions of the SEQ bioregion. The Project area is located close to the boundary of the Brigalow Belt South bioregion located to the west which encompasses Toowoomba and the Great Dividing Range. The SEQ Bioregion has a sub-tropical climate with warm and wet summers and mild winters. The region contains the most urbanised areas in Queensland and is subject to a range of land uses including grazing, agriculture, residential and industrial urban areas, and rural residential. The Bioregion also comprises extensive areas set aside for conservation including the Gondwana Rainforests of Australia World Heritage Area located to the south of the ecology study area.

Within the wider area low lying alluvial river and creek flats have been extensively cleared and remnant patches of open forest woodlands on floodplains are typically confined to constrained gullies with limited access and creek channels. These fringing woodlands are typically comprised of Blue gum (*Eucalyptus tereticornis*), River she-oak (*Casuarina cunninghamiana*) and Paperbark (*Melaleuca spp.*), with Grey box (*E. moluccana*) and Red ironbark (*E. crebra*) sometimes present in more elevated areas of the floodplain.

Undulating landscapes and foothills such as in the Helidon and Little Liverpool Range areas are dominated by open eucalypt forests on sedimentary rocks, typically comprised of Brown bloodwood (*Corymbia trachyphloia subsp. trachyphloia*), Lemon-scented gum (*Corymbia citriodora subsp. variegata*), Narrow-leaved ironbark (*E. crebra*), Red ironbark (*E. fibrosa subsp. fibrosa).* Within elevated parts of the Great Dividing Range, there are remnant pockets of Narrow-leaved ironbark woodland, which contains Narrow-leaved ironbark (*E. crebra*), Blue gum (*Eucalyptus tereticornis*), Moreton Bay ash (*Corymbia tessellaris*), Smooth-barked apple (*Angophora spp.*), Silver-leaved ironbark (*E. melanophloia*).

The western section of the alignment passes to the north of the township of Helidon intersecting the lower slopes of the Helidon Hills. The area to the north encompasses a rugged landscape dominated by sandstone formations with extensive tracts of remnant vegetation and several sandstone quarries. This encompasses several protected areas including Lockyer National Park, Lockyer Resources Reserve and Lockyer State Forest. The area comprises habitat for a number of threatened fauna species, including the Powerful owl (*Ninox strenua*) and Glossy-black cockatoo (*Calyptorhynchus lathami*), and several plants with a restricted range such including the Helidon ironbark (*Eucalyptus taurina*). The alignment itself passes through a mosaic of cleared grazing lands, rural residential properties and remnant and regrowth vegetation as far east as the Warrego Highway.

The alignment crosses to the south of the highway and heads east to Gatton, the largest town in the Lockyer Valley. Here the landscape becomes progressively more degraded being dominated by grazing, rural residential properties and irrigated agriculture. Scattered patches of remnant and regrowth vegetation occur largely to the north and outside of the alignment. Large trees occur as scattered paddock trees and along the existing West Moreton System rail line which the alignment follows for much of this section. The alignment crosses Lockyer Creek before entering Gatton itself. Creek line vegetation is highly degraded along the creek with little native tree cover in the vicinity of the crossing point.

From Gatton east to Forest Hill and then Laidley the landscape is relatively flat and highly modified being dominated by irrigated agriculture and grazing lands. There are scattered patches of remnant and regrowth vegetation in the landscape, largely to the south of the alignment. No mapped vegetation communities occur within this section of the alignment with large trees only occurring as scattered paddock trees and as a thin strip along Laidley Creek.

The area of the Little Liverpool Range to the north and east of the Project alignment (between Laidley and Grandchester) is part of a volcanic shield system of Tertiary age which includes Main Range to the south. The peak elevation of the land intersected by the Project is reached as the alignment intersects Little Liverpool Range at an approximate elevation of 240 m. While the slopes of the range in this area remain vegetated with a mixture of remnant and regrowth vegetation, rural housing occupies the ridge line where the proposed tunnel is to be constructed.

The landscape within the Grandchester-Calvert area (east of the Little Liverpool Range) is characterised by very high levels of anthropogenic disturbance in the vicinity of Western Creek with most extant remnant and regrowth vegetation located on higher ground outside of the alignment. This presents a highly fragmented environment dominated primarily by pasture grasses, isolated trees and areas of woody regrowth. Whilst much of the area is subject to grazing and other agricultural practices, Western Creek retains a thin but relatively continuous strip of riparian vegetation and has a limited potential to act as local fauna movement conduit.

4.2.2 Catchment values

The majority of the Project is located in the Lockyer Creek catchment which extends east to Laidley where the Little Liverpool Range forms the boundary of the catchment. The western portion of the alignment (from Helidon to Gatton) runs roughly parallel to the creek and the Project intersects Lockyer Creek on the north-west edge of Gatton township. The project intersects a number of waterways within the catchment including Laidley Creek and Sandy Creek and their associated floodplains west of the Little Liverpool Range. To the east of the Little Liverpool Range (Grandchester to Calvert) the Project is located within the upper reach of Western Creek which is within the Bremer River catchment. The alignment crosses Western Creek in four locations. There are no large dams located upstream of the Project. There are a number of smaller dams in the area including Lake Dyer near Laidley.

Both catchments are considered to be in poor health, with freshwater health continuing to decline, being in very poor condition due to a decrease across most indicators, particularly water quality, fish and macroinvertebrate community health (Healthy Land and Water 2019a). Site investigations indicate that watercourses that intersect the project are in relatively very poor condition. Laidley Creek in particular was considered to be in very poor condition and noted as being dry for the first time since sampling at this site had begun (Healthy Land and Water 2019a).

4.2.3 Groundwater values

There are numerous moderate and low potential aquatic groundwater dependent ecosystems (GDEs) (from regional studies) within the study area, including Lockyer Creek, Laidley Creek and Western Creek (and their tributaries). These are generally described as wetlands associated with alluvial aquifers on the Bureau of Meteorology GDE Atlas. There are no registered groundwater springs within the study area based on a review of the QLD Globe website, with the nearest being Helidon Spring located 4 km south of Ch 26.00 km.

There are no World heritage areas, National heritage areas, Commonwealth marine areas or Great Barrier Reef Marine Park areas located within or in close proximity to the MNES study area and these areas are sufficiently displaced from the Project that downstream impacts will be negligible. For example, the Project is located over 65 km upstream of Moreton Bay, a wetland of international importance (Ramsar wetland).

4.3 Results of desktop study

The following subsections provide a comprehensive description of the desktop study results within the ecology study area and broader landscape.

The results of the database searches are presented in full in Appendix C. Results associated with previous surveys and surveys conducted concurrently with the EIS field investigations (i.e. additional ecological surveys associated with siting of geotechnical assessment locations) have been incorporated into the predictive habitat mapping and the relevant sections of this EIS and has informed the impact assessment section of this document where appropriate.

4.3.1 Flora

4.3.1.1 Conservation significant flora species

In total, 19 conservation significant flora species listed under the provisions of the NC Act have been identified from databases searches associated with the ecology study area (refer Table 4.1). Of these species, 16 are also listed as MNES (i.e. identified as threatened species under the EPBC Act). For further information related to these 16 MNES species, refer to EIS Appendix J - Matters of National Environmental Significance Technical Report as they are not discussed further within this document.

The remaining three conservation significant flora species (i.e. those species listed solely under the provisions of the NC Act) have been identified from databases searches associated with the ecology study area or have previously been identified in proximity to the ecology study area (refer Table 4.1).

The location of desktop-derived species records in relation to the Ecology study area is provided in Figure 4.1. Appendix B provides detailed profiles of each of the threatened species identified in Table 4.1 that do not constitute an MNES.

Table 4.1 Conservation significant flora species identified from database searches

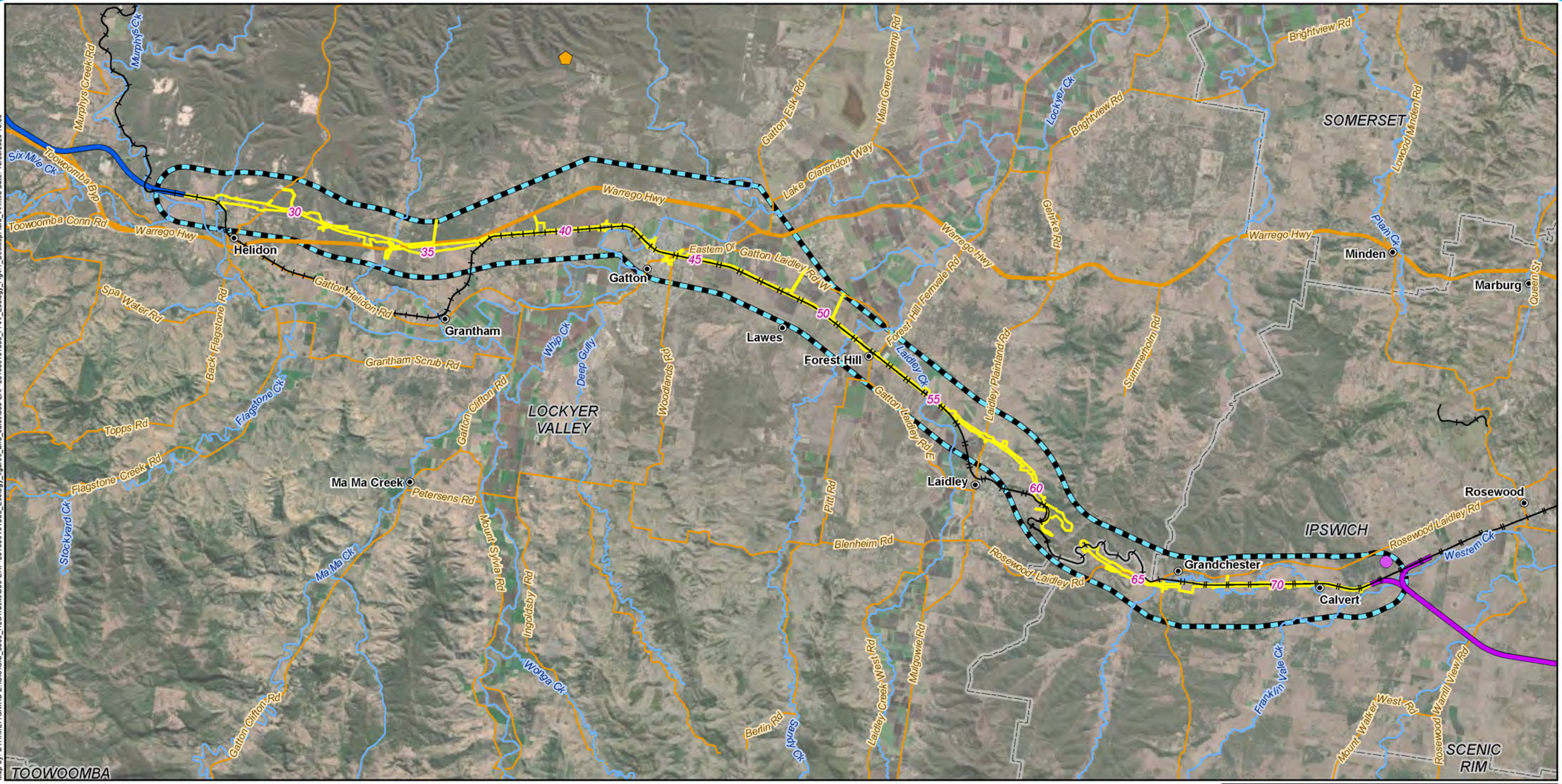
Family	Species name	Common name	NC Act	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Poaceae	*Arthraxon hispidus** #	Hairy-joint grass	V		✓	✓	Possible*
Cupressaceae	*Callitris baileyi*^	Bailey's cypress pine	NT				Possible
Myrtaceae	*Eucalyptus taurina*^	Helidon ironbark	V				Possible
Orchidaceae	*Bulbophyllum globuliforme** #	Miniature moss-orchid	NT		✓		Unlikely. No suitable rainforest habitat likely present and no records within 50 km of Project*
Surianaceae	*Cadellia pentastylis**	Ooline	V			✓	Unlikely, this species is out of its known distribution in the region*

Family	Species name	Common name	NC Act	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Euphorbiaceae	*Fontainea venosa**	Bahrs Scrub Fontainea	V			✓	Unlikely. Species only known from small populations in Beenleigh, Gympie and Kilcoy*
Proteacaea	*Grevillea quadricauda** #	Four-tailed grevillea	V	✓	✓	✓	Possible*
Haloragaceae	*Haloragis exalata velutina** #	Tall velvet sea-berry	V			✓	Unlikely. No suitable habitat present for this species. *
Rutaceae	*Leionema obtusifolium** #	Blunt-leaved leionema	V				Possible*
Characeae	*Lychnothamnus barbatus**	A green algae	V			✓	Unlikely. Known only from Warrill Creek and Wallace Creek in the Boonah area. Project does not intersect these waterways*
Proteceae	*Macadamia integrifolia** #	Macadamia nut	V		✓		Unlikely. No suitable rainforest habitat likely present and no nearby records. Planted specimens (i.e. not in the wild) may be present but these are considered beyond the intent of the EPBC Act listing*
Oleaceae	*Notelaea lloydii** #	Lloyd's native olive	V	✓	✓	✓	Likely*
Poaceae	*Paspalidium grandispiculatum** #	A grass	V			✓	Possible*
Rutaceae	*Phebalium distans** #	Mt Berryman phebalium	E			✓	Possible*
Asteraceae	*Rhaponticum australe** #	Austral cornflower	V	✓	✓	✓	Unlikely, potential habitat for this species is marginal and no recent historic records close to the Project (all nearby records are pre-1950)*
Simaroubaceae	*Samadera bidwillii** #	Quassia	V			✓	Unlikely. No records in wider area and species occurs between Mackay and Gympie (DAWE 2020a)*
Fabaceae	*Sophora fraseri** #	Brush sophora	V				Possible*
Santalaceae	*Thesium australe** #	Austral toadflax	V	✓	✓	✓	Likely*
Myrtaceae	*Melaleuca irbyana*	Swamp tea-tree	E	✓	✓		Likely

Table notes:

E = Endangered V = Vulnerable NT = Near threatened
* = MNES species. These species are discussed further in EIS Appendix J – Matters of National Environmental Significance Technical Report and are not discussed further within this technical report.
# = Species identified in the ToR but not returned from database searches
✓ = species present within database record within the ecology study area
^ = species not returned in database searches but has been included as it has been previously identified in proximity to the ecology study area. # - species identified from ToR

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Swamp tea-tree (*Melaleuca irbyana*)

Stakeholder supplied record

- Helidon ironbark (*Eucalyptus taurina*)
- Existing rail
- G2H project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.1: Location of specimen backed records of conservation significant flora species derived from desktop assessments (excluding MNES species)

4.3.1.2 Priority Back on Track flora species

There are 31 non-MNES Back on Track priority flora species listed for the SEQ NRM region (DERM 2010a) (refer Table 4.2). This includes two species (i.e. Bailey's cypress (*Callitris baileyi*) and Swamp tea-tree (*Melaleuca irbyana*)) which are also listed as threatened under the NC Act and have the potential to inhabit the ecology study area (refer Table 4.1). Species that are listed as threatened MNES (i.e. controlling provisions under the EPBC Act), which are also listed as Back on track species (e.g. *Sophora fraseri*) have not been included within in Table 4.2. These species are assessed within EIS Appendix J - Matters of National Environmental Significance Technical Report.

Of the 31 Back on Track priority flora taxa (terrestrial, semi-aquatic and aquatic) identified as part of the database review and Project EIS field assessments, seven flora species have potential to occur within the ecology study area. It must be noted that many of the species listed in Table 4.2 are not geographically located within proximity to the ecology study area.

Where those Back on Track species are identified as potentially present within the ecology study area, but are not listed under either the NC Act or the EPBC Act they have been identified as a sensitive environmental receptor potentially impacted by the Project (refer Section 4.5.2) and are assessed as such within the impact assessment section (refer Section 5.3.2).

Table 4.2 Back on Track priority flora species for the SEQ natural resource management region and likelihood of occurrence within the ecology study area

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Acacia baueri subsp. *baueri*	Tiny wattle	H	V	Found on infertile and often seasonally waterlogged sands in coastal heath (wallum) habitat and adjacent plateaus and low open woodland (Wetland Info 2009).	Unlikely, outside of the species known coastal range
Acacia saxicola	Mt. Maroon wattle	H	E	Occurs in heath at an altitude of approximately 900 m above sea level. It grows on rocky slopes, in soil pockets within rock crevices (Wetland Info 2009).	Unlikely, outside of these species' natural ranges. Specimen known only from Mt Maroon.
Aponogeton elongatus subsp. *elongatus*[@]	-	H	NT	Grows in rivers and streams with thick sediments or in floodplain billabongs (Wetland Info 2009).	Unlikely, preferred habitat is poorly represented in the ecology study area
Arthropodium sp. (Mt Cordeaux P.I. Forster+ PIF22065)	-	Cr	LC	The following description has been inferred from information on the genus as no species-specific information was available. Moderately widespread in open-forests of foothill country (Royal Botanic Gardens Foundation Victoria (RBGFV) 2015).	Possible
Blandfordia grandiflora	Christmas bells	H	E	Usually found in wet coastal heaths on sandy soils (Australian Native Plants Society 2017).	Unlikely, outside of the species known coastal range
Boronia safrolifera	-	H	LC	Occurs in swamps or badly draining, wet, sandy areas in heath (wallum) (Wetland Info 2009).	Unlikely, outside of the species known coastal range
Brunoniella spiciflora	-	H	LC	Grows along creeks and gullies in rainforest, vine forest and wet sclerophyll forest. It has been recorded growing in dark, loamy, alluvium and volcanic soils (Wetland Info 2009).	Possible

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Callitris baileyi	Bailey's cypress	Cr	NT	Grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum. The New South Wales (NSW) population occurs in an open grassy eucalypt forest near creeks (Wetland Info 2009).	Possible
Caustis blakei subsp. *macrantha*	-	Cr	V	Inhabits tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone (Wetland Info 2009).	Unlikely, outside of the species known coastal range
Chamaecrista maritima	-	H	LC	Grows in open situations on grassy windswept headlands and hillsides near the sea. It also occurs in open eucalypt forest, wallum heath, grassy shrubland and sandstone rocks. It occurs mainly on sandy soils and near sandstone rocks (Wetland Info 2009).	Unlikely, outside of the species known coastal range
Corynocarpus rupestris subsp. *arborescens*	Southern corynocarpus	H	V	Inhabits dry rainforest on steep, rocky basaltic slopes. Persists in areas where fire is excluded due to the terrain and lack of ground litter (Threatened Species Scientific Committee (TSSC) 2008a).	Unlikely, preferred habitat is poorly represented in the ecology study area
Cupaniopsis newmanii	Long-leaved tuckeroo	H	NT	Grows on the margins and in warmer rainforest (PlantNet 2018).	Unlikely, outside of the species known distribution
Discaria pubescens	-	H	NT	Grows in woodland and forest on soils derived from granite or traprock, or sometimes on heavy, sometimes rocky, basalt-derived soils in woodland and grassland vegetation (Wetland Info 2009).	Unlikely, not known to occur within this area
Durringtonia paludosa	-	Cr	NT	Grows in closed sedgeland communities in coastal swamps (PlantNET 2018).	Unlikely, outside of the species known coastal range
Eucalyptus bancroftii	Bancroft's red gum	H	LC	Occurs on a variety of landforms, but mostly on wallum flats on sandy soils in coastal lowlands or on low rises close to the coast (Wetland Info 2009).	Unlikely, not known to occur within this area
Glycyrrhiza acanthocarpa	Native liquorice	H	LC	Grows in various habitats, especially on heavy soils prone to flooding (PlantNET 2018).	Unlikely, preferred habitat is poorly represented in the ecology study area
Hydrocharis dubia[@]	Frogbit	H	LC	Inhabits dams, lakes and slow-moving streams. It may be floating in deep water or be rooted in shallows by the edges of calm water (Wetland Info 2009).	Possible

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Lepidosperma quadrangulatum	-	Cr	LC	Grows in coastal wet heath or swampy forest dominated by eucalypt or melaleuca species with a shrubby understorey. It occurs among sedges in the seepage area at the base of mountain slopes and in association with *Allocasuarina emuina* (Wetland Info 2009).	Unlikely, outside of the species known distribution
Lilaeopsis brisbanica[$]	-	H	E	Grows along tidal riverbanks in grey saline mud, in association with mangrove trees. Although occurring naturally in areas near saline waters, fresh water is satisfactory (Wetland Info 2009).	Unlikely, this species grows in tidal waterways associated with the Brisbane river
Macarthuria complanata	-	H	NT	Information deficient.	Unlikely, outside of the species known costal distribution
Melaleuca groveana	-	H	NT	Grows on exposed rocky ridges, high mountain slopes and the summits of mountains, at altitudes between 340 to 600 m above sea level. It generally occurs in heaths and eucalypt woodlands and forests with heath understoreys. It is also found in tall open forest with a grassy understorey and in microphyll vine forests. It has been recorded growing on red sandy loams, brown loams, skeletal rocky soils and sandy soils over sandstone rock (Wetland Info 2009).	Unlikely, preferred habitat is poorly represented within the ecology study area
Melaleuca irbyana	Swamp tea-tree	H	E	Grows in flat areas that are periodically waterlogged, in eucalypt forest, mixed forest and Melaleuca woodland with a sparse and grassy understorey. It grows on poorly draining, heavy clay soils (Wetland Info 2009).	Likely
Pararistolochia praevenosa	Richmond birdwing vine	H	NT	Found in subtropical rainforests on the eastern coast and lower ranges (<600 m), with plant communities on nutrient-rich volcanic, alluvial or, uncommonly, sandy soils (Grimshaw et. al. 2015).	Unlikely, outside of the species known distribution
Picris conyzoides	-	H	V	Information deficient.	Unlikely, outside of current distribution
Platysace sp. (Mt Ninderry P.R. Sharpe+ 2092)	-	Cr	LC	A mountain top specialist, probably inhabiting heathland (Wetland Info 2009).	Unlikely, large mountains are generally absent
Seringia sp. (Chermside S.T. Blake 23068)	-	H	-	The following description has been inferred from information on the genus as no species-specific information was available. According to other species of *Seringia*, it grows mostly on sandstone in moist eucalypt forests (PlantNET 2018).	Unlikely, outside of the species known distribution

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Swainsona fraseri	Brush swainsona	H	LC	Occurs in grassy pastures on loamy soils, tall open eucalypt forest in disturbed areas and along creek flats and riverbanks with eucalypts. It may also grow on loose rocky slopes (Wetland Info 2009).	Possible
Tephrosia sp. (Wyreema R.J. Fensham 2082)	-	H	LC	Information deficient.	Possible
Thismia rodwayi	-	H	NT	Restricted to damp humus and leaf-litter in deeply shaded tall forests and fern gullies (RBGFV 2015).	Unlikely, outside of the species distribution
Zieria exsul	-	H	E	Occurs in the ecotone between complex notophyll vineforest and open forest of *Eucalyptus propinqua, Corymbia intermedia* and *Lophostemon confertus*, in loamy soil on metasediments (TSSC 2008b).	Unlikely, outside of the species coastal distribution
Zieria furfuracea subsp. *gymnocarpa*	-	Cr	E	Occurs as an understorey shrub in open forest of *Acacia disparrima, Allocasuarina littoralis, Eucalyptus* species and brush box (*Lophostemon confertus*). It has also been found in regrowth vegetation dominated by guinea grass (*Megathyrsus maximus var. pubiglumis*) and *A. disparrima* (Wetland Info 2009).	Unlikely, outside of the species coastal distribution

Table notes:

- = No common name or conservation listing
H = High priority LC = Least Concern
NT = Near Threatened V = Vulnerable
Cr = Critical priority E = Endangered
MP = Medium priority
$ = Semi-aquatic @ = aquatic

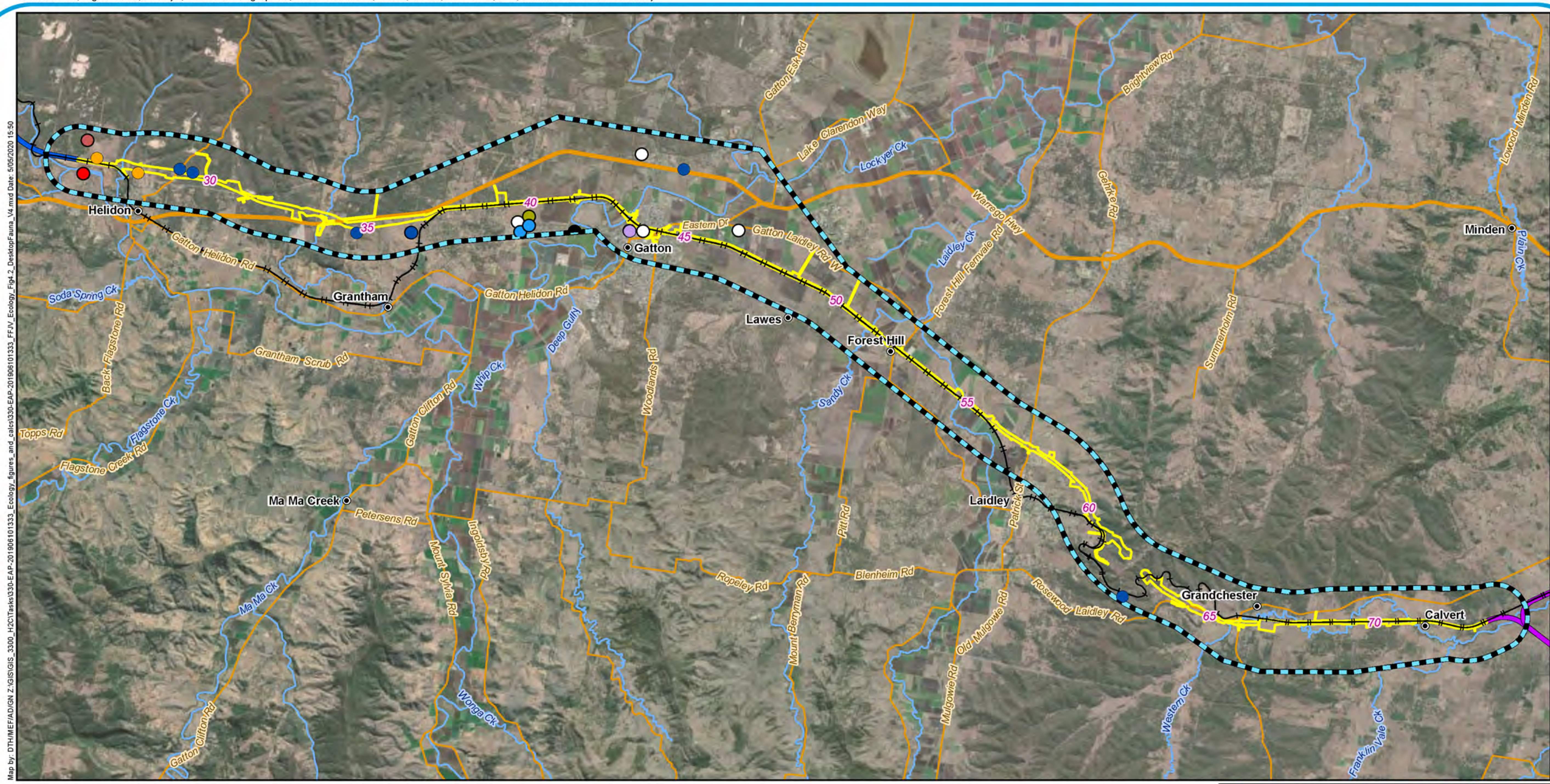
4.3.2 Fauna

4.3.2.1 Conservation significant fauna species

In total, 31 conservation significant fauna species listed under the provisions of the NC Act have been identified from databases searches associated with the ecology study area (refer Table 4.3). Of these species, 25 are also listed as MNES (i.e. identified as threatened species under the EPBC Act). For further information related to these 25 MNES species, refer to EIS Appendix J - Matters of National Environmental Significance Technical Report as they are not discussed further within this document.

The remaining three conservation significant fauna species (two species of bird and one species of reptile) listed as threatened under the provisions of the NC Act (excluding all species listed under the EPBC Act) have been identified from database searches associated with the ecology study area (refer Table 4.3). The location of historic specimen backed records for these conservation significant species is provided in Figure 4.2. In addition to threatened species listed under the NC Act, the table identified two special least concern species as occurring in the ecology study area (Platypus (*Ornithorhynchus anatinus*) and Short-beaked echidna (*Tachyglossus aculeatus*)).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- Localities
- Glossy black cockatoo (*Calyptorhynchus lathami lathami*)
- Platypus (*Ornithorhynchus anatinus*)
- Short-beaked echidna (*Tachyglossus aculeatus*)
- Common sandpiper (*Actitis hypoleucos*)
- Pacific swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Red-necked stint (*Calidris ruficollis*)
- Oriental plover (*Charadrius veredus*)
- Latham's snipe (*Gallinago hardwickii*)
- Gull-billed tern (*Gelochelidon nilotica*)
- Caspian tern (*Hydroprogne caspia*)
- Black-tailed godwit (*Limosa limosa*)
- Black-faced monarch (*Monarcha melanopsis*)
- Glossy ibis (*Plegadis falcinellus*)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*)
- Existing rail
- G2H project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area

A3 scale: 1:125,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.2: Location of specimen backed records of conservation significant fauna (non-MNES) and migratory species

Table 4.3 Conservation significant fauna species identified from database searches

Family	Species name	Common name	NC Act	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Birds							
Cacatuidae	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo	V	✓	✓		Likely
Accipitridae	*Erythrotriorchis radiatus** #	Red goshawk	E	✓		✓	Possible*
Apodidae	*Hirundapus caudacutus** #	White-throated needletail	V			✓	Likely*
Ardeidae	*Botaurus poiciloptilus** #	Australasian bittern	E			✓	Possible*
Columbidae	*Geophaps scripta scripta** #	Squatter pigeon (southern subspecies)	V	✓	✓	✓	Unlikely. The species is typically associated with the westerns slopes of the Great Dividing Range. While there are several records of this species within the broader project context, the majority of these are older and there are no recent records (>1980s) within 5 km of the project disturbance footprint (AoLA 2020)*
Dasyornithidae	*Dasyornis brachypterus** #	Eastern bristlebird	E				Unlikely, species occurs in montane areas in eucalypt forests with a dense tussock grass layer (DAWE 2020c). Habitat does not occur and the species has never occurred in or near the ecology study area.*
Meliphagidae	*Anthochaera phrygia** #	Regent honeyeater	CE			✓	Possible*
Meliphagidae	*Grantiella picta** #	Painted honeyeater	V			✓	Possible*
Passeridae	*Poephila cincta cincta** #	Southern black-throated finch	E			✓	Unlikely. Expert advice indicates that this species is locally extinct within SEQ (DAWE 2020c)
Psittacidae	*Cyclopsitta diophthalma coxeni** #	Coxen's fig-parrot	E				Unlikely. No records close to MNES study area and no reliable records of the species from the year 2000 onwards. Preferred habitats featuring fig trees (lowland rainforest, warm and cold subtropical as well as cool temperate rainforests) (BirdLife International 2020) do not occur within or near the ecology study area.*
Psittacidae	*Lathamus discolor** #	Swift parrot	E		✓	✓	Possible*
Rostratulidae	*Rostratula australis** #	Australian painted snipe	E	✓	✓	✓	Possible*

Family	Species name	Common name	NC Act	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Scolopacidae	*Calidris ferruginea** #	Curlew sandpiper	CE	✓		✓	Possible*
Scolopacidae	*Numenius madagascariensis** #	Eastern curlew	E			✓	Unlikely. Species is essentially a coastal specialist*
Turnicidae	*Turnix melanogaster** #	Black-breasted button-quail	V			✓	Possible*
Strigidae	*Ninox strenua*	Powerful owl	V	✓			Possible
Mammals							
Dasyuridae	*Dasyurus maculatus maculatus** #	Spotted-tail quoll	V			✓	Possible*
Macropodidae	*Petrogale penicillata** #	Brush-tailed rock-wallaby	V	✓	✓	✓	Possible*
Muridae	*Pseudomys novaehollandiae* *#	New Holland mouse	V			✓	Possible*
Petauridae	*Petauroides volans volans** #	Greater glider	V	✓		✓	Possible*
Phascolarctidae	*Phascolarctos cinereus** #	Koala	V	✓	✓	✓	Likely*
Potoroidae	*Potorous tridactylus tridactylus** #	Long-nosed potoroo	V				Possible*
Pteropodidae	*Pteropus poliocephalus** #	Grey-headed flying-fox	V	✓		✓	Likely*
Vespertilionidae	*Chalinolobus dwyeri** #	Large-eared pied bat	V			✓	Unlikely. No nearby database records (AoLA 2020) and habitat is to be unlikely to be present. Nearest record is older (1994) and from Main Range National Park.*
Ornithorhynchidae	*Ornithorhynchus anatinus*	Platypus	SL	✓	✓		Possible
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	SL	✓	✓		Likely
Reptiles							
Elapidae	*Hemiaspis damelii**	Grey snake	E		✓		Possible
Pygopodidae	*Delma torquata** #	Collared delma	V			✓	Likely*
Elapidae	*Furina dunmalli** #	Dunmall's snake	V			✓	Possible*
Scincidae	*Anomalopus mackayi** #	Five-clawed worm-skink	V			✓	Possible*

Family	Species name	Common name	NC Act	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Scincidae	*Coeranoscincus reticulatus** #	Three-toed snake-tooth skink	V				Unlikely. Largely occurs in wet rainforest and wet sclerophyll forest habitats (DAWE 2020c) which does not occur within or near the footprint. Nearest record is from Mount Tamborine (AoLA 2020).*

Table notes:

- = Species not listed CE = Critically endangered E = Endangered V = Vulnerable M= Migratory NT = Near threatened LC = Least concern SLC = Special least concern
X = species present within database record within the ecology study area @ = aquatic # = Identified in the ToR
* = MNES species. These species are discussed further in EIS Appendix J – Matters of National Environmental Significance Technical Report and are not discussed further within this technical report.

In addition to those species listed in Table 4.3, 22 migratory species as listed under the EPBC Act (also listed as Special Least Concern under the NC Act) that have not been identified as a controlling provision of the Project under the EPBC Act, are predicted to occur within the ecology study area (refer Table 4.4).

Migratory marine birds (e.g. Pelagic species and those specifically associated with marine and estuarine mudflats such as the Eastern Curlew (*Numenius madagascariensis*)) were excluded from this list due to the absence of marine environments within the ecology study area.

The location of historic specimen backed records for non-marine migratory species is provided in Figure 4.2.

Table 4.4 Migratory fauna species identified from database searches

Family	Species name	Common name	EPBC Act	NC Act	Data source			Likelihood of occurrence
					WildNet	PMST	Atlas of Living Australia	
Aerial species								
Apodidae	*Apus pacificus*	Fork-tailed swift	M	SLC			✓	Likely
Migratory terrestrial species								
Charadriidae	*Charadrius veredus*	Oriental dotterel	M	SLC	✓			Possible
Cuculidae	*Cuculus optatus*	Oriental cuckoo	M	SLC		✓		Likely
Dicruridae	*Monarcha melanopsis*	Black-faced monarch	M	SLC		✓	✓	Likely
Dicruridae	*Myiagra cyanoleuca*	Satin flycatcher	M	SLC		✓		Possible
Dicruridae	*Motacilla flava*	Yellow wagtail	M	SLC		✓		Possible
Dicruridae	*Symposiachrus trivirgatus*	Spectacled monarch	M	SLC	✓	✓		Likely
Muscicapidae	*Rhipidura rufifrons*	Rufous fantail	M	SLC		✓	✓	Likely
Migratory wetlands species								
Accipitridae	*Pandion haliaetus*	Eastern osprey	M	SLC		✓		Possible
Charadriidae	*Pluvialis fulva*	Pacific golden plover	M	SLC	✓			Possible

Family	Species name	Common name	EPBC Act	NC Act	Data source			Likelihood of occurrence
					WildNet	PMST	Atlas of Living Australia	
Laridae	*Gelochelidon nilotica*	Gull-billed tern	M	SLC	✓			Possible
Laridae	*Hydroprogne caspia*	Caspian tern	M	SLC	✓			Possible
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	M	SLC		✓		Likely
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	M	SLC	✓	✓		Likely
Scolopacidae	*Calidris melanotos*	Pectoral sandpiper	M	SLC		✓		Possible
Scolopacidae	*Calidris ruficollis*	Red-necked stint	M	SLC	✓			Possible
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	M	SLC	✓	✓	✓	Likely
Scolopacidae	*Limosa limosa*	Black-tailed godwit	M	SLC	✓			Possible
Scolopacidae	*Phalaropus lobatus*	Red-necked Phalarope	M	SLC			✓	Possible
Scolopacidae	*Tringa nebularia*	Common greenshank	M	SLC		✓		Possible
Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper	M	SLC	✓	✓		Possible
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	M	SLC	✓		✓	Possible

Table notes:

M = Migratory CE = Critically endangered SLC = Special least concern

4.3.2.2 Priority Back on Track fauna species

There are 16 non-MNES/non-marine Back on Track priority fauna species (aquatic, semi-aquatic and terrestrial) for the SEQ NRM (ERM 2010a) (refer Table 4.5).

Four (4) of the non-MNES Back on Track priority fauna taxa were identified as having a potential (i.e. possible occurrence) to occur within the ecology study area, including the Grey snake (*Hemiaspis damelii*) which is listed as threatened under the NC Act. The remining 12 species are considered unlikely to occur within the ecology study area based on distributional limitations or the absence of habitat of suitable type/size/quality (refer Table 4.5).

Table 4.5 Back on Track priority fauna species for the SEQ natural resource management region and likelihood of occurrence within the ecology study area

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Molluscs					
Pallidelix bennetti (Brazier, 1872) comb. nov	Bennett's woodland snail	H	-	Information deficient. Records from wider area including Logan.	Possible

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Butterflies and moths					
Acrodipsas illidgei	Illidge's ant-blue butterfly	C	V	Occurs in mangroves and adjacent areas (Redland City Council 2018).	Unlikely, no suitable habitat present and out of range of the species
Ornithoptera richmondia	Richmond birdwing butterfly	H	V	Breeds in moist subtropical rainforests wherever the two food plants occur. Habitats are nearly always on rich soils, such as those of volcanic origin (e.g. basalt-derived) or of alluvial origin (e.g. in riparian zones near watercourses). Depending on food plant availability, habitats are distinctly lowland (to 600 m altitude) near the coast or occasionally and seasonally at altitudes above 600 m (Wildlife Preservation Society of Queensland 2018).	Unlikely, suitable habitat is not contained within the ecology study area
Tisiphone abeona rawnsleyi	Varied sword-grass brown (Queensland subspecies)	H	LC	Inhabits glades and clearings in open woodland habitats at elevations between about 50 to 1,200 m according to locality (Hoskins 2018).	Possible
Fish					
Rhadinocentrus ornatus	Ornate rainbowfish@	H	-	It is usually found in slow-flowing streams, ponds and dune lakes (Australian Museum 2018).	Unlikely, habitat of suitable quality is not contained within the ecology study area. Outside of the species known range.
Frogs					
Crinia tinnula	Wallum Froglet	H	V	Restricted to freshwater swamps in lowland coastal areas and is found in associated vegetation communities such as heath, sedgeland and woodland on nutrient-poor sandy soils. Acidic swamps and lakes in these areas provide essential breeding habitat for wallum-dependent frog species. The wallum froglet has also been observed in disturbed heath habitat (DES 2018b).	Unlikely, no suitable habitat present. Outside of the species known range.
Reptiles					
Delma plebeia	Common delma	H	LC	Inhabitant of ground debris and leaf-litter in heaths, dry sclerophyll forests and savannah woodlands, and tolerant of disturbed areas adjacent to brigalow communities and Spinifex sand-plains west of Brisbane (Wildlife QLD 2018).	Possible
Eroticoscincus graciloides	Elf skink	H	LC	Prefers wet habitats including rainforest, wet sclerophyll, vine thickets and wet depressions in dry sclerophyll forest. Occurs from Mt Nebo north to Fraser island (Wilson 2015).	Unlikely, habitat of suitable quality is not contained within the ecology study area. Species known distribution is north of Project.

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Hemiaspis damelii	Grey snake	H	E	Favours woodlands, usually on heavier, cracking clay soils, particularly in association with water bodies or in areas with small gullies and ditches. It shelters under rocks, logs and other debris as well as in soil cracks (DES 2018b).	Possible
Hoplocephalus bitorquatus	Pale-headed snake	H	LC	Found in wet and dry sclerophyll forest, and open woodlands (especially *Callitris* woodland) on floodplains and near watercourses. They are strictly arboreal and rely heavily on old and dead standing trees with hollows and exfoliating bark for shelter sites (Australian Museum 2018).	Unlikely, habitat of suitable quality is not contained within the ecology study area
Hoplocephalus stephensii	Stephens' banded snake	C	LC	Lives in rainforests, moist forests, heaths and vine thickets (QLD Museum 2018).	Unlikely, suitable habitat does not occur within the ecology study area
Birds					
Pezoporus wallicus wallicus	Ground parrot	H	V	Occurs mostly in coastal heathland or sedgeland with very dense cover and a high density of the parrot's food plants (DAWE 2020c).	Unlikely, habitat of suitable quality is not contained within the ecology study area
Sternula albifrons	Little tern	H	LC	Inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches (DAWE 2020c).	Unlikely, habitat of suitable quality is not contained within the ecology study area
Mammals					
Kerivoula papuensis	Golden-tipped bat	H	LC	Found in rainforest and adjacent wet and dry sclerophyll forest up to 1,000 m. Roost mainly in rainforest gullies in usually abandoned hanging Scrubwren and Gerygone nests. Bats may also roost under thick moss on tree trunks, in tree hollows, dense foliage and epiphytes (OEH 2018a).	Unlikely, habitat of suitable quality is not contained within the ecology study area
Petaurus australis australis	Yellow-bellied glider (southern subspecies)	H	LC	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. In the south they are found in moist coastal gullies and creek flats to tall montane forests (OEH 2017a).	Unlikely, habitat of suitable quality is not contained within the ecology study area
Scoteanax rueppellii	Greater broad-nosed bat	H	LC	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Usually roosts in tree hollows and buildings (OEH 2017b).	Unlikely, habitat of suitable quality is not contained within the ecology study area

Table notes:

C = Critical priority H = High priority Me = Medium priority
V = Vulnerable LC = Least Concern - = Not listed @ = aquatic species

4.3.3 MSES wildlife habitat and essential habitat (VM Act)

Habitat for threatened flora and fauna (including some special least concern (SLC) animals) as listed under the provisions of the NC Act are defined as MSES under the Queensland SPP 2017. This includes areas listed as 'essential habitat' for threatened species as mapped under the VM Act. This mapping layer includes modelled or known habitat for species that meet the following criteria:

- Threatened wildlife under the NC Act including
  - Endangered species
  - Vulnerable species
- Special least concern animals under the NC Act including:
  - Echidna (*Tachyglossus aculeatus*)
  - Platypus (*Ornithorhynchus anatinus*)
  - Migratory birds (JAMBA, CAMBA, Bonn).

A review of government datasets identified the following areas mapped as Essential habitat (VM Act):

- Lockyer National Park, north of Helidon
- Lockyer Creek
- Land north east of Placid Hills
- Gatton National Park, south east of Gatton
- Little Liverpool Range

Mapped MSES wildlife habitat (incorporating essential habitat) occurring within the Project disturbance footprint is identified in Figure 4.3a-b. The amount of MNES wildlife habitat and essential habitat within the ecology study area is presented in Table 4.6. Much of this habitat has been mapped for the Koala (*Phascolarctos cinereus*). Further details related to the Koala is provided within EIS Appendix J: Matters of National Environmental Significance Technical Report.

Table 4.6 Matters of State environmental significance wildlife habitat present within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
Identified Wildlife Habitat	2940.06	19.84
Essential habitat	2679.75	95.66

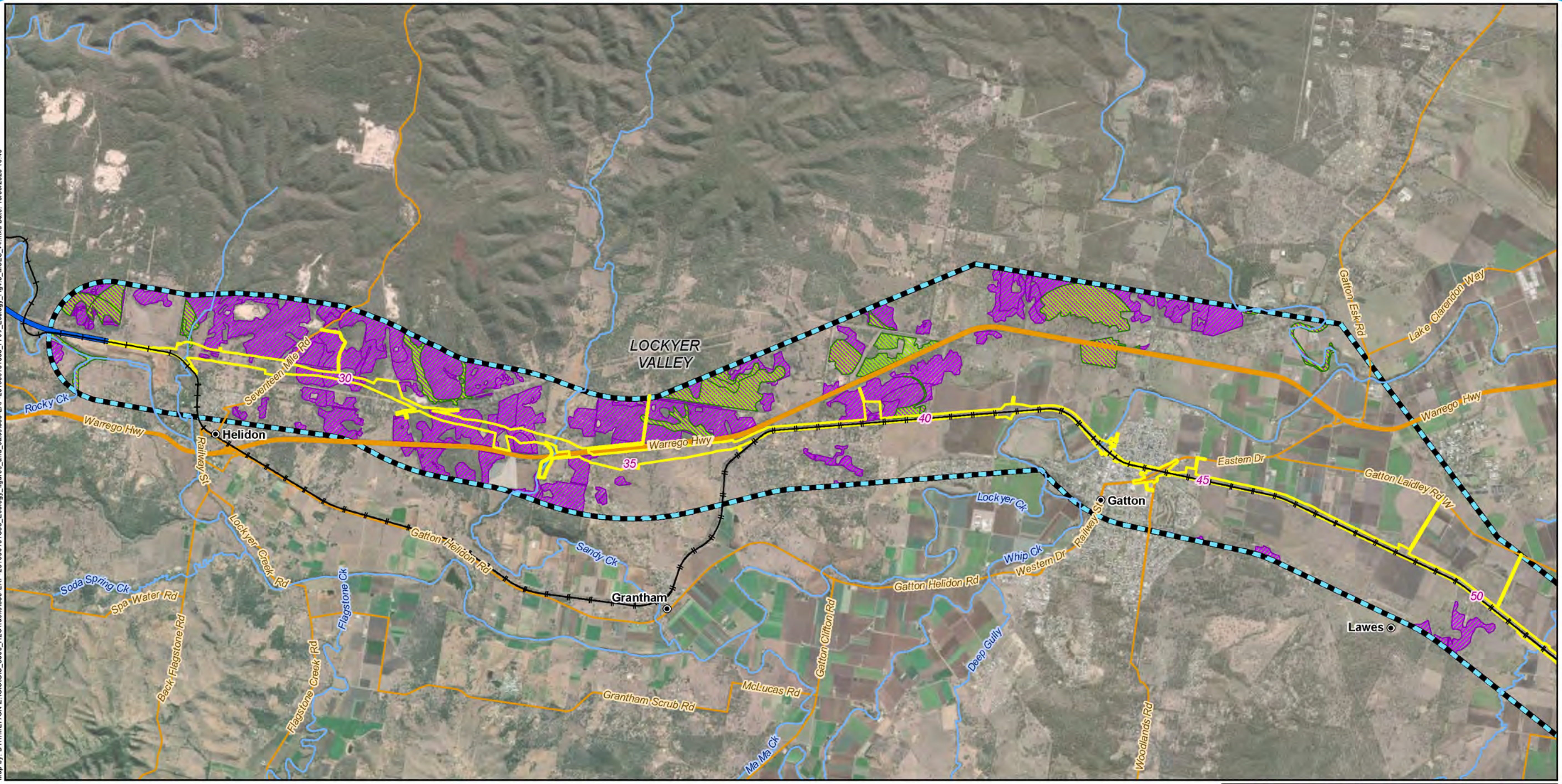
4.3.4 Invasive species biosecurity areas

The ecology study area is contained within fire ant biosecurity zone 2 (refer Figure 4.4). Red imported fire ant biosecurity zones are in place in areas of Queensland to restrict the movement of materials that could spread the red imported fire ant (*Solenopsis invicta*). In addition to the species' potential impact on agricultural and lifestyle activities, the species is also a threat to native flora and fauna, along with the supporting vegetation communities.

Areas associated with Purga and Willowbank, to the east of the ecology study area , are contained within fire ant biosecurity zone 1, and all other areas of the Project are located within fire ant biosecurity zone 2.

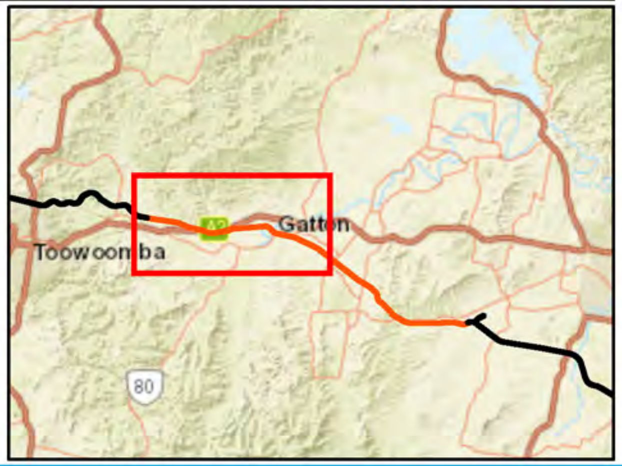
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.3_MSES_v4.mxd Date: 10/05/2020 16:40



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- MSES wildlife habitat
- Essential habitat
- Local Government Areas



A3 scale: 1:70,000

0 1 2 3 4 5km

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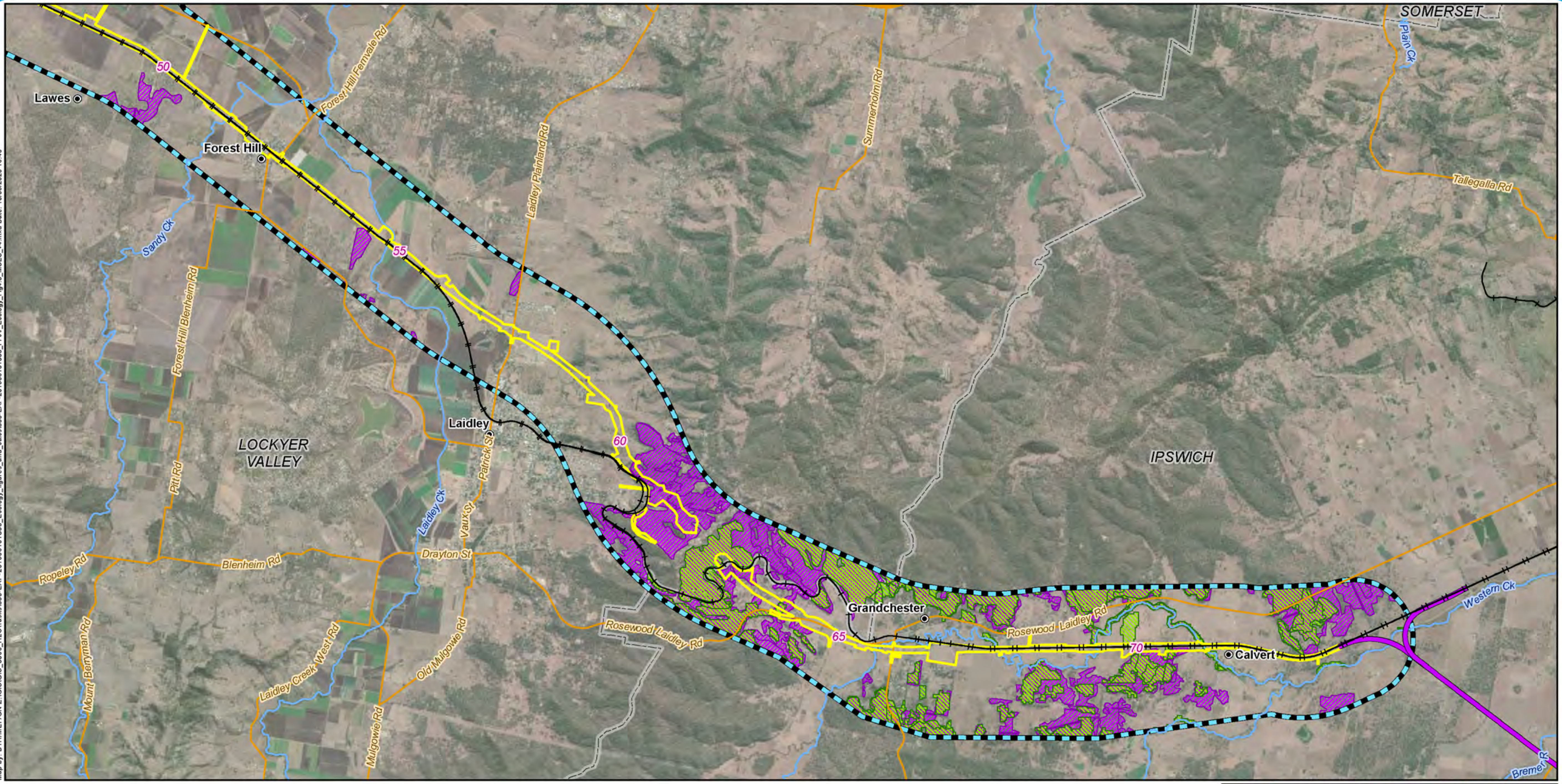
Helidon to Calvert

Figure 4.3a:
Matters of state environmental significance (MSES) wildlife habitat

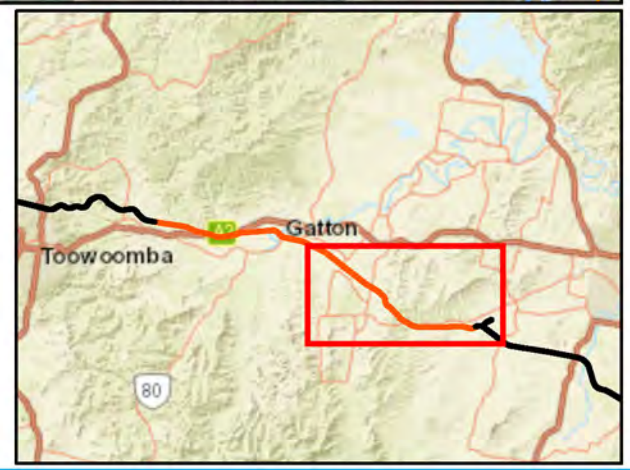
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.3_MSES_v4.mxd Date: 10/05/2020 16:40



Legend

- Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- MSES wildlife habitat
- Essential habitat
- Local Government Areas



A3 scale: 1:70,000

0 1 2 3 4 5km

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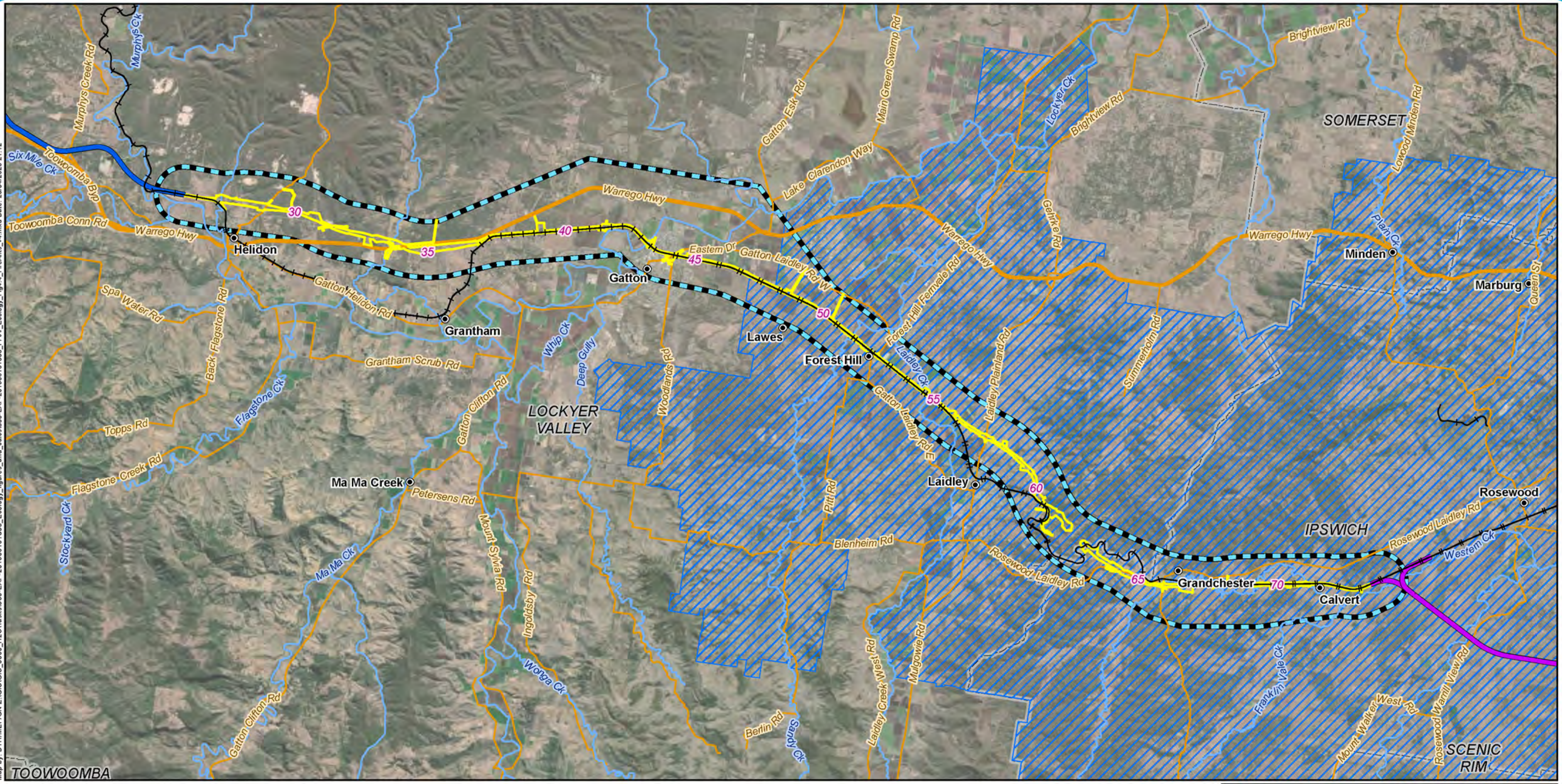
Helidon to Calvert

Figure 4.3b:

Matters of state environmental significance (MSES) wildlife habitat

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.4_FireAnts_v4.mxd Date: 23/04/2020 21:12

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Fire ant biosecurity zone 2
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.4:
Fire ant biosecurity zones

Given that areas to the east of the ecology study area are within a 'fire ant biosecurity zone 1', the following fire ant carrier movement restrictions apply (DAF):

- Moving soil: To move soil from a property within biosecurity zone 1 you must have a biosecurity instrument permit unless:
  - The soil remains within zone 1 or
  - The soil is moved to a waste facility within zone 1 or zone 2
- Moving other fire ant carriers i.e. mining/quarrying products or by-products; To move these fire ant carriers from a property within biosecurity zone 1 you must either:
  - Move the material to a waste facility within zone 1 or 2 or
  - Move the material within 24 hours of being on the property or
  - Obtain a biosecurity instrument permit from an inspector.

4.3.5 Defined watercourses

Under the Water Act, a watercourse is defined as a river, creek or other stream, which includes a stream in the form of an anabranch or a tributary, where water flows either permanently or intermittently regardless of flow frequency. A watercourse however does not include any section of a feature that has a tidal influence or is downstream of a defined limit (Department of Natural Resources, Mines and Energy (DNRME) 2019).

A number of defined watercourses under the Water Act (refer Figure 4.5) and unmapped (or undefined) waterways and waterbodies occur within the ecology study area. Defined watercourses crossed by the Project include:

- Sandy Creek (Grantham) – at chainage location Ch 33.70 km
- Lockyer Creek – at chainage location Ch 43.20 km
- Sandy Creek (Forest Hill) – at chainage location Ch 51.40 km
- Laidley Creek – at chainage location Ch 54.80 km
- Western Creek – at chainage locations Ch 65.70 km, Ch 67.60 km, Ch 69.30 km and Ch 71.10 km.

The unmapped waterways will be required to be verified during the detailed design phase to determine their status (i.e. defined or not) under the Water Act. Further consultation with Department of Regional Development, Manufacturing and Water (DRDMW) (formerly DNRME) and DAF, along with DTMR is required to determine the status of the watercourses under the Water Act and where applicable the Fisheries Act.

4.3.6 Stream order mapping

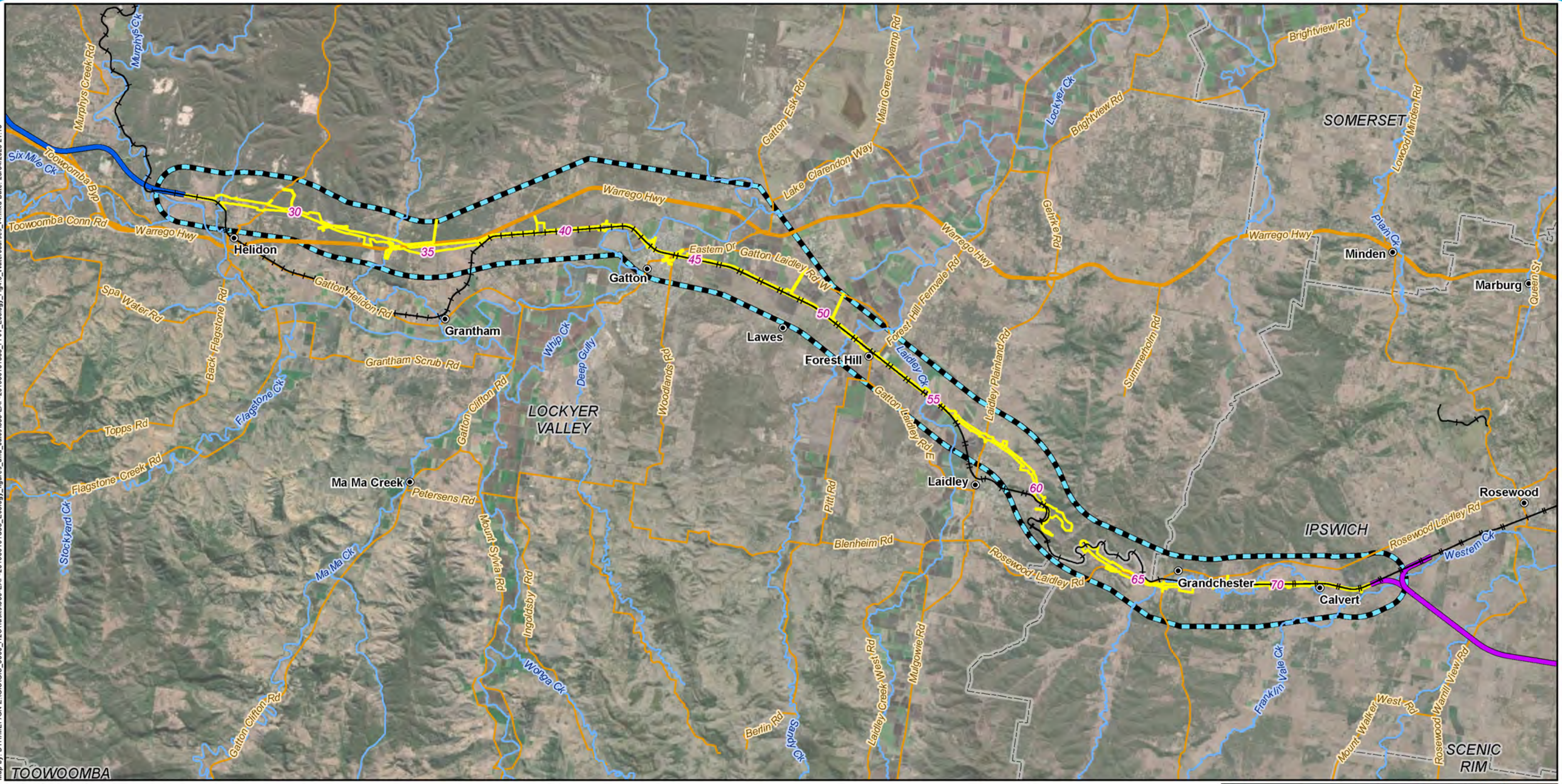
Stream order mapping provides a simplified assessment of stream size via hierarchical status of tributaries feeding into the watercourse of interest. Adopted from Strahler (1952), this system is used to provide an indication on waterway complexity and therefore the potential aquatic habitat present.

Headwaters or 'new' flow paths are given a stream order of one (or 'first order'), where two first order flow paths converge, the new stream is referred to as a second order stream. Where two second order streams join, a third order stream is formed. Third order streams and above are considered likely to reflect valuable fish habitat, capable of supporting viable populations.

The stream orders for waterways contained within the ecology study area are outlined in Table 4.7 and indicated in Figure 4.5. Note that the majority of the first-order waterways within the ecology study area are anticipated to flow only during periods of high seasonal rainfall and as such are not expected to provide high-value fish habitat except during periods of high rainfall or unless semi-permanent or permanent pool habitat is present.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.5_Watercourses_v4.mxd Date: 23/04/2020 21:13



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.5:
Water Act 2000 watercourses

Table 4.7 Stream orders present within the ecology study area

Stream order (DRDMW)	Waterway (approximate chainage)
6	■ Lockyer Creek (Ch 43.20 km)
4	■ Sandy Creek (Grantham) (Ch 33.60 km) ■ Sandy Creek (Forest Hill) (Ch 51.40 km) ■ Laidley Creek (Ch 54.80 km) ■ Western Creek (Ch 65.70 km) ■ Western Creek (Ch 67.60 km) ■ Western Creek (Ch 69.30 km) ■ Western Creek (Ch 71.10 km)
3	■ Un-named tributary of Lockyer Creek (Ch 27.40 km) ■ Un-named tributary of Laidley Creek (Ch 56.80 km)
2	■ Un-named tributary of Lockyer Creek (Ch 28.10 km) ■ Un-named tributary of Sandy Creek (Grantham) (Ch 32.80 km) ■ Un-named tributary of Sandy Creek (Grantham) (Ch 33.40 km) ■ Un-named tributary of Sandy Creek (Forest Hill) (Ch 49.50 km) ■ Un-named tributary of Laidley Creek (Ch 59.40 km) ■ Un-named tributary of Western Creek (Ch 64.40 km) ■ Un-named tributary of Western Creek (Ch 64.80 km) ■ Un-named tributary of Western Creek (Ch 73.30 km)
1	■ Un-named tributary of Lockyer Creek (Ch 27.10 km) ■ Un-named tributary of Lockyer Creek (Ch 29.60 km) ■ Un-named tributary of Lockyer Creek (Ch 30.20 km) ■ Un-named tributary of Lockyer Creek (Ch 30.50 km) ■ Un-named tributary of Sandy Creek (Grantham) (Ch 35.10 km) ■ Un-named tributary of Lockyer Creek (Ch 36.80 km) ■ Un-named tributary of Laidley Creek (Ch 61.10 km) ■ Un-named tributary of Laidley Creek (Ch 61.60 km) ■ Un-named tributary of Western Creek (Ch 63.00 km) ■ Un-named tributary of Western Creek (Ch 63.60 km) ■ Un-named tributary of Western Creek (Ch 72.00 km) ■ Un-named tributary of Western Creek (Ch 72.40 km)

Source: DNRME (2020)

4.3.7 Waterways for waterway barrier works mapping

Fish passage requirements are dictated by the hierarchy of waterways and the risk of impact determined by the Queensland Government. The level of risk is based on stream order, stream slope, flow regime, number of fish species and fish swimming ability.

Under the Fisheries Act a waterway is defined as a river, creek, stream, waterway or inlet of the sea. Waterways for waterway barrier works are regulated under the Fisheries Act and development approvals under the Planning Act when barriers to fish movement including partial barriers, are installed across waterways. Barrier works include construction, raising, replacement and some maintenance works on structures such as culverts, crossings, bed level and low-level crossings, weirs and dams, both permanent and temporary.

A review of the *DAF Queensland Waterways for Waterway Barrier Works* mapping was undertaken, identifying a total of 26 waterways for waterway barrier works (including bridge and culvert infrastructure) which cross the Project alignment. Of the 26 waterways, several of the waterways are crossed by the alignment several times (refer Table 4.8). These waterways are classified as follows:

- Low risk of impact (category 1) – nine (9) waterways mapped as ‘Low’ intercept the alignment

- Moderate risk of impact (category 2) – seven (7) waterways mapped as 'Moderate' intercept the alignment
- High risk of impact (category 3) – two (2) waterways mapped as 'High' intercept the alignment
- Major risk of impact (category 4) – eight (8) waterways mapped as 'Major' intercept the alignment.

The level of risk relating to each waterway will be considered by the detailed design team responsible for the design of infrastructure such as culverts, bridges and other potential barriers. At this stage of Project design, access roads are considered to be proximal to currently identified waterways intersecting the alignment. Designs will need to be in accordance with the DAF factsheet 'What is not a waterway barrier work?', or accepted development requirements for operational work that is constructing or raising waterway barrier works, or under a relevant development approval.

Of the 26 waterway barrier works, eight of the barriers (or crossings) are likely to require development approval, as they are exceeding the risk of impact of self-assessable works. These eight waterway barrier works are associated with bridge infrastructure crossings of major waterways (refer Table 4.8) potentially incorporating in-stream components such as piers and scour protection. Final assessment of risk to fish passage would be assessed as part of the approval of infrastructure during the detailed design phase and will comprise of waterway barrier works elements associated with identified waterway crossings (i.e. bridge infrastructure).

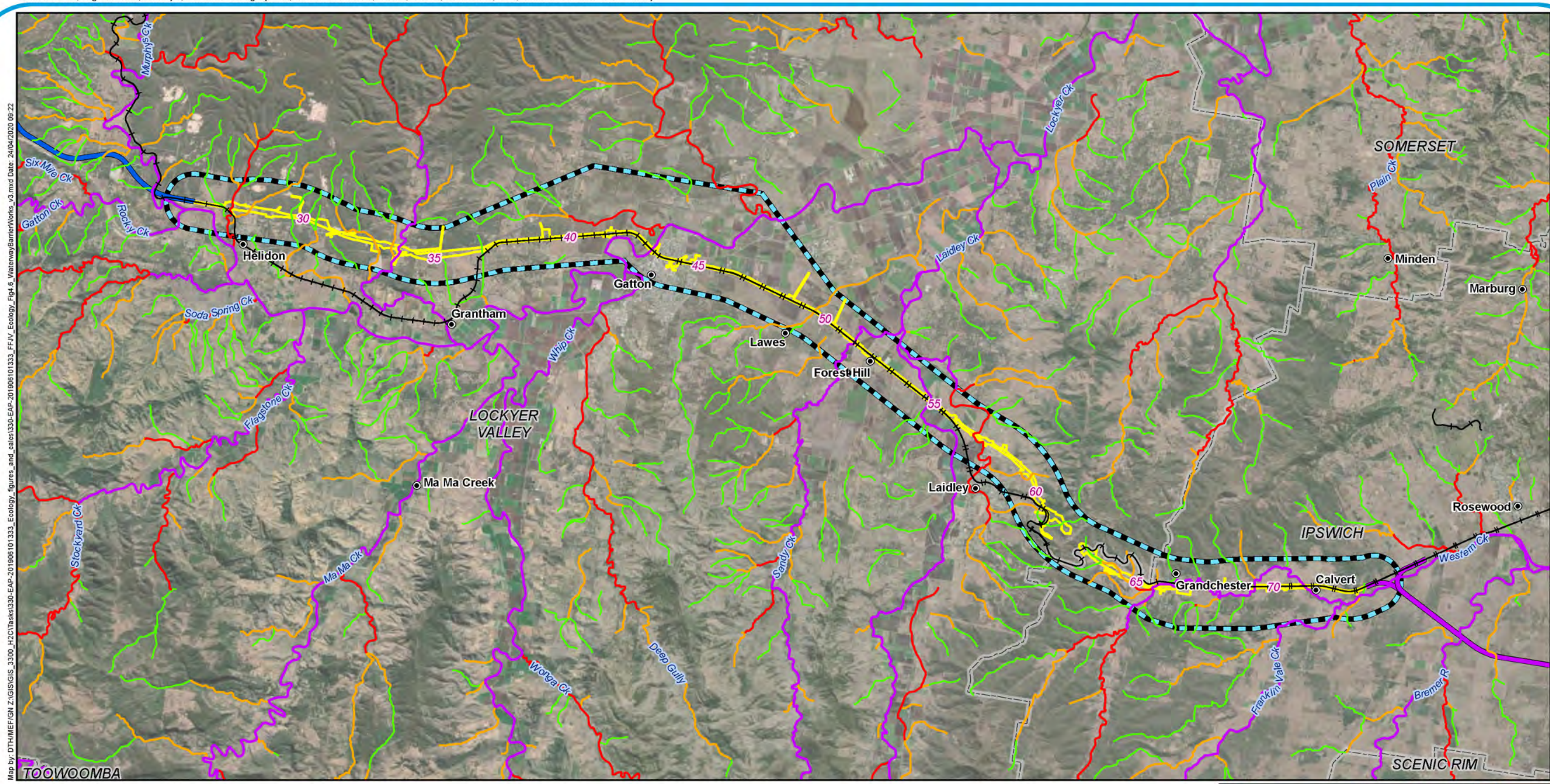
Table 4.8 identifies the waterways which cross the alignment and the relevant stream order whilst Figure 4.6 identifies the location of the DAF mapped waterways for waterway barrier works.

Table 4.8 Waterways for waterway barrier works that cross the proposed Project alignment

Waterway impact risk (DAF)	Waterway (approximate chainage)
Major (Category 4)	▪ Sandy Creek (Grantham) (Ch 33.60 km) ▪ Lockyer Creek (Ch 43.20 km) ▪ Sandy Creek (Forest Hill) (Ch 1.40 km) ▪ Laidley Creek (Ch 54.80 km) ▪ Western Creek (Ch 65.70 km) ▪ Western Creek (Ch 67.60 km) ▪ Western Creek (Ch 69.30 km) ▪ Western Creek (Ch 71.10 km)
High (Category 3)	▪ Un-named tributary of Lockyer Creek (Ch 27.40 km) ▪ Un-named tributary of Laidley Creek (Ch 56.80 km)
Moderate (Category 2)	▪ Un-named tributary of Lockyer Creek (Ch 28.10 km) ▪ Un-named tributary of Sandy Creek (Grantham) (Ch 32.80 km) ▪ Un-named tributary of Sandy Creek (Grantham) (Ch 33.40 km) ▪ Un-named tributary of Sandy Creek (Forest Hill) (Ch 49.50 km) ▪ Un-named tributary of Laidley Creek (Ch 59.40 km) ▪ Un-named tributary of Western Creek (Ch 64.40 km) ▪ Un-named tributary of Western Creek (Ch 64.80 km)
Low (Category 1)	▪ Un-named tributary of Lockyer Creek (Ch 27.10 km) ▪ Un-named tributary of Lockyer Creek (Ch 29.60 km) ▪ Un-named tributary of Lockyer Creek (Ch 30.20 km, Ch 30.50 km) ▪ Un-named tributary of Sandy Creek (Grantham) (Ch 35.10 km) ▪ Un-named tributary of Lockyer Creek (Ch 36.80 km) ▪ Un-named tributary of Laidley Creek (Ch 61.60 km) ▪ Un-named tributary of Western Creek (Ch 63.00 km) ▪ Un-named tributary of Western Creek (Ch 63.60 km) ▪ Un-named tributary of Western Creek (Ch 73.30 km)

Source: Queensland Government (2020i)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Risk of Impact

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

A3 scale: 1:150,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.6: Department of Agriculture and Fisheries waterway barrier works waterways

4.3.8 Wetlands

There are no Wetlands of International Importance (Ramsar wetlands) in, or within 10 km of the ecology study area. Several high ecological significance (HES) (under EPP (Water and Wetland Biodiversity) 2019), are present within the ecology study area, with some intersecting with the Project alignment. Specifically, these occur at the western end of the ecology study area, proximal to Lockyer Creek (Ch 27.40 km). Two HES wetlands (MSES) are located at the eastern end of the ecology study area, proximal to Western Creek (Ch 72.40 km and Ch 73.20 km) (refer Figure 4.7). These are located approximately <100 m from the current Project alignment.

There are also high ecological value (HEV) wetlands mapped as occurring in the western extent of the ecological study area. These wetlands are associated with Sheepstation Creek and Wright's Creek, which are tributaries of Lockyer Creek in the Helidon area. Aquatic conservation assessment (DEHP 2015) indicate Aquascores of 'high' as present in these wetland areas (refer Table 4.10). The Project disturbance footprint will intersect the mapped HEV wetland areas.

The area of HES and HEV wetlands contained with the ecology study area and the Project disturbance footprint is presented in Table 4.9.

There are also wetlands mapped under the VM Act occurring within the ecology study area. These areas are discussed in Section 4.3.18.

Table 4.9 High ecological significance wetlands present within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
HES Wetlands	22.77	0.00
HEV Wetlands	64.57	6.44

4.3.9 AquaBAMM

The aquatic conservation assessment using AquaBAMM assesses the conservation and ecological value of wetland systems based on a series of national and international criteria, including naturalness (aquatic and catchment), diversity and richness, threatened species/ecosystems, priority species/ecosystem, special features, connectivity and representativeness (DEHP 2015).

The AquaBAMM scores for each catchment are separated into both riverine and non-riverine wetland categories with the eight discrete criteria spatially assessed across the catchment as a whole. The resulting modelled score (as a categorical, standardised score of overall ecological value) gives an indicative representation of expected wetland ecological value (refer Table 4.10).

Table 4.10 Aquatic conservation assessment of wetlands associated with the water quality study area

Catchment	AquaBAMM score (%)				
	Very low	Low	Medium	High	Very high
Riverine wetlands					
Lockyer Creek catchment	4% of the catchment had an Aquascore of very low	0% of the catchment had an Aquascore of low	50% of the catchment had an Aquascore of medium	6% of the catchment had an Aquascore of high	40% of the catchment had an Aquascore of very high
Bremer River Catchment	3% of the catchment had an Aquascore of very low	3% of the catchment had an Aquascore of low	64% of the catchment had an Aquascore of medium	12% of the catchment had an Aquascore of high	18% of the catchment had an Aquascore of very high

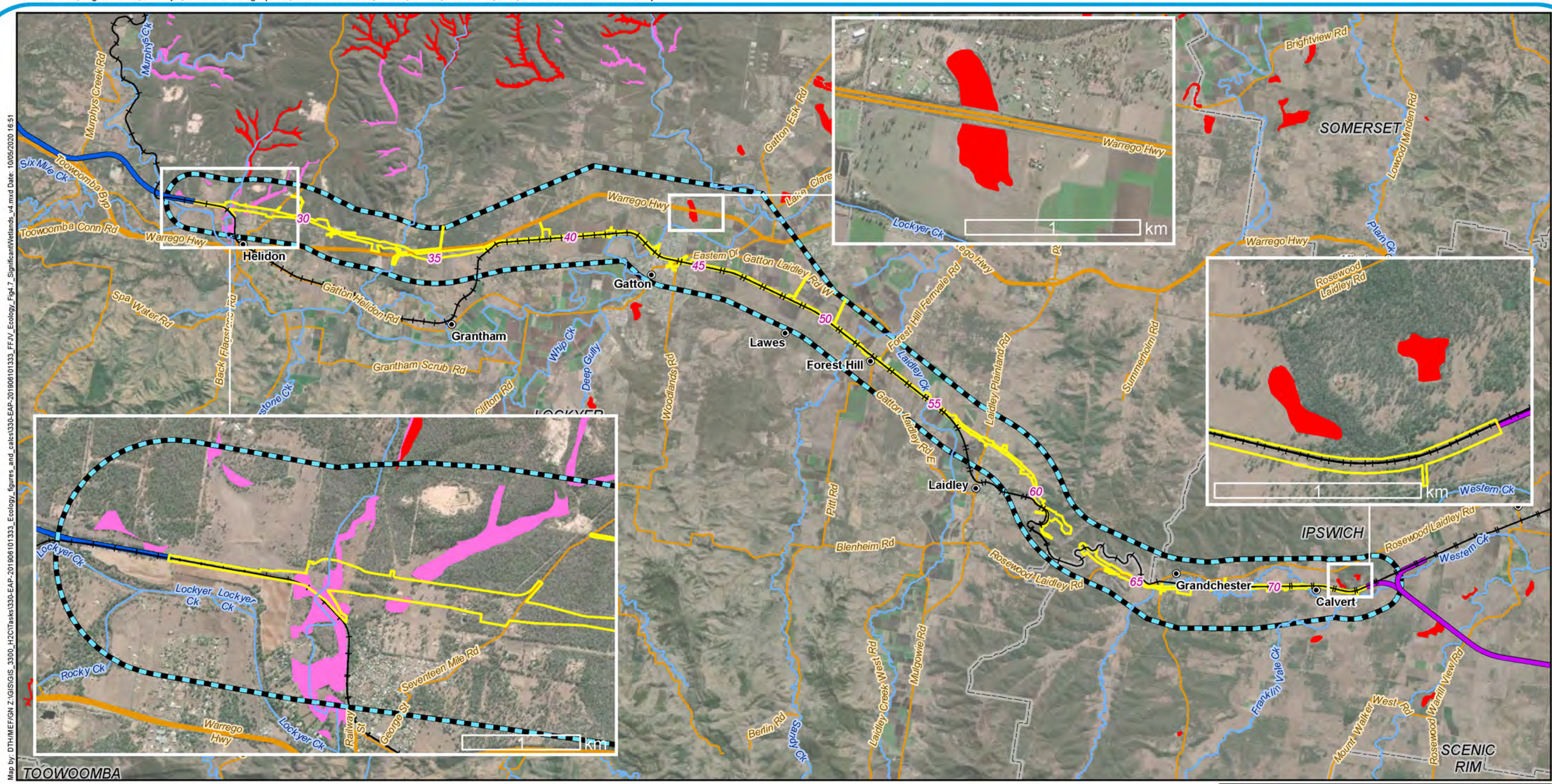
Catchment	AquaBAMM score (%)				
	Very low	Low	Medium	High	Very high
Non riverine wetlands					
Lockyer Creek (non-riverine wetland) *	0% of the catchment had an Aquascore of very low	0% of the catchment had an Aquascore of low	1% of the catchment had an Aquascore of medium	20% of the catchment had an Aquascore of high	78% of the catchment had an Aquascore of very high
Bremer River (non-riverine wetland)	5% of the catchment had an Aquascore of very low	1% of the catchment had an Aquascore of low	64% of the catchment had an Aquascore of medium	0% of the catchment had an Aquascore of high	30% of the catchment had an Aquascore of very high

Table note:

* Rounding (<1%) within AquaBAMM *very low* and *low* categories resulted in 99% overall score

Source: DEHP (2015)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- High Ecological Significance wetlands
- High Ecological Value wetlands
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Figure 4.7: High Ecological Significance (HES) and High Ecological Value (HEV) wetlands

The results of the Aquascore riverine assessment against each water quality monitoring site are presented in Table 4.11. All of the monitoring sites had Aquascores of Medium indicating a moderate condition across the Project alignment.

Table 4.11 Specific Riverine AquaBAMM Aquascore for all water quality monitoring sites

Aquascore	Monitoring site	Associated watercourse
Very Low	Nil	-
Low	Nil	-
Medium	2A, 3A, 4A, 7A, 9A, 10A, 11A, 12A, 13A, 14A, 17A, 18A	Lockyer Creek Sandy Creek (Grantham), Sandy Creek (Forest Hill), Laidley Creek and Western Creek
High	Nil	-
Very High	Nil	-

Source: DEHP (2015)

4.3.10 Springs and groundwater dependent ecosystems

Groundwater dependent ecosystems (GDE) are ecosystems that require access to groundwater on a permanent or periodic basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

The Groundwater Dependent Ecosystems (GDE) Atlas (BoM 2020) identifies three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater – this includes surface water ecosystems which may have a groundwater component (i.e. rivers, wetlands, springs)
- Terrestrial ecosystems that rely on the subsurface presence of groundwater – this includes all vegetation ecosystems
- Subterranean ecosystems – this includes cave and aquifer ecosystems.

As the assessment using the BoM atlas is modelled at a large scale, the identification of potential GDEs in the Atlas therefore does not confirm that a particular ecosystem is groundwater dependent. Noting this, the atlas has identified several potential aquatic and terrestrial groundwater dependant systems including wetland systems and watercourses (refer Figure 4.8).

A review of refined scale potential GDE mapping (Queensland Government 2020f) has been undertaken and the following GDEs aquifer categories have the potential to occur within the ecology study area:

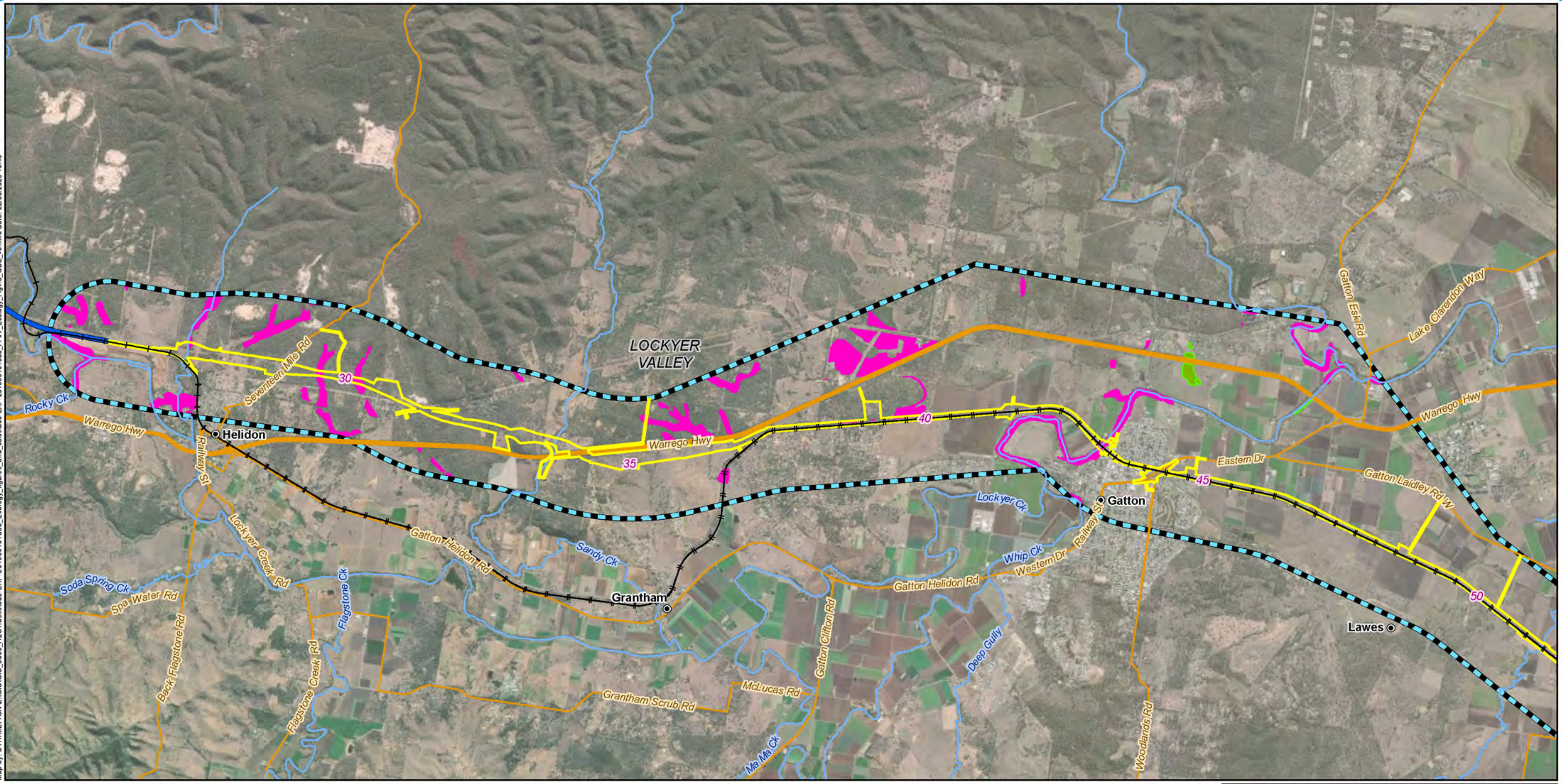
- Unconsolidated sedimentary aquifers
- Consolidated sedimentary aquifers
- Metamorphic rock aquifers.
- The extent of aquifers was used as a proxy for the location of potential GDEs. GDEs were assumed to be present in line with the precautionary approach taken for the assessment.

There are no springs known to occur within the ecology study area. However, terrestrial groundwater dependent ecosystems and surface areas are present within the ecology study area. The location of ground water dependent ecosystems and surface areas is provided in Figure 4.8 and quantified in Table 4.12.

The mapping indicates the potential presence of ‘low potential’ GDEs in the vicinity of the tunnel through the Little Liverpool Range. The GDEs are associated with local gully lines in the range area, the nearest of which lies adjacent to the north side of the east portal of the tunnel. It is noted the mapped GDEs have not been confirmed as present through field verification studies.

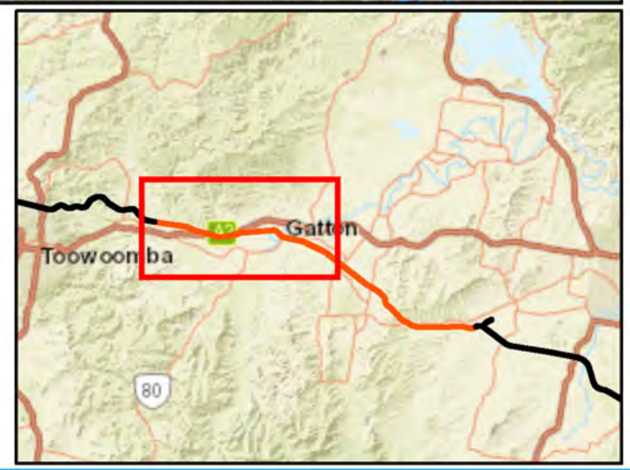
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.8_GDE_v5.mxd Date: 22/06/2020 13:49



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas
- Groundwater Dependant Ecosystems - Surface areas*
- Groundwater Dependant Ecosystems - Terrestrial*



* Source: Groundwater Dependent Ecosystem Atlas, Bureau of Meteorology, Australian Government

A3 scale: 1:70,000

0 1 2 3 4 5km

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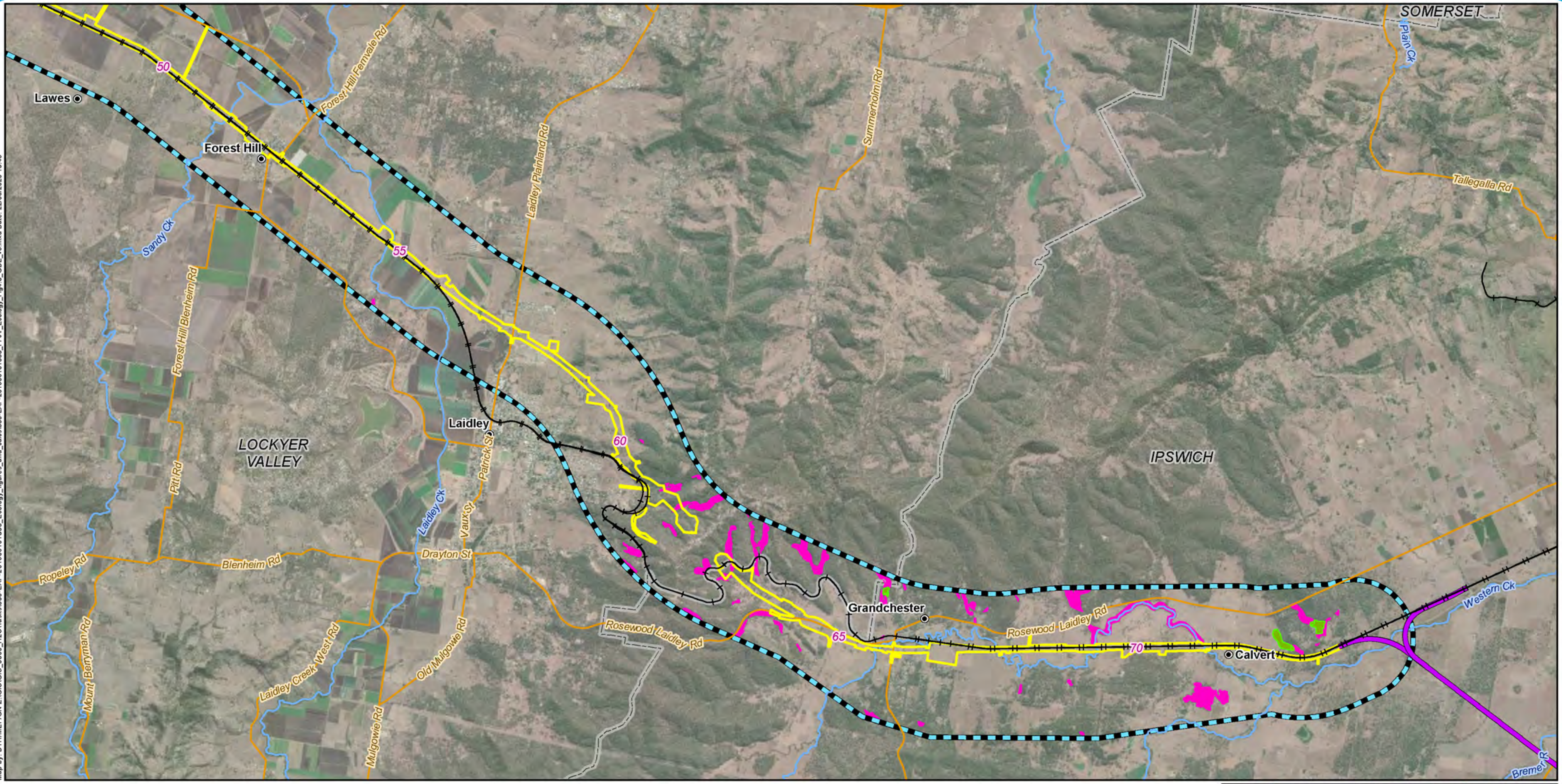
Helidon to Calvert

Figure 4.8a: Mapped terrestrial groundwater dependant ecosystems and surface areas present within the ecology study area

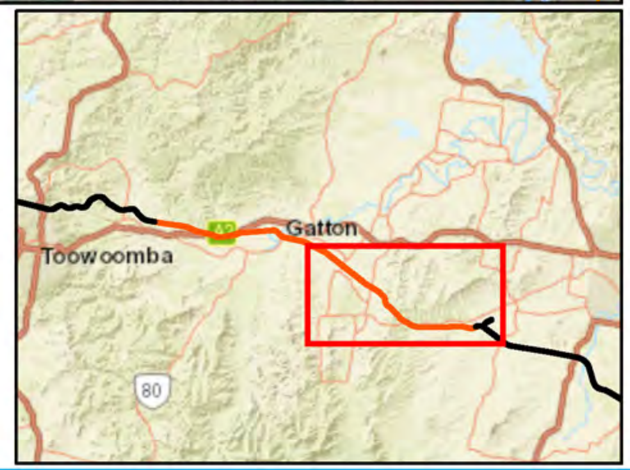
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.8_GDE_v5.mxd Date: 22/06/2020 13:49

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas
- Groundwater Dependant Ecosystems - Surface areas*
- Groundwater Dependant Ecosystems - Terrestrial*



* Source: Groundwater Dependent Ecosystem Atlas, Bureau of Meteorology, Australian Government

A3 scale: 1:70,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.8b: Mapped terrestrial groundwater dependant ecosystems and surface areas present within the ecology study area

Table 4.12 **Extent of springs, ground water dependant ecosystems and surface areas within the ecology study area**

Feature	**Extent (ha)**	
	Ecology study area	**Project disturbance footprint**
Springs	0.00	0.00
Groundwater dependant ecosystems	415.43	8.09
Surface areas	20.53	0.00
Total	**435.96**	**8.09**

4.3.11 Declared fish habitat areas

A declared fish habitat area is an area protected against physical disturbance from coastal development, while still allowing legal fishing.

There are no declared fish habitat areas mapped within the ecology study area.

4.3.12 Local fisheries, fishing clubs and impoundment stocking

The Fisheries Act provides provisions for ecology sustainable development principles to be applied to developments which may have an impact on fishing clubs and stocking organisations which utilise water resources on an ongoing basis.

There are no fishing clubs within the ecology study area. However, Lake Dyer located 2.2 km south of the Project area, is the only fishing spot available to the public within the Lockyer Valley. Lake Dyer also offers a number of water activities in addition to fishing. Lake Dyer has been artificially stocked with Australian bass (*Percalates novemaculeata*), Golden perch (*Macquaria ambigua*), Mary River cod (*Maccullochella mariensis*) and Silver perch (*Bidyanus bidyanus*). In 2017/18, 4,000 Australian bass, 13,727 Golden perch and 4,000 Silver perch were introduced into Lake Dyer. A total of 81,915 Australian bass, 200 Mary River cod, 97,227 Golden perch and 50,300 Silver perch have been artificially stocked in Lake Dyer.

4.3.13 Protected areas

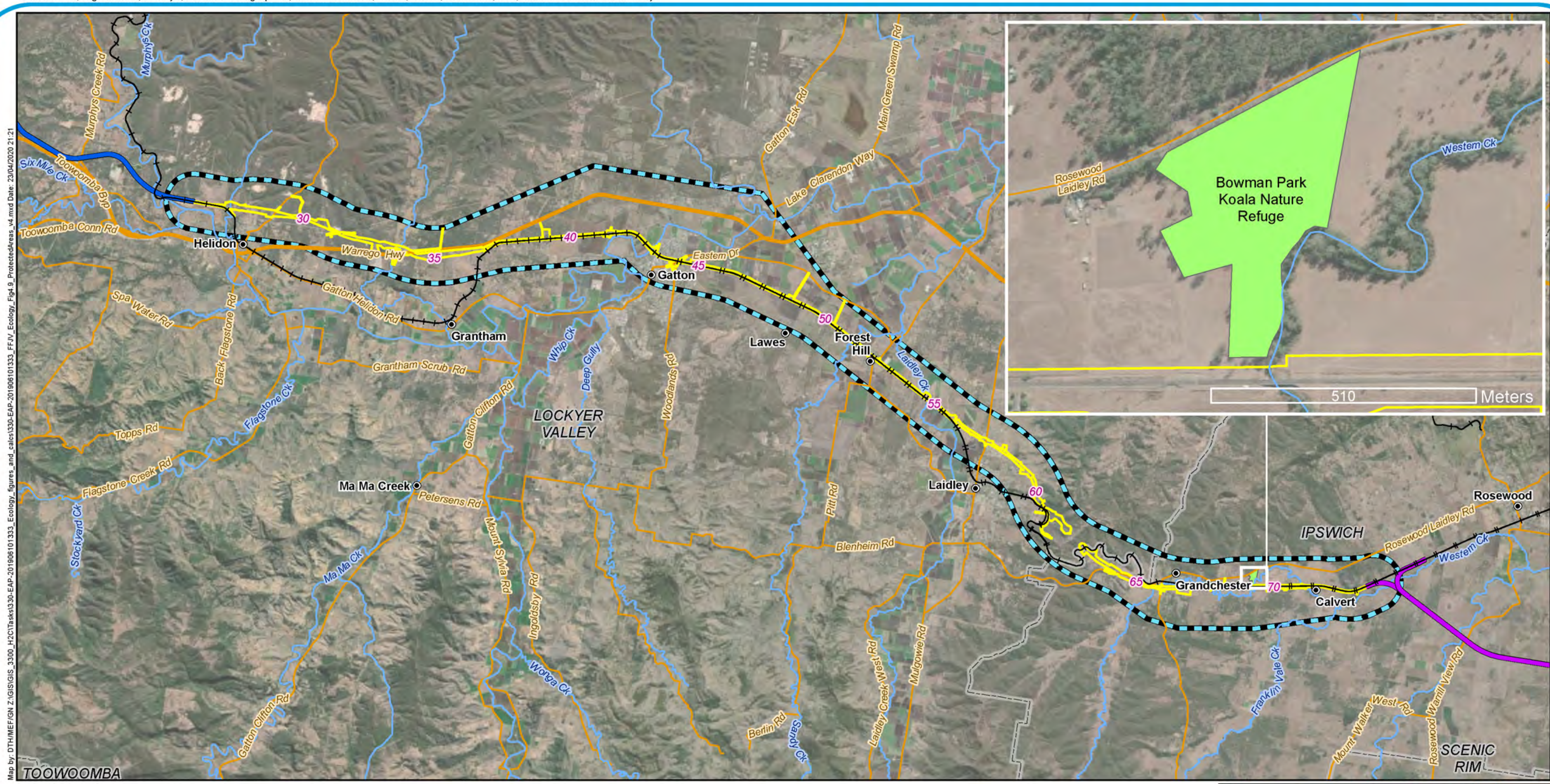
A single area protected under the Nature Conservation (Protected Areas) Regulation 1994 is located within the ecology study area, this being the Bowman Park Koala Nature Refuge (located west of Calvert). The Bowman Park Koala Nature Refuge has a total extent of 10 ha (refer Table 4.13) and is located adjacent to the northern edge of the Project disturbance footprint (refer Figure 4.9).

Table 4.13 **Extent of Protected areas contained within the ecology study area**

Area name	**Extent (ha)**	
	Ecology study area	**Project disturbance footprint**
Bowman Park Koala Nature Refuge	9.97	0.00
Total	**9.97**	**0.00**

Other protected areas including the Lockyer Resources Reserve and Lockyer National Park are not contained within the Project disturbance footprint or the ecology study area and are therefore not subject to impacts including fragmentation as a result of the Project.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas
- Bowman Park Koala Nature Refuge

* Source: Groundwater Dependent Ecosystem Atlas, Bureau of Meteorology, Australian Government

A3 scale: 1:150,000

0 1 2 3 4 5km

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Figure 4.9: Protected areas under the Nature Conservation (Protected Areas) Regulation 1994

4.3.14 Nature Conservation (Koala) Conservation Plan 2017

The ecology study area is wholly contained within Koala district A which is defined as South East Queensland under the Planning Regulation 2017 (Qld). Within this area, the Nature Conservation (Koala) Conservation Plan 2017 categorises areas into four distinct categories: Koala Priority Areas, Koala Habitat Areas, Koala Habitat Restoration Areas, Locally Refined Koala Habitat Areas.

Koala Priority Areas are large, connected areas where a focus will be on habitat protection, habitat restoration and threat mitigation to safeguard Koala populations in South East Queensland. The Little Liverpool Range and the forested areas to the north-west of Helidon are mapped as Koala Priority Areas. Koala Priority Areas constitute the second largest habitat category within the Ecology study area and the Project disturbance footprint.

Koala Habitat Areas (core) represent the best quality Koala habitat, based on modelling of biophysical measures (such as climate), suitable vegetation (for both food and shelter), and Koala sighting records. Koala Habitat Areas relevant to the Project include remnant vegetation to the north of the Warrego Highway and Little Liverpool Range, while between the Warrego Highway and Little Liverpool Range these areas are to the south of the Project. This mapping also generally aligns with the essential habitat mapping for Koalas.

Koala habitat areas (locally refined) are currently protected in South East Queensland and include areas of remnant (uncleared) or high-value regrowth vegetation previously protected by local governments. None of these areas occur within the ecology study area. These areas are absent from the Ecology study area and the Project disturbance footprint.

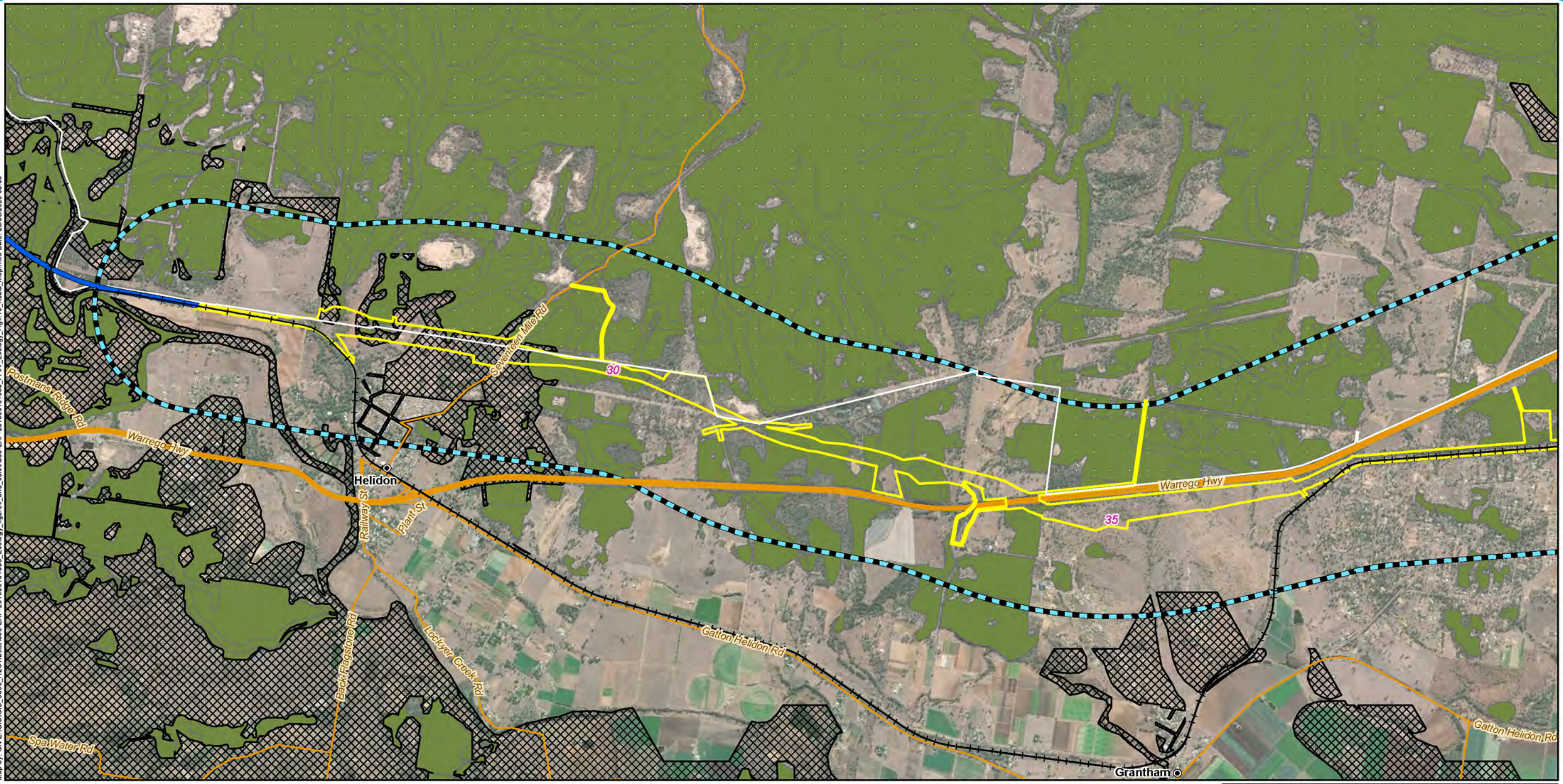
Koala Habitat Restoration Areas is land that could be restored and established as Koala habitat. Offsets for impacts to Koala habitat are encouraged to utilise Koala Habitat Restoration Areas, particularly where they occur in a Koala Priority Area. These areas are not formally protected under current State legislation but feature low threats or constraints, and high conservation opportunities. The majority of the ecology study area east of Gatton is mapped as Koala Habitat Restoration Areas, including areas within the Koala Priority Area. This mapping includes areas substantially cleared for agriculture, along with Lockyer and Laidley creeks. Koala restoration areas (i.e. Koala Habitat Restoration Area - Koala Priority Area and Koala Habitat Restoration Areas) constitute the largest habitat category within the Ecology study area and the Project disturbance footprint.

The extent of these areas is shown in Figure 4.10 and defined in Table 4.14.

Table 4.14 The extent of Koala mapping within the ecology study area

Habitat category	Extent (ha)	
	Ecology study area	**Project disturbance footprint**
Koala Priority Areas	4407.30	193.49
Koala Habitat Areas	2649.01	95.62
Koala Habitat Restoration Area - Koala Priority Area	1,638.38	119.50
Koala Habitat Restoration Areas	3,962.79	161.07
Locally Refined Koala Habitat Areas	0.00	0.00

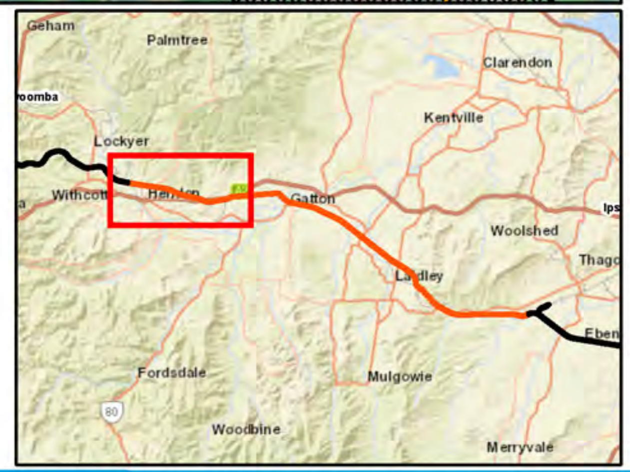
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.10_Koala_map.mxd Date: 23/06/2020 08:39

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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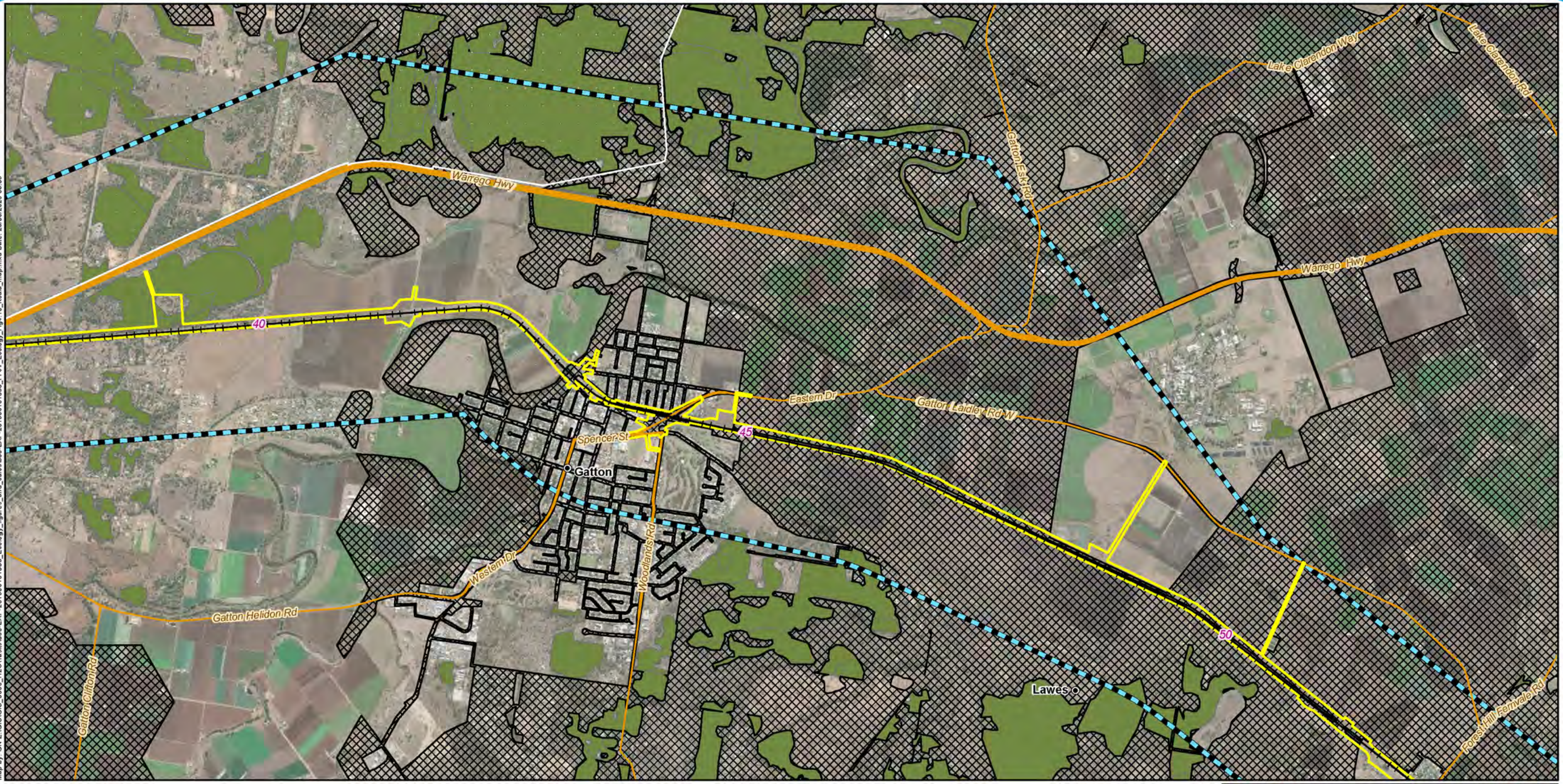
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.10a: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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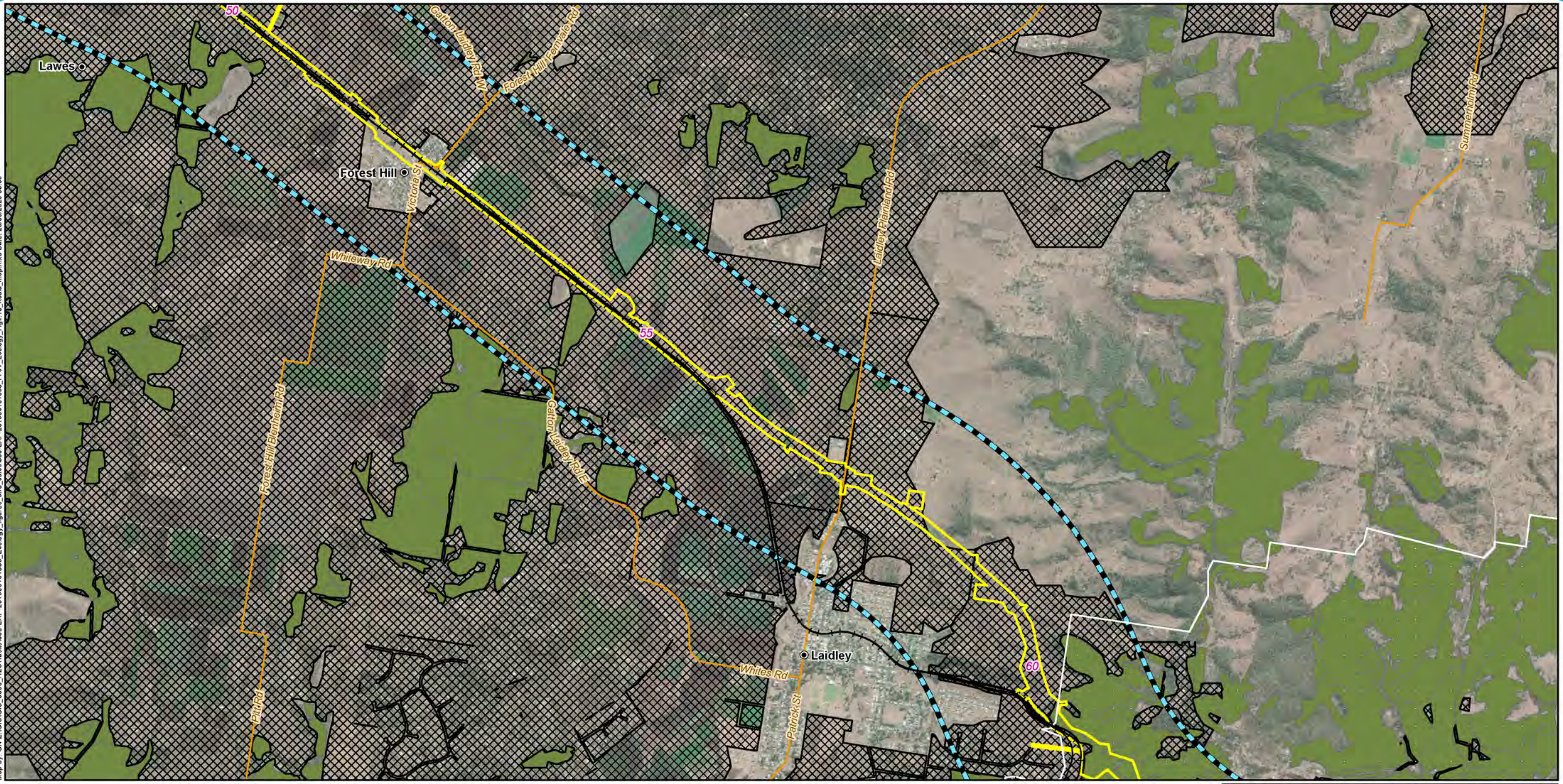
Figure 4.10b: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

Map by: GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4-10_Koala_map.mxd Date: 23/06/2020 08:39

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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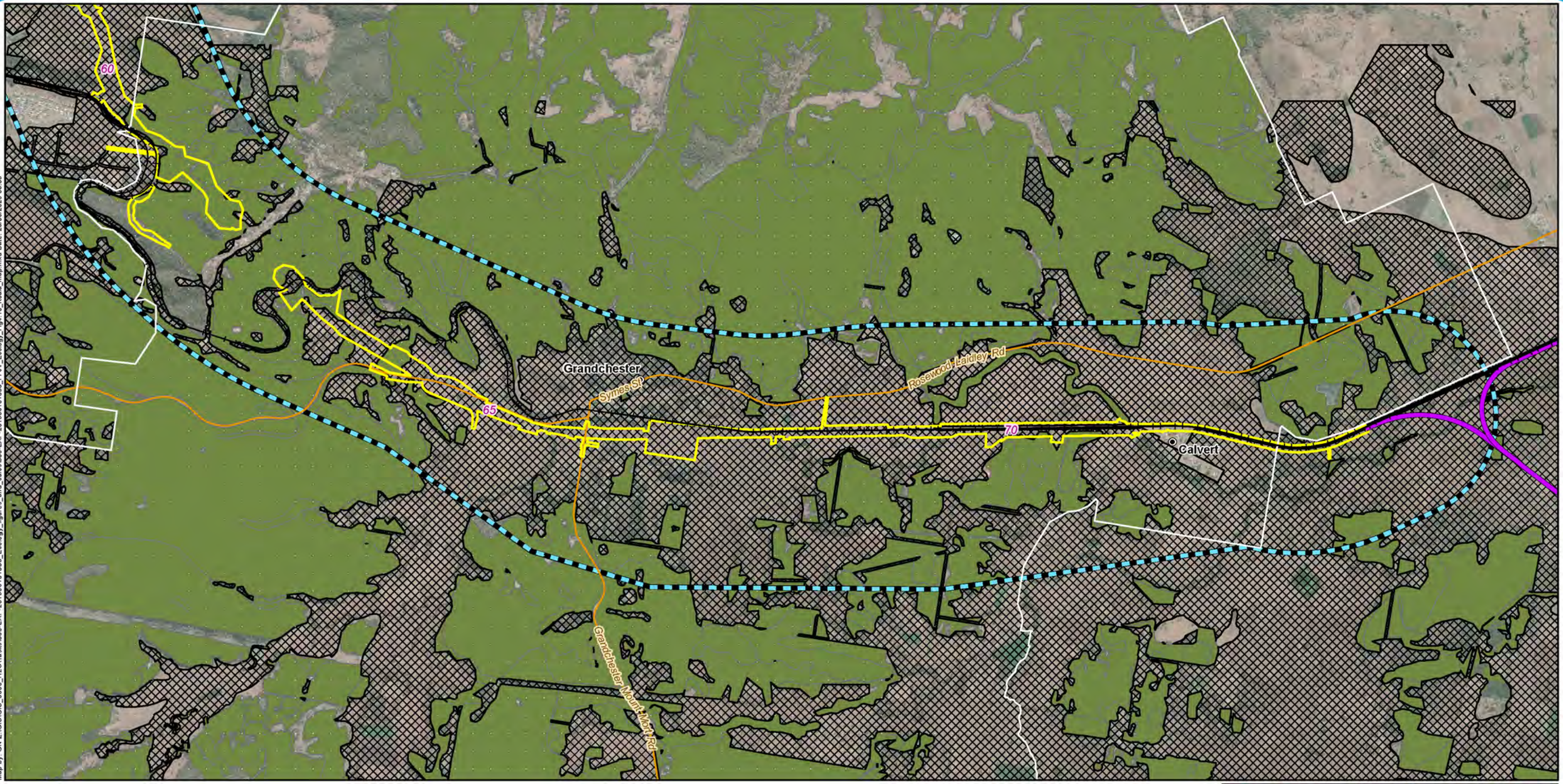
Helidon to Calvert

Figure 4.10c: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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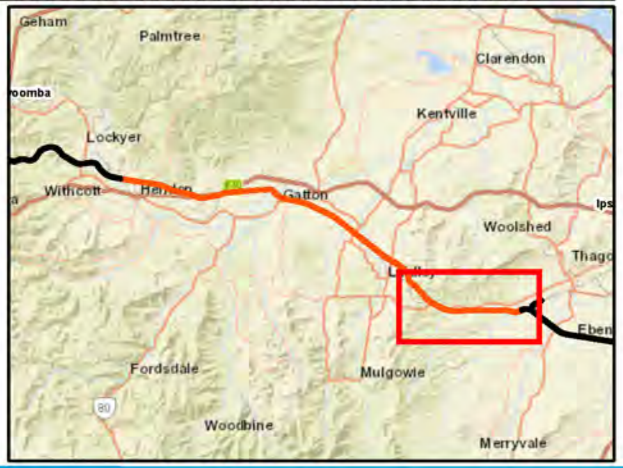
Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.10d: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

4.3.15 Biodiversity Planning Assessment

DES attributes biodiversity significance on a bioregional scale through a BPA. A BPA involves the integration of ecological criteria using the Biodiversity Assessment and Mapping Methodology (BAMM).

BPAs assign three levels of overall biodiversity significance as identified below:

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or State scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened taxa, are identified as 'State Habitat for EVNT taxa'.
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at State or regional scales. Local values are of significance at the local government scale.

The results of the BPA assessment for habitat values and corridors are provided in Sections 4.3.15 and 4.3.15.3 respectively.

4.3.15.1 Special area decisions

The BPA Expert panel derived *Special area decisions* are used to assign values to Other Essential Criteria. The specific decisions to the ecology study area include the following:

- **Forested Estates with high vertebrate diversity** (Regional significance) – Lowland mature vegetation communities likely to support reasonable densities of hollow bearing trees. Preferential clearing of lowland areas for agriculture and urban expansion has resulted in reduced habitat complexities across remnant communities in SEQ.
- **Lowland areas likely to contain reasonable densities of hollow bearing trees** (State significance) – Large contiguous areas of relatively undisturbed vegetation dominated by species such as *Lophostemon confertus, Eucalyptus microcorys, E. racemosa, E. acmenoides, E. psammitica, E. helidonica, E. carnea, E. latisinensis, E. contracta, E. tereticornis, E. major, E. moluccana, A. leiocarpa, E. longirostrata, Corymbia intermedia* have significant wildlife refugial and nesting value due to their tendencies to form hollows
- **Helidon Hills** (State significance) – Collectively, the area delineated has very high flora and landscape values. It is an area of sedimentary geology in places capped by the remnants of an old duricrusted surface of Tertiary age. It has weathered surfaces throughout. Watercourses have cut gorges through the sandstone beds especially on the western side. This area includes the following:
  - SEQ endemic taxa including narrow endemic taxa
  - Wildlife refugia
  - Disjunct taxa
  - Climate refugia
- **Terrestrial bioregional corridors** (State and regional significance) – refer Section 4.3.15.3

- **Riparian lowland forest systems** (other than riparian/gallery rainforests systems) (State significance) - Riparian lowland forest ecosystems are important components of the lowland landscape, frequently exhibiting higher species richness and abundance than surrounding habitats. They act as movement pathways along riparian systems for a number of species, especially birds. They also often provide critical resources for many species in terms of food, shelter and nesting sites. For example, the seasonal flowering of melaleuca is important for species of honeyeaters, whilst narrow bands of flooded gum along watercourses are significant habitat for Koalas (*Phascolarctos cinereus*), especially in times of drought. Large trees in these systems also act as a source of nest hollows for many species of birds, bats and arboreal mammals. Due to historical and preferential clearing in SEQ, remaining systems are often heavily fragmented and have undergone a substantial reduction in their extent. In many areas, condition is often poor and subject to considerable weed problems.

4.3.15.2 State and regional habitat values

The ecology study area includes areas of local and other values, regional and State habitat values, and State habitat for EVNT taxa. Areas of identified habitat values are presented in Table 4.15. No non-bioregional ecosystem habitat values are mapped. Table 4.15 summarises these habitat values across the ecology study area and are shown in Figure 4.11. These areas overlap substantially with those mapped as essential habitat and MSES Wildlife habitat (refer Section 4.3.3).

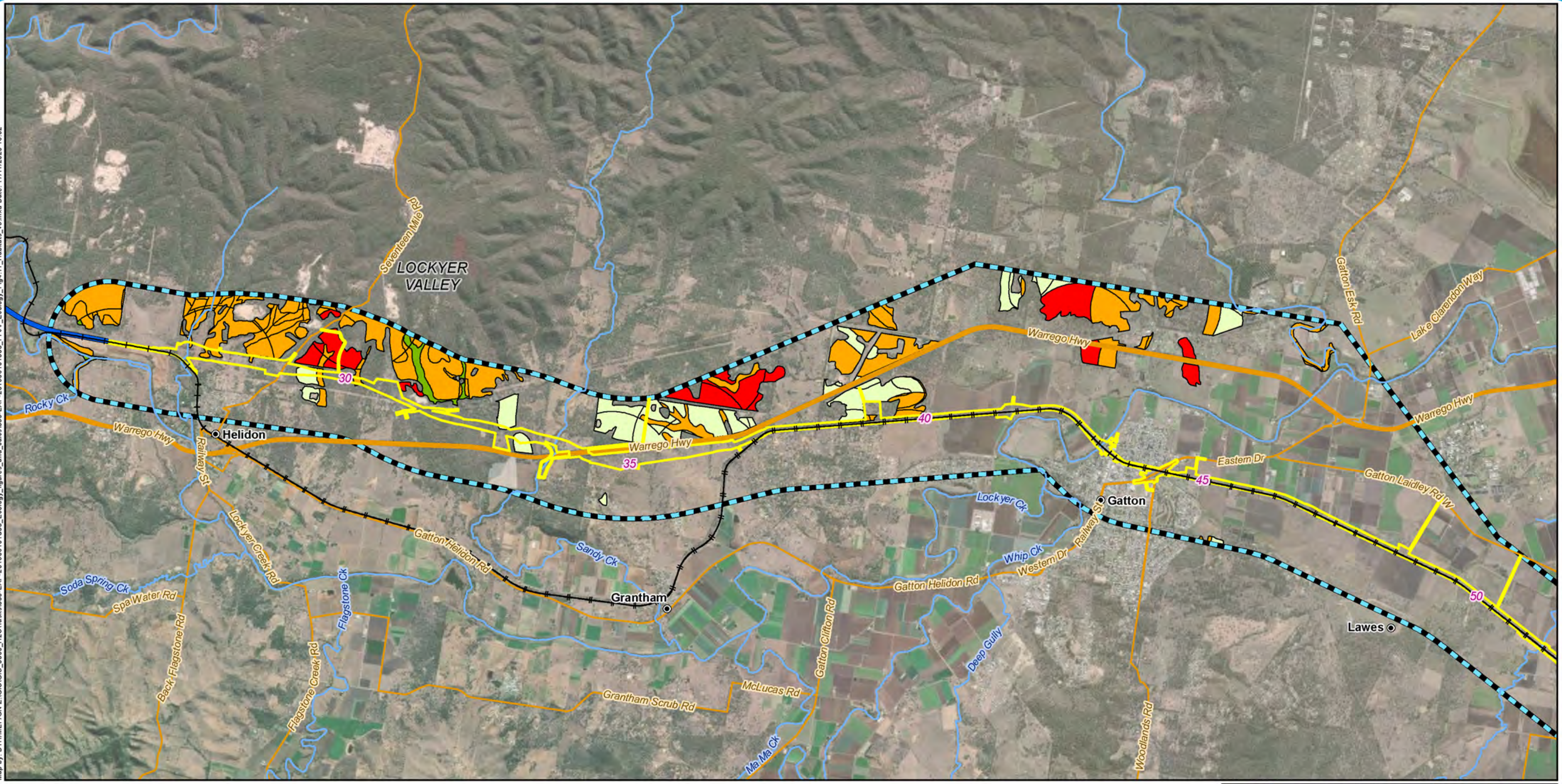
Table 4.15 The extent of BPA biodiversity significance values within the ecology study area

Habitat values	Extent (ha)	
	Ecology study area	Project disturbance footprint
Local or Other Values	277.44	10.65
Regional	667.14	9.10
State	635.09	9.61
State Habitat for EVNT taxa*	155.12	2.90

Table note:

* This is a category of the BPA and a government issued dataset. The BPA mapping does not provide the specific species for which this designation has been mapped and is therefore not included. Information related to the special designations of the areas is provided in Section 4.3.15.1.

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



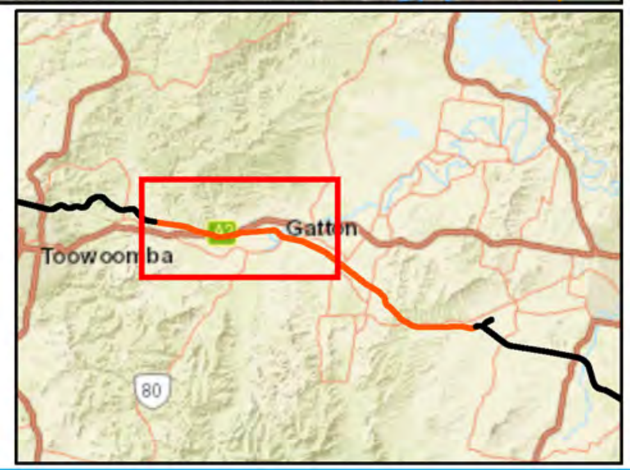
Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.11_Habitats_v5.mxd Date: 17/11/2020 16:02

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Habitat significance (BPA)

- Local or Other Values
- Regional Habitat
- State Habitat
- State Habitat for EVNT taxa



A3 scale: 1:70,000

0 1 2 3km

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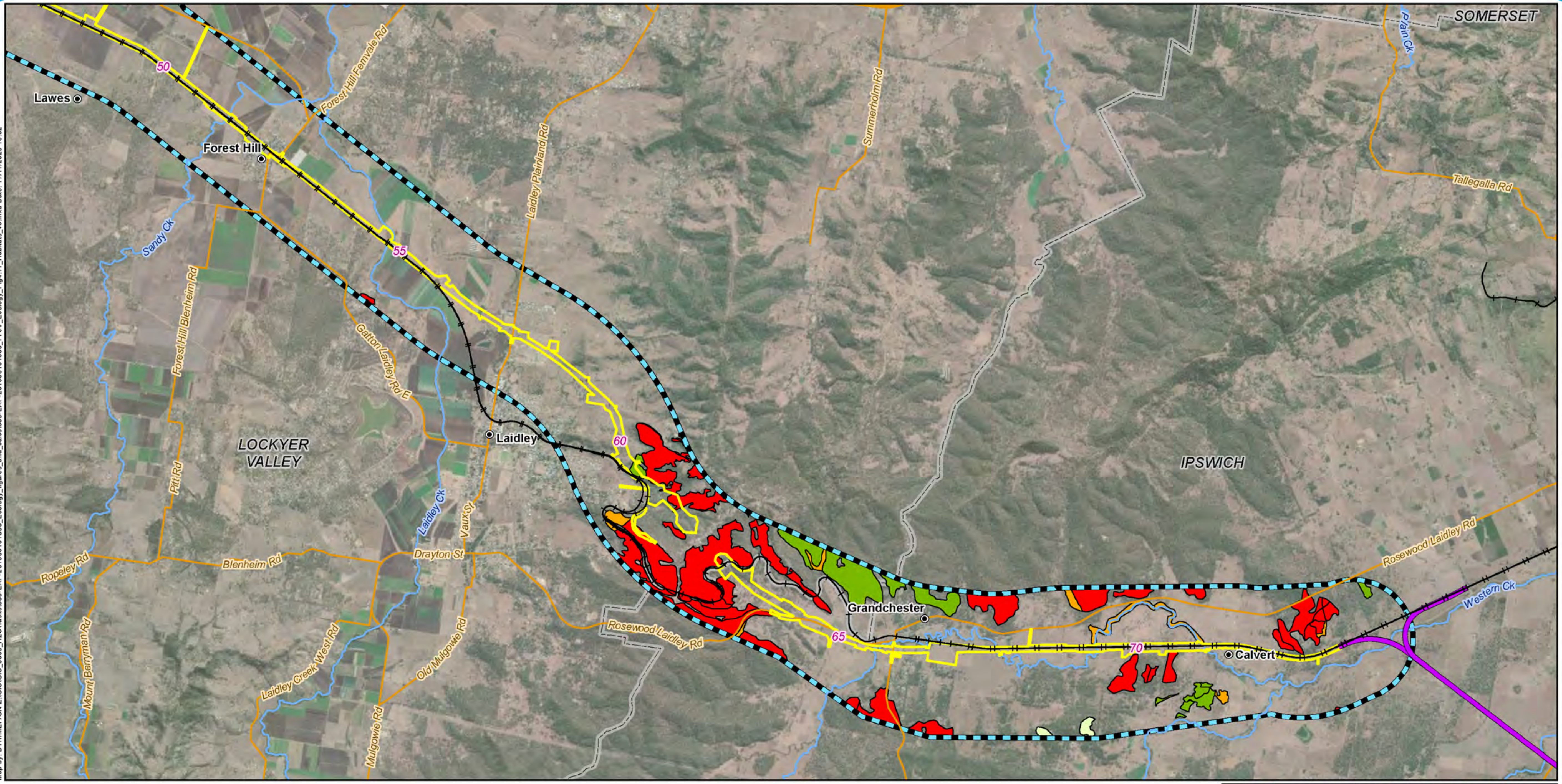
Helidon to Calvert
Figure 4.11a:
State, regional and local habitat significance mapping

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.11_Habitats_v5.mxd Date: 17/11/2020 16:02

Legend

- 5 Chainage (km)
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- Minor roads
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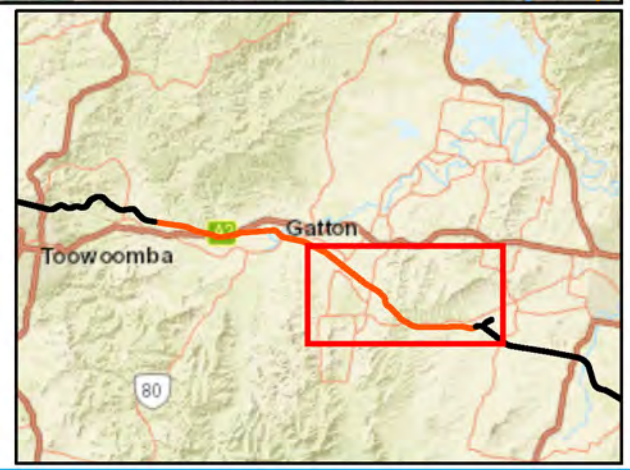
- Ecology study area
- Local Government Areas

Habitat significance (BPA)

- Local or Other Values
- Regional Habitat
- State Habitat
- State Habitat for EVNT taxa



A3 scale: 1:70,000

0 1 2 3km

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Figure 4.11b:
State, regional and local habitat significance mapping

4.3.15.3 State and regionally significant corridors

Areas identified under the BPA as corridors qualify either because they are existing vegetated corridors important for contiguity including regrowth or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and 'stepping stones'. The function of Terrestrial and Riparian corridors is outlined below:

- **Terrestrial Bioregional corridors**, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:
  - Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time
  - Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change
  - Maintaining large scale seasonal/migratory species processes and movement of fauna
  - Maximising connectivity between large tracts/patches of remnant vegetation
  - Identifying key areas for rehabilitation and offsets
- **Riparian Bioregional Corridors** also maintain and encourage connectivity of riparian and associated ecosystems.

The location of the corridors is determined by the following principles:

- Terrestrial
  - Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity)
  - Follow major watershed/catchment and/or coastal boundaries
  - Incorporate major altitudinal/geological/climatic gradients
  - Include and maximise connectivity between large tracts/patches of remnant vegetation
  - Include and maximise connectivity between remnant vegetation in good condition
- Riparian
  - Located on the major river or creek systems within the bioregion in question.

The ecology study area is traversed by two terrestrial corridors of regional significance (associated with vegetation in the Helidon Hills and Little Liverpool Range) and three riparian corridors of State significance. The location of these corridors is provided in Figure 4.12 and quantified in Table 4.16.

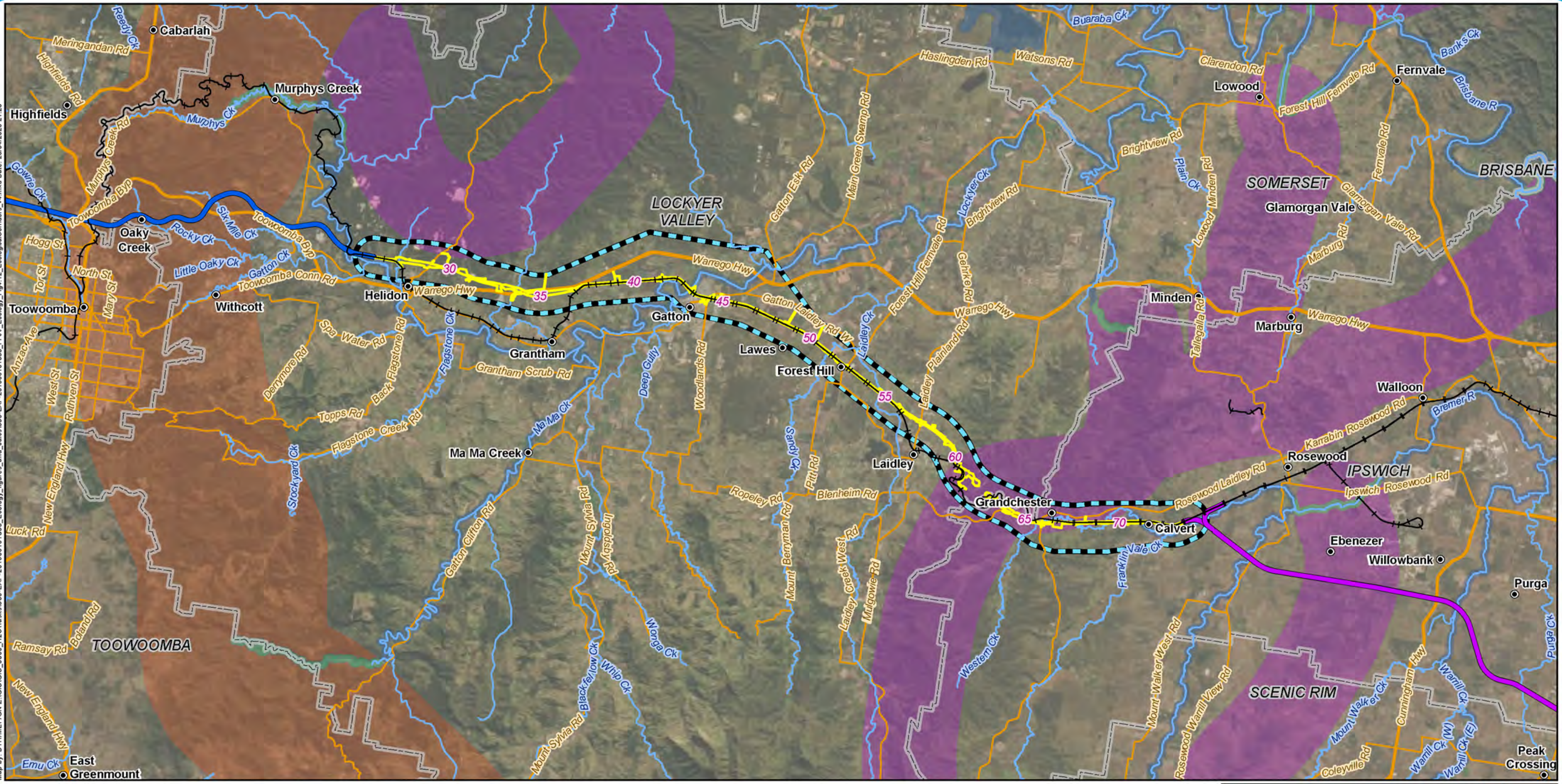
Table 4.16 The extent of BPA terrestrial and riparian ecological corridors within the ecology study area

Corridor type	Extent (ha)	
	Ecology study area	Project disturbance footprint
Regional Terrestrial	1,805.81	140.81
State Riparian	720.47	22.52
State Riparian/Terrestrial	2.54	0.00

4.3.16 Register of critical habitats

No critical habitats, included in the Register of Critical Habitat, occur within the ecology study area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.12_EcologicalCorridors_v4.mxd Date: 23/04/2020 21:28

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Ecological corridors (BPA mapping)

- Riparian, State
- Riparian/Terrestrial, State
- Terrestrial, Regional
- Terrestrial, State

A3 scale: 1:220,000

0 3.5 7 10.5 14 17.5km

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Figure 4.12:
Terrestrial and riparian ecological corridors

4.3.17 Regional Planning Interests Regulation 2014

No designated precincts, in a strategic environmental area under the Regional Planning Interests Regulation 2014, Schedule 2, Part 5, Section 15(3), are located within the ecology study area.

4.3.18 Regulated vegetation mapping

Vegetation regulated under the VM Act is categorised into five separate categories as follows:

- **Category A**: vegetation that is subject to compliance notices, offsets and voluntary declarations
- **Category B**: remnant vegetation shown on RE or remnant map as an endangered RE, an of concern RE or a least concern RE
- **Category C**: high-value regrowth vegetation
- **Category R**: regrowth watercourse area
- **Category X**: vegetation that is generally exempt from requirements under vegetation management laws.

In addition to the five categories presentenced above, vegetation associated with Categories A, B, C and R have been assigned a specific three-digit RE code.

REs are vegetation communities that are consistently associated with a particular combination of geology, landform and soil in a bioregion. REs are shown on the vegetation management supporting map. Each RE has been assigned a vegetation management status based on its current remnant extent—that is, how much of it remains in a bioregion. The three vegetation management codes are as follows:

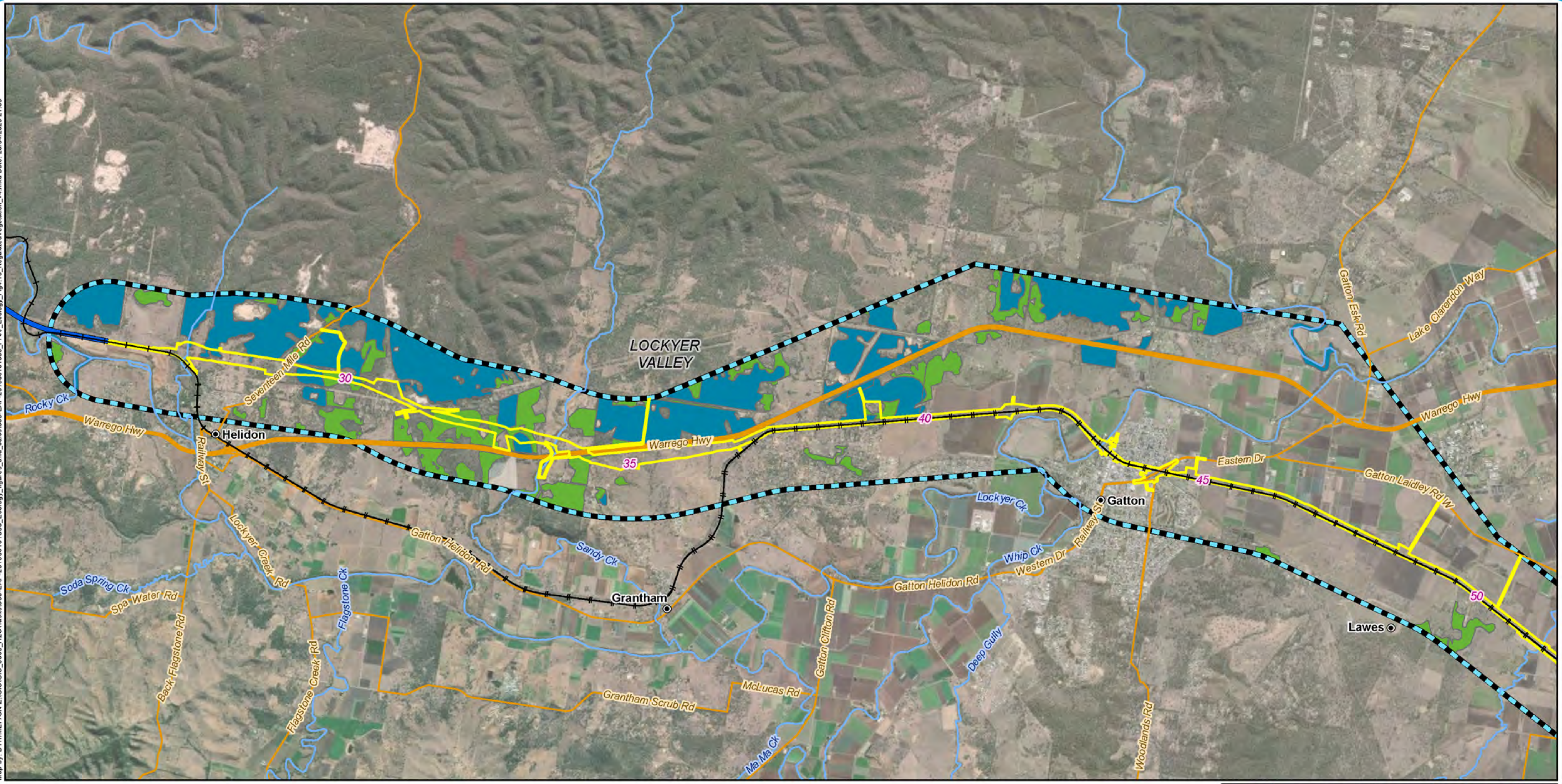
- **Endangered status**: the area of remnant vegetation is less than 10 per cent of the pre-clearing extent of the RE or the area of remnant vegetation is 10–30 per cent of the pre-clearing extent of the RE, and less than 10 000 hectares remains.
- **Of concern status**: the area of remnant vegetation is 10–30 per cent of the pre-clearing extent of the RE or the area of remnant vegetation is more than 30 per cent of the pre-clearing extent of the RE, and less than 10 000 hectares remains.
- **Least concern status**: the area of remnant vegetation is more than 30 per cent of the pre-clearing extent of the RE and more than 10 000 hectares remains
- Analysis of the State based Regulated vegetation mapping (Queensland Government 2020c), indicates that the ecology study area contains Category B and C regulated vegetation. This vegetation is listed as Endangered, Of concern and Least concern. The ecology study area does not contain vegetation mapped as Category R (refer Table 4.17 and Figure 4.13a-b).

Regulated vegetation identified as an MSES includes that mapped as category B, C, R areas of Endangered RE or Of concern RE, and category A, B, C, R areas intersecting a watercourse or wetland when they meet the following criteria:

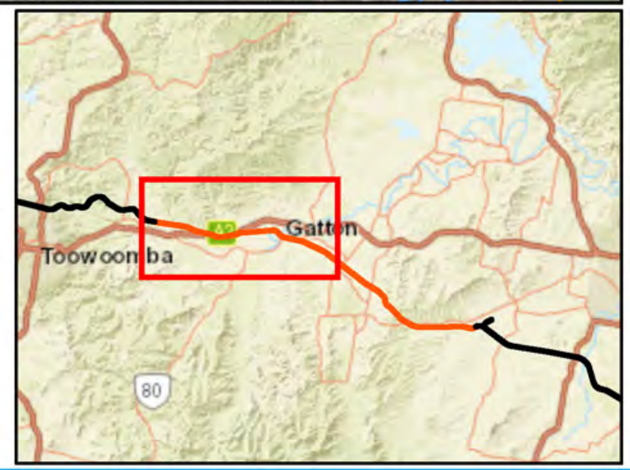
- Category A, B, C and R areas that are located within a defined distance from the defining banks of a relevant watercourse identified on the vegetation management watercourse and drainage feature map
- Category A, B, C and R areas that are located within 100 m from the defining bank of a wetland identified on the vegetation management wetlands map.

Table 4.17 summarises the extent of category B, C, R areas of regulated vegetation that are Endangered or Of concern REs within the ecology study area. The extent of Category B vegetation analysed by VM Act status is presented in Table 4.18

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.13_RegulatedVegetation_v4.mxd Date: 23/04/2020 21:33



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Regulated vegetation

- Category B - Remnant vegetation
- Category C - High value regrowth

A3 scale: 1:70,000

0 1 2 3 4 5km

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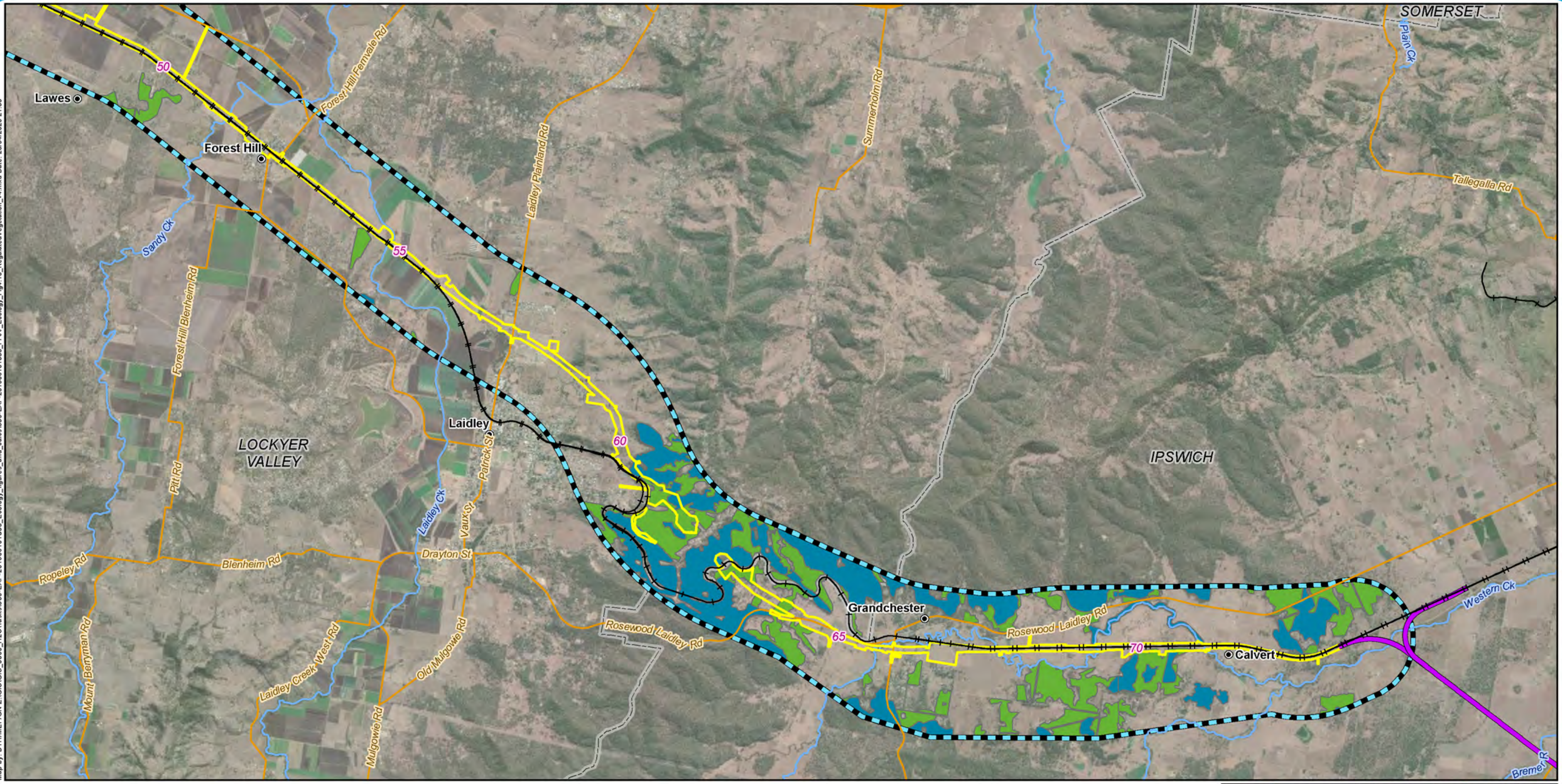
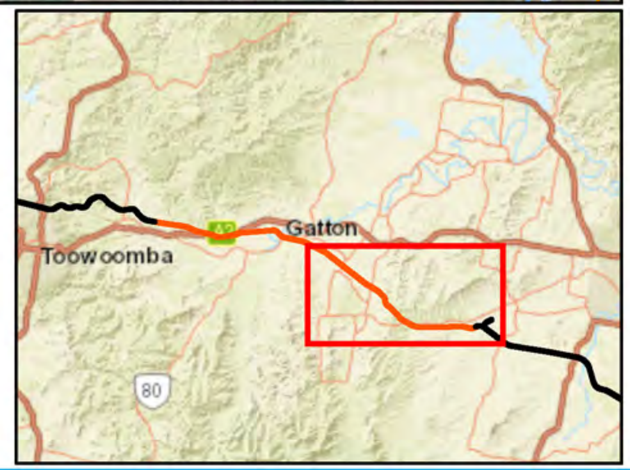
Helidon to Calvert

Figure 4.13a:
Regulated vegetation management mapping

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.13_RegulatedVegetation_v4.mxd Date: 23/04/2020 21:33

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Regulated vegetation

- Category B - Remnant vegetation
- Category C - High value regrowth

A3 scale: 1:70,000

0 1 2 3 4 5km

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Figure 4.13b: Regulated vegetation management mapping

Table 4.17 Extent of category B, C, R and X areas of regulated vegetation that are Endangered or Of concern Regional Ecosystems within the ecology study area

Regulated vegetation category	Extent (ha)	
	Ecology study area	Project disturbance footprint
Category R - Remnant vegetation	0.00	0.00
Category B - Remnant vegetation	1,703.32	32.26
Category C - High value regrowth	1,093.72	66.39
Category X – Non-remnant	9,057.47	535.12

Table 4.18 Extent of Category B regulated vegetation (i.e. Endangered, Of concern and Least concern Regional Ecosystems) contained within the ecology study area

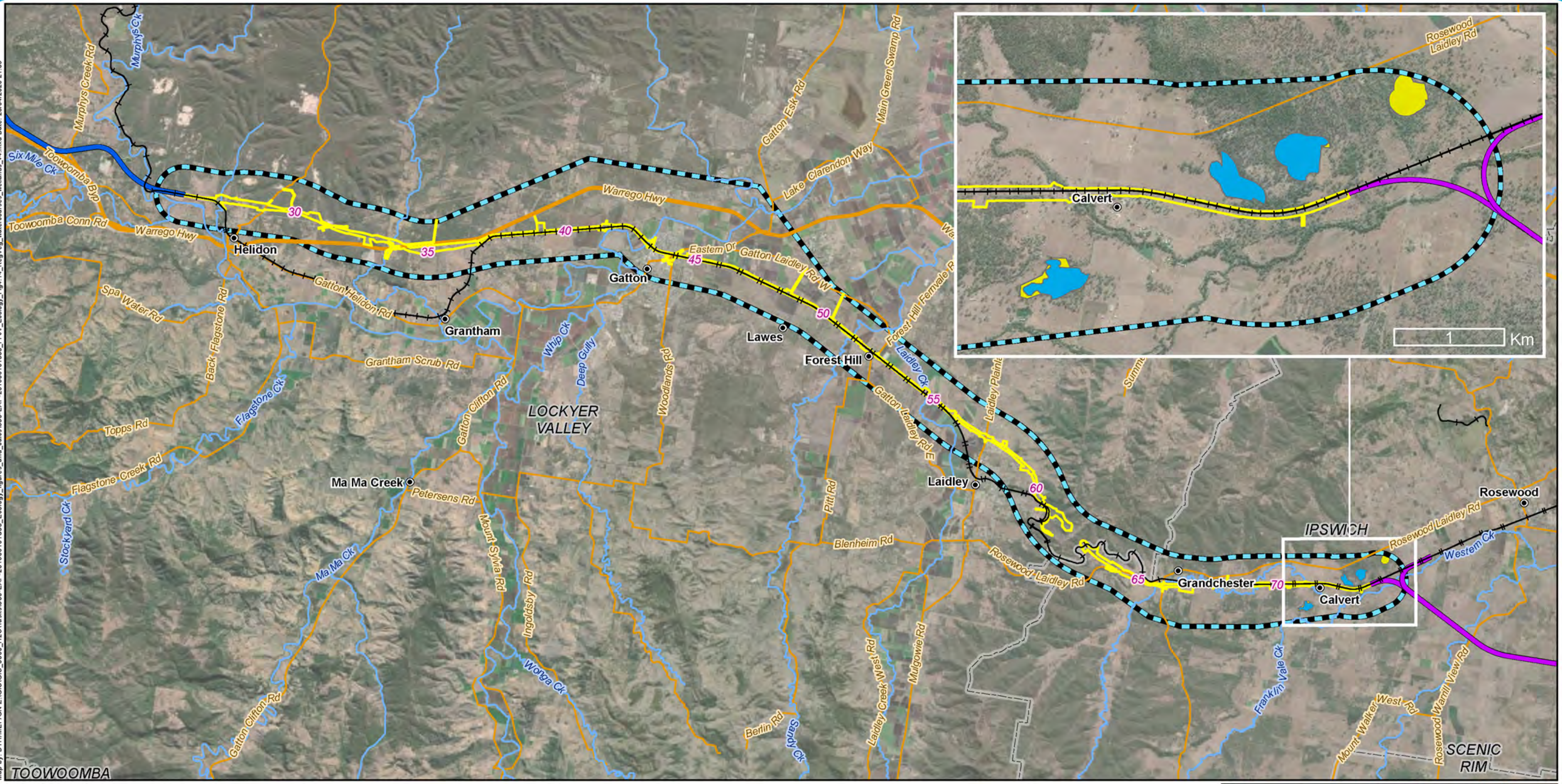
Category B regulated vegetation (VM Act status)	Extent (ha)	
	Ecology study area	Project disturbance footprint
Endangered: ▪ 12.3.3 ▪ 12.3.3d ▪ 12.3.19 ▪ 12.3.18 ▪ 12.9-10.27	104.97	1.62
Of concern: ▪ 12.3.2 ▪ 12.3.8 ▪ 12.9-10.3 ▪ 12.9-10.7	136.24	1.08
Least concern: ▪ 12.3.7 ▪ 12.9-10.2 ▪ 12.9-10.5 ▪ 12.9-10.5a ▪ 12.9-10.19	1,462.09	29.56

Category B and C regulated vegetation intersecting a watercourse and wetlands (mapped under the VM Act) occur within the ecology study area. Category R regulated vegetation intersecting a watercourse/wetland does not occur. The extent of regulated vegetation intersecting watercourses and wetlands is summarised in Table 4.19 and shown in Figure 4.14. It is noted no wetlands (mapped under the VM Act), or associated remnant vegetation, occur within the Project disturbance footprint. The comprehensive list of the 17 REs that occur within the ecology study area is provided in Table 4.20 and shown in Figure 4.15a-b.

Table 4.19 The extent of regulated vegetation intersecting watercourses and wetlands within the ecology study area

Regulated vegetation category	Extent (ha)	
	Ecology study area	Project disturbance footprint
A	0.00	0.00
B	63.45	0.77
C	30.71	1.52
X	428.07	17.53

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Areas within 100 m of wetlands

- Category B - Remnant
- Category C - Regrowth

A3 scale: 1:150,000

0 1 2 3 4 5km

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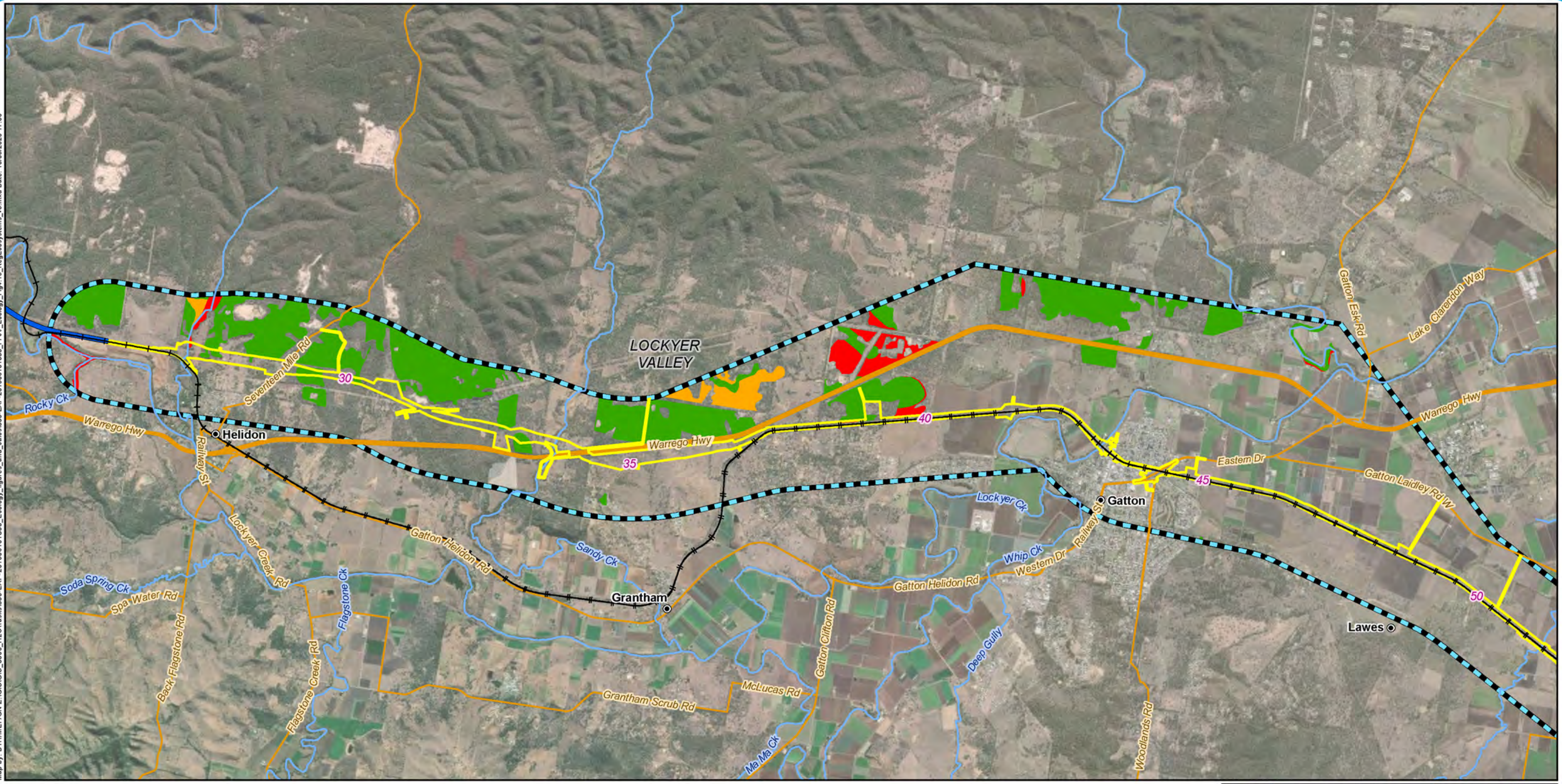
Figure 4.14:

Regulated vegetation intersecting watercourses and wetlands

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



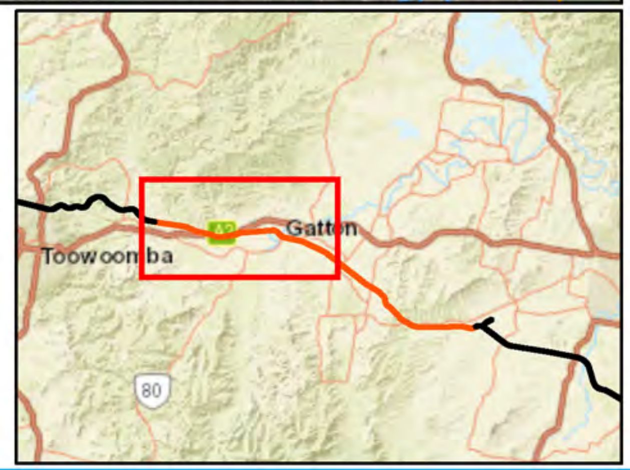
Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.15_RegEcosystems_v5.mxd Date: 10/05/2020 17:06

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Regional ecosystems

- Category A or B area containing endangered
- Category A or B area containing of concern
- Category A or B area that is least concern



A3 scale: 1:70,000

0 1 2 3 4 5km

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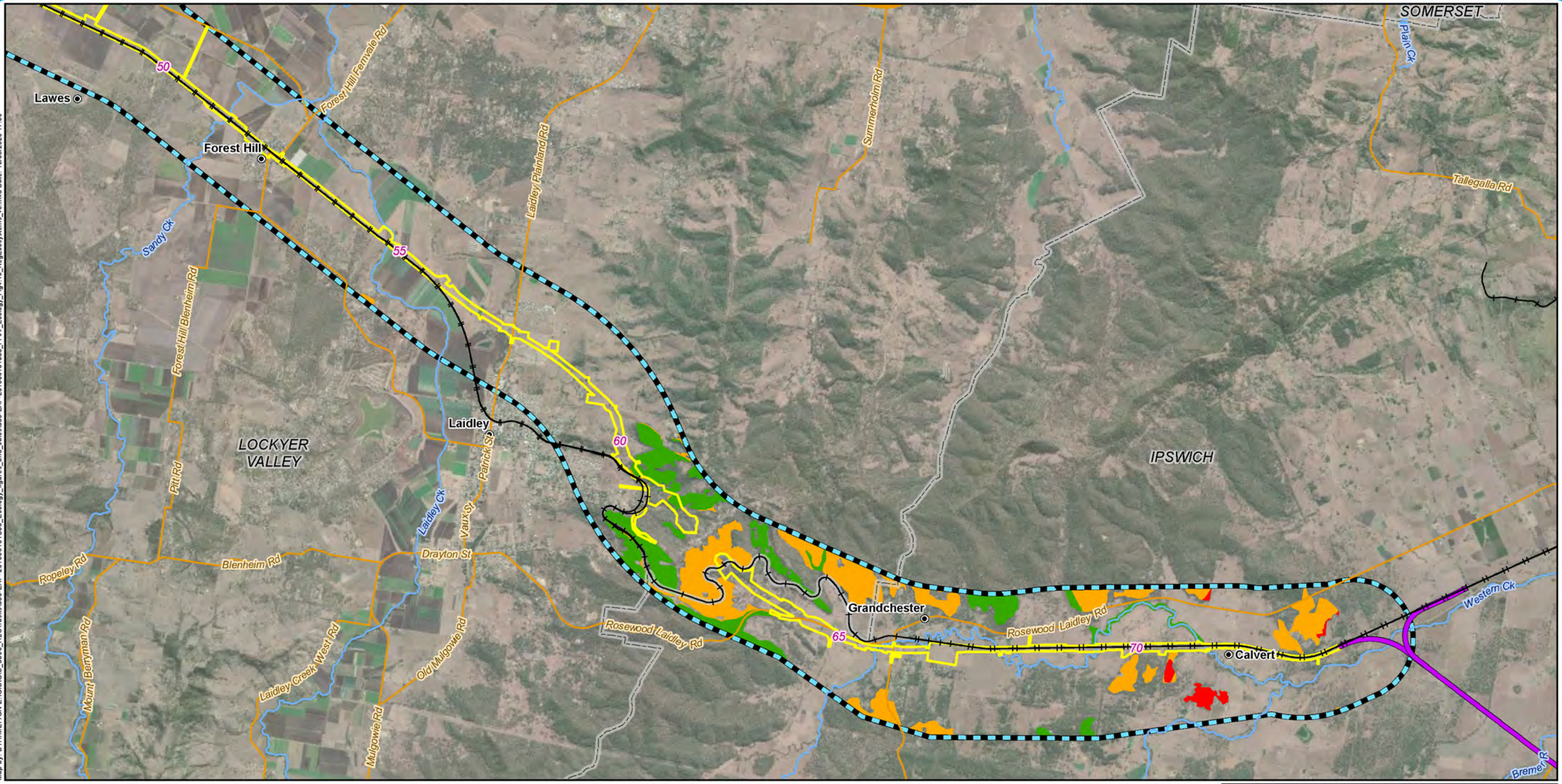
Helidon to Calvert

Figure 4.15a: Distribution of Regional Ecosystems

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



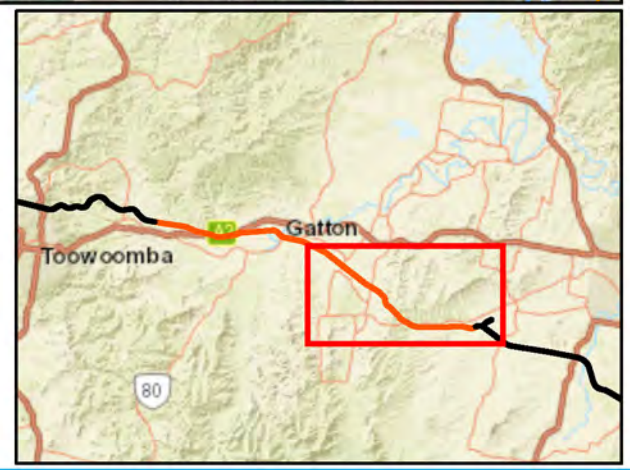
Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.15_RegEcosystems_v5.mxd Date: 10/05/2020 17:06

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

Regional ecosystems

- Category A or B area containing endangered
- Category A or B area containing of concern
- Category A or B area that is least concern



A3 scale: 1:70,000

0 1 2 3 4 5km

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Integrating Community, Environment and Engineering

Issue date: 24/04/2020 Version: 5
Coordinate System: GDA 1994 MGA Zone 56

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Figure 4.15b: Distribution of Regional Ecosystems

Table 4.20 Descriptions of Regional Ecosystems (Category B and C) within the ecology study area

Regional ecosystems (REs)	Management status		Description (REDD Version 11)	Category B Extent (ha)		Category C Extent (ha)	
	VM Act	BD status		Within ecology study area	Project disturbance footprint	Within ecology study area	Project disturbance footprint
12.3.2	OC	OC	*Eucalyptus grandis* +/- *E. microcorys*, *Lophostemon confertus* tall open forest with vine forest understorey ('wet sclerophyll'). Patches of *Eucalyptus pilularis* sometimes present especially in vicinity of sedimentary rocks (e.g. around Palmwoods). Fringing streams and in narrow gullies in high rainfall areas.	0.03	0.00	0.00	0.00
12.3.3	E	E	*Eucalyptus tereticornis* woodland. *Eucalyptus crebra* and *E. moluccana* are sometimes present and may be relatively abundant in places, especially on edges of plains and higher-level alluvium. Other species that may be present as scattered individuals or clumps include *Angophora subvelutina* or *A. floribunda, Corymbia clarksoniana, C. intermedia, C. tessellaris, Lophostemon suaveolens* and *E. melanophloia*. Occurs on Quaternary alluvial plains, terraces and fans where rainfall is usually less than 1,000 mm/y.	85.72	1.62	117.86	8.16
12.3.3d	E	E	*Eucalyptus moluccana* woodland. Other frequently occurring species include *Eucalyptus tereticornis*, *E. crebra*, *E. siderophloia*, *Corymbia citriodora* subsp. *variegata*, *Angophora leiocarpa* and *C. intermedia*. Occurs on margins of Quaternary alluvial plains often adjacent sedimentary geologies. May also occur on stranded Pleistocene river terraces. Floodplain (other than floodplain wetlands).	2.08	0.00	12.34	0.00
12.3.7	LC	OC	Narrow fringing woodland of *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca viminalis*. Other species associated with this RE include *Melaleuca bracteata*, *M. trichostachya*, *M. linariifolia*. North of Brisbane *Waterhousea floribunda* commonly occurs and may at times dominate this RE. *Melaleuca fluviatilis* occurs in this RE in the north of the bioregion. *Lomandra hystrix* often present in stream beds. Occurs on fringing levees and banks of rivers and drainage lines of alluvial plains throughout the region.	131.15	2.24	18.66	1.31
12.3.8	OC	OC	Swamps with characteristic species including *Cyperus* spp., *Schoenoplectus* spp., *Philydrum lanuginosum*, *Eleocharis* spp., *Leersia hexandra*, *Cycnogeton procerus*, *Nymphaea* spp., *Nymphoides indica*, *Persicaria* spp., *Phragmites australis*, *Typha* spp. and a wide range of sedges grasses or forbs. Emergent *Melaleuca* spp. may sometimes occur. Occurs in freshwater swamps associated with floodplains.	7.99	0.00	0.95	0.00
12.3.10a	E	E	*Acacia harpophylla* open forest to woodland. Occurs on Quaternary alluvial plains where minor areas of cracking clay soils prevail.	0.00	0.00	0.58	0.00

Regional ecosystems (REs)	Management status		Description (REDD Version 11)	Category B Extent (ha)		Category C Extent (ha)	
	VM Act	BD status		Within ecology study area	Project disturbance footprint	Within ecology study area	Project disturbance footprint
12.3.18	E	E	*Melaleuca irbyana* low open forest or thicket. Emergent *Eucalyptus moluccana*, *E. crebra*, *E. tereticornis* or *Corymbia citriodora* subsp. variegata may be present. Occurs on Quaternary alluvial plains where drainage of soils is impeded. Analogous to the EPBC Act-listed Swamp Tea-tree (*Melaleuca irbyana*) Forest of South-east Queensland Threatened Ecological Community (refer Appendix J)	4.59	0.00	1.18	0.00
12.3.19	E	E	*Eucalyptus moluccana* and/or *Eucalyptus tereticornis* and *E. crebra* open forest to woodland, with a sparse to mid-dense understorey of *Melaleuca irbyana*. Occurs on margins of Quaternary alluvial plains.	7.79	0.00	2.75	0.00
12.9-10.2	LC	NC	*Corymbia citriodora* subsp. variegata open forest or woodland usually with *Eucalyptus crebra*. Other species such as *Eucalyptus tereticornis*, *E. moluccana*, *E. acmenoides* and *E. siderophloia* may be present in scattered patches or in low densities. Understorey can be grassy or shrubby. Shrubby understorey of *Lophostemon confertus* (whipstick form) often present in northern parts of bioregion. Occurs on Cainozoic and Mesozoic sediments.	1154.95	27.32	547.88	34.64
12.9-10.3	OC	OC	*Eucalyptus moluccana* open forest. Other canopy species include *Eucalyptus siderophloia* or *E. crebra*, *E. tereticornis* and *Corymbia citriodora* subsp. *variegata*. Understorey generally sparse but can become shrubby in absence of fire. Occurs on Cainozoic and Mesozoic sediments, especially shales. Prefers lower slopes.	13.90	0.00	29.91	2.86
12.9-10.5	LC	NC	Shrubby woodland complex. More widely distributed and abundant species include *Corymbia trachyphloia* subsp. *trachyphloia*, *C. citriodora* subsp. *variegata*, *Eucalyptus crebra*, *E. fibrosa* subsp. *fibrosa,* E. *major*, *Angophora leiocarpa*, *E. helidonica*. Understorey of sclerophyllous shrubs. Localised occurrences of *Eucalyptus baileyana*, *E. pilularis*, *Corymbia henryi*, *E. dura*, *E. decorticans* (extreme west of bioregion), *E. taurina*, *Angophora woodsiana*, *Lysicarpus angustifolius* and *Lophostemon confertus*. Tends to shrubland or monospecific woodland of species such as *Eucalyptus dura* on shallow lithosols. Occurs on quartzose sandstone scarps and crests.	9.93	0.00	27.21	2.86
12.9-10.5a	LC	NC	*Eucalyptus helidonica*, *Corymbia citriodora* subsp. *variegata* open forest +/- *C. trachyphloia* subsp. *trachyphloia*, *Eucalyptus fibrosa* subsp. *fibrosa*, *E. taurina*, *E. dura*, *E. baileyana*, *C. gummifera*, *Angophora woodsiana* and *Lysicarpus angustifolius*. Occurs on quartzose sandstone scarps and crests.	153.10	0.00	36.45	0.00
12.9-10.6	E	E	*Acacia harpophylla* open forest +/- *Casuarina cristata* and vine thicket species. Occurs on Cainozoic and Mesozoic sediments, especially fine-grained rocks. Analogous to the EPBC Act-listed Brigalow (*Acacia harpophylla*) dominant and codominant Threatened Ecological Community (refer Appendix J)	0.00	0.00	4.53	0.00

Regional ecosystems (REs)	Management status		Description (REDD Version 11)	Category B Extent (ha)		Category C Extent (ha)	
	VM Act	BD status		Within ecology study area	Project disturbance footprint	Within ecology study area	Project disturbance footprint
12.9-10.7	OC	OC	*Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland. Occurs on Cainozoic and Mesozoic sediments.	114.32	1.08	212.64	9.53
12.9-10.17a	LC	NC	*Lophostemon confertus* or *L. suaveolens* dominated open forest usually with emergent Eucalyptus and/or Corymbia species. Occurs in gullies and southern slopes on Cainozoic and Mesozoic sediments.	0.00	0.00	18.38	0.19
12.9-10.19	LC	NC	*Eucalyptus fibrosa* subsp. *fibrosa* woodland +/- *Corymbia citriodora* subsp. *variegata*, *E. acmenoides* or *E. portuensis*, *Angophora leiocarpa*, *E. major*. Understorey often sparse. Localised occurrences of *Eucalyptus sideroxylon*. Occurs on Cainozoic and Mesozoic sediments.	12.96	0.00	61.92	6.84
12.9-10.27	E	E	*Corymbia citriodora* subsp. *variegata*, *Eucalyptus crebra* and/or *E. moluccana*, *E. tereticornis* open forest with a sparse to mid-dense understorey of *Melaleuca irbyana*. Occurs on lower slopes and elevated flats with impeded drainage on Mesozoic sediments.	4.79	0.00	0.48	0.00
Non-remnant	-	-	*Not applicable*	9,057.47	535.12	-	-

Table notes:

VM = Vegetation Management Act 1999 (Qld) LC = Least concern NC = No concern at present
OC = Of concern E = Endangered BD = Biodiversity

4.3.19 Offset areas

There are no known legally secured offset areas located within the ecology study area.

4.3.20 Protected plants flora survey trigger map

High risk areas on protected plant flora trigger survey mapping represents areas where Endangered, Vulnerable or Near threatened plants are known to exist or are likely to exist, are located within the ecology study area. The distribution of high-risk areas is shown in Figure 4.16 and quantified in Table 4.21. A substantial portion of the mapped area was surveyed during surveys associated with geotechnical investigation for the Project (refer Table 3.3). Two protected plants have been recorded during Project surveys (refer Section 4.4.1).

Table 4.21 Extent of high risk areas contained within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
High risk area	1429.36	35.76

4.4 Results of field assessments

This sections provides a description of the existing environmental values of the ecology study area based on the results of the field assessments. The results presented in this section detail the existing flora and fauna species (including weeds and pests), habitats and vegetation communities, aquatic values and predicted habitat mapping for conservation significant species as listed under the provisions of the NC Act.

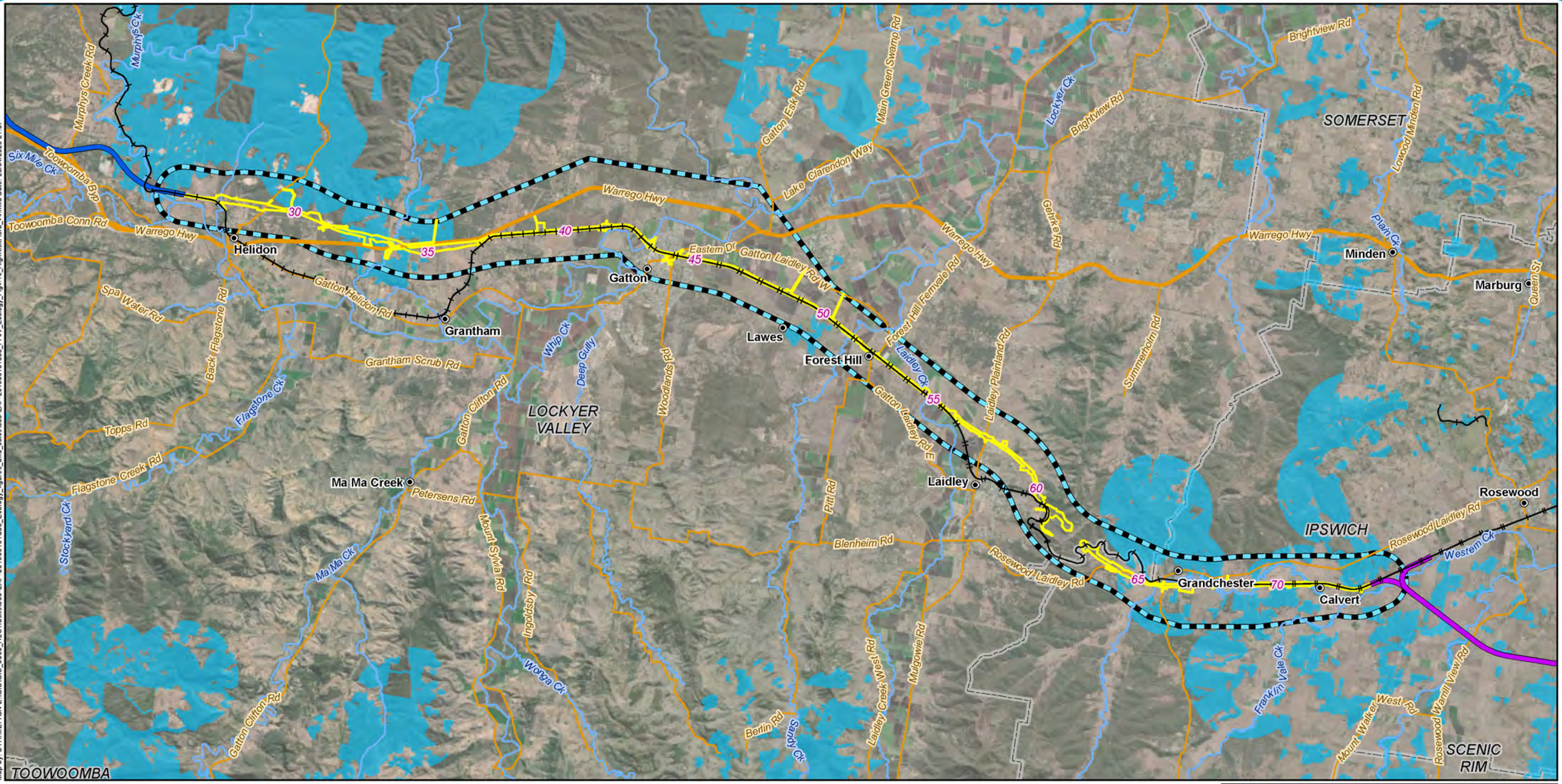
4.4.1 Flora

4.4.1.1 Species richness

A total of 421 plant species were identified within the Ecology study area during the Project EIS field assessment, including 287 native species (68.2 per cent) and 134 non-native species (31.8 per cent) (refer Appendix D and Appendix H).

Non-native species were typically more abundant and diverse in areas of high anthropogenic disturbance when compared to those characterised by an intact canopy of native species such as remnant vegetation/intact bushland. However, encroachment of non-native species, particularly those spread by birds (e.g. *Lantana camara* and *Lantana montevidensis*) was evident in relatively undisturbed areas. These species have the potential to outcompete, replace and exclude native flora species within such environments. Aquatic macrophytes were poorly represented throughout the ecology study area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas
- High risk flora (v7.1*)

* Source: Flora Survey Trigger Map for Clearing Protected Plants in Queensland - Version 7.1
© State of Queensland (Department of Environment and Science) 2019

A3 scale: 1:150,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.16:
High risk flora areas

4.4.1.2 NC Act conservation significant and special least concern flora species

Excluding MNES species, one threatened flora species, listed under the provision of the NC Act, was recorded within the ecology study area: Swamp tea-tree (*Melaleuca irbyana*). A single specimen of this species was identified immediately to the south of Rosewood Laidley Road, within Lot 112 on CH31344 (refer Figure 4.17).

In addition, 11 SLC flora species were observed throughout the ecology study area. Whist these species were relatively common, they were most abundant in areas containing in-tact remnant vegetation. A summary of the conservation significant and SLC flora species identified during EIS field assessments is presented in Table 4.22. Figure 4.17 illustrates the location of observed conservation significant flora species (excluding MNES and SLC species). Information related to the occurrence of MNES flora species (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance Technical Report.

Field investigations also confirmed the presence of habitat, including:

- Bailey's cypress (*Callitris baileyi*) – the presence of rocky slopes, and hilly/mountainous areas
- Swamp tea-tree (*Melaleuca irbyana*) – presence of habitat in the form of flat areas that are periodically waterlogged on poorly draining, heavy clay soils.

No habitat for Helidon ironbark (*Eucalyptus taurina*) was observed within or close to the Project disturbance footprint.

This information was used to inform the predictive habitat modelling and mapping for each of the threatened flora species (refer Appendix F for species habitat maps).

Table 4.22 Special least concern flora species observed within the ecology study area

Family	Species name	Common name	NC Act status
Campanulaceae	*Lobelia purpurascens*	White root	SLC
Campanulaceae	*Wahlenbergia glabra*	Native bluebell	SLC
Campanulaceae	*Wahlenbergia gracilis*	Sprawling bluebell	SLC
Campanulaceae	*Wahlenbergia stricta*	Small bluebell	SLC
Myrtacae	*Melaleuca irbyana*	Stamp tea-tree	V
Orchidaceae	*Cymbidium canaliculatum*	Black orchid	SLC
Polypodiaceae	*Platycerium bifurcatum*	Elkhorn fern	SLC
Potamogetonaceae	*Potamogeton crispus*	Curly pondweed	SLC
Potamogetonaceae	*Potamogeton ochreatus*	Blunt pondweed	SLC
Sterculiaceae	*Brachychiton acerifolius*	Flame tree	SLC
Sterculiaceae	*Brachychiton discolor*	Lacebark tree	SLC
Sterculiaceae	*Brachychiton populneus*	Kurrajong	SLC

Table notes:

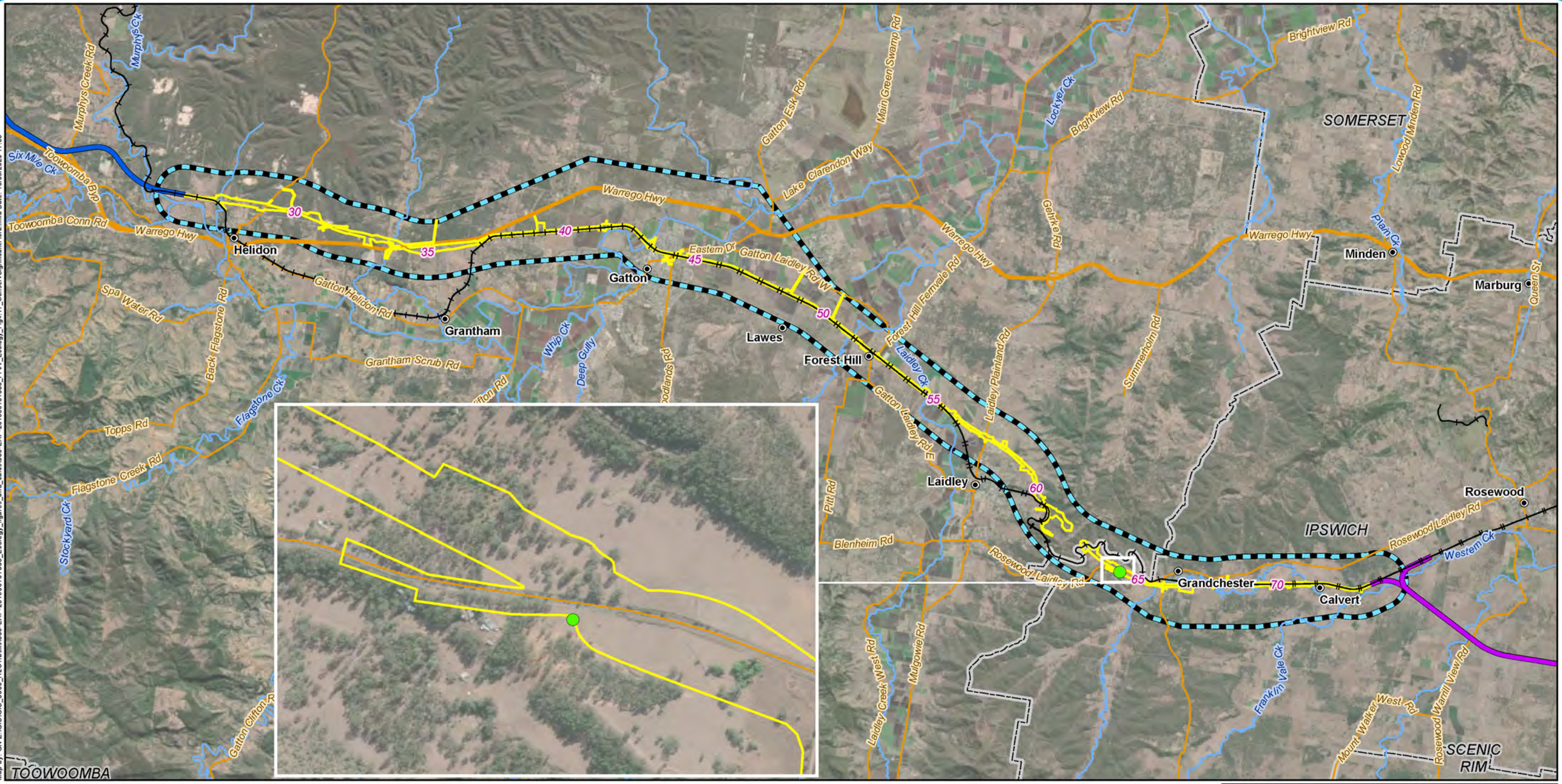
- = Species not listed SLC = Special least concern V = Vulnerable

4.4.1.1 Weed species

The Project EIS field assessments identified 18 restricted matters flora species (under the Biosecurity Act) from the ecology study area (refer Table 4.23).

Of the total restricted matters, 10 are listed as Weeds of National Significance (WoNS). A total of 134 introduced flora species were identified during the Project EIS field investigations (refer Appendix D and Appendix H). Weeds were prevalent across the entire ecology study area but were most abundant in areas subject to anthropogenic disturbance such as roadsides and areas subject to cattle grazing.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Swamp tea-tree (*Melaleuca irbyana*)
- Existing rail
- G2H project alignment
- C2K project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.17: Observed conservation significant flora species (excluding threatened MNES)

Table 4.23 **Restricted matters identified within the ecology study area**

Family name	Species name	Common name	Schedule 2 of the Biosecurity Act	Weeds of National Significance	Relative abundance within the ecology study area	Typical areas of occurrence within the ecology study area
Anacardiaceae	*Schinus terebinthifolius*	Broadleaved peppertree	Category 3	No	Occasional to common	Riparian forest and bushland
Apocynaceae	*Cryptostegia grandiflora*	Rubber vine	Category 3	No	Uncommon	Riparian forest
Asparagaceae	*Asparagus aethiopicus*	Asparagus fern	Category 3	Yes	Common	Bushland
Asparagaceae	*Asparagus asparagoides*	Bridal creeper	Category 2,3,4,5	Yes	Uncommon	Bushland
Asparagaceae	*Asparagus plumosus*	Climbing asparagus fern	Category 3	Yes	Common	Drainage lines and riparian areas
Asteraceae	*Ambrosia artemisiifolia*	Annual ragweed	Category 3	No	Common	Bushland, agricultural areas and road reserves
Asteraceae	*Baccharis halimifolia*	Groundsel bush	Category 3	Yes	Common	Agricultural areas and road reserves
Asteraceae	*Senecio madagascariensis*	Fireweed	Category 3	Yes	Very common	Agricultural areas and road reserves
Basellaceae	*Anredera cordifolia*	Madeira vine	Category 3	Yes	Common	Drainage lines and riparian areas
Bignoniaceae	*Tecoma stans var. stans*	Yellow bells	Category 3	No	Common	Bushland
Cactaceae	*Opuntia stricta*	Common pest pear	Category 3	Yes	Common	Bushland and agricultural areas
Cactaceae	*Opuntia tomentosa*	Velvety tree pear	Category 3	Yes	Very common	Bushland and agricultural areas
Crassulaceae	*Bryophyllum delagoense*	Mother-of-millions	Category 3	Yes	Very common	Bushland and agricultural areas
Lauraceae	*Cinnamomum camphora*	Camphor laurel	Category 3	No	Common	Riparian forest and bushland
Oleaceae	*Ligustrum lucidum*	Broad-leaved privet	Category 3	No	Common	Drainage lines and riparian areas
Ulmaceae	*Celtis sinensis*	Chinese celtis	Category 3	No	Very common	Drainage lines and riparian areas
Verbenaceae	*Lantana camara*	Lantana	Category 3	Yes	Very common	All areas
Verbenaceae	*Lantana montevidensis*	Creeping lantana	Category 3	No	Common	Bushland and agricultural areas

Table notes:

Each restriction category number identifies an obligation or an offence provision that applies to biosecurity matter assigned that category number. These numbers are defined as follows:

- Category 3 = includes noxious fish, weeds and pest animals which must not be distributed. This means it must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under permit.
- Category 5 = includes noxious fish, weeds and pest animals. These invasive plants cannot be moved, kept, released into the environment, or given away or sold as a plant or as something infested with its seeds

4.4.1.2 Aquatic flora

Aquatic flora species were relatively poorly represented (i.e. low diversity) within the ecology study area (refer Photograph 4.1, Photograph 4.2, Photograph 4.3 and Photograph 4.4).

The Project EIS field assessments identified nine aquatic flora species from the ecology study area (refer Table 4.24 and Appendix D). All aquatic species identified were generally common and widespread were suitable conditions for their colonisation were available (i.e. permanent water).

Photograph 4.1 Lockyer Creek at Project alignment waterway crossing displaying absence of aquatic macrophytes (FFJV 2017)

Photograph 4.2 Western Creek at the Project alignment waterway crossing illustrating poor diversity of aquatic flora (FFJV 2017)

Photograph 4.3 Laidley Creek, downstream of the proposed Project alignment illustrating the poor diversity of aquatic flora (FFJV 2017)

Photograph 4.4 Unnamed tributary within the Lockyer Creek catchment illustrating the absence of aquatic flora species (FFJV 2017)

Table 4.24 Aquatic flora identified within the ecology study area

Family name	Species name	Common name
Araceae	*Lemna* sp.	Duckweed
Cyperaceae	*Cyperus* sp.	Sedge
Hydrocharitaceae	*Elodea* sp.	Canadian pondweed
Hydrocharitaceae	*Vallisneria* sp.	Ribbonweed
Juncaceae	*Juncus* sp.	Rush

Family name	Species name	Common name
Plantaginaceae	*Callitriche* sp.	Starwart
Polygonaceae	*Persicaria* sp.	Knotweed
Potamogetonaceae	*Potamogeton* sp.	Pondweed
Typhaceae	*Typha* sp.	Cambungi

4.4.2 Fauna

This section outlines the fauna species richness observed within the ecology study area. This section also provides information related to conservation significant species listed under the provisions of the NC Act and/or EPBC Act (i.e. non-threatened migratory species) as well as information related to pest species declared under the Biosecurity Act that were recorded within the ecology study area.

4.4.2.1 Species richness

The Project EIS field investigations identified a total of 168 fauna species (refer Appendix E), including 156 native species (92.9 per cent) and 12 non-native species (7.1 per cent) from within the ecology study area. Recorded species consisted of 120 (71.43 per cent) birds, 32 (19.05 per cent) mammals (16 of which are microbat species), 12 (7.14 per cent) reptiles, four (2.38 per cent) amphibians.

Given the fragmented nature of bushland areas within the ecology study area, their vagile nature and ability to persist in fragmented landscapes it is to be expected that birds would constitute the largest percentage of observed species. However, their dominance of the recorded species is also likely to be an artefact of their detectability when compared to more cryptic species such as amphibians and reptiles.

4.4.2.2 NC Act conservation significant and special least concern fauna species

Excluding threatened MNES, two conservation significant fauna species, were identified within the ecology study area during project related field investigations (refer Table 4.25 and Figure 4.18). Both of these species were identified within close proximity to waterways. Photographs showing typical habitat for observed conservation significant species is provided in Photograph 4.5 and Photograph 4.6.

Table 4.25 Migratory fauna species observed within the ecology study area

Family	Species name	Common name	EPBC Act status	NC Act status
Dicruridae	*Monarcha melanopsis*	Black-faced monarch	M	SLC
Dicruridae	*Symposiachrus trivirgatus*	Spectacled monarch	M	SLC

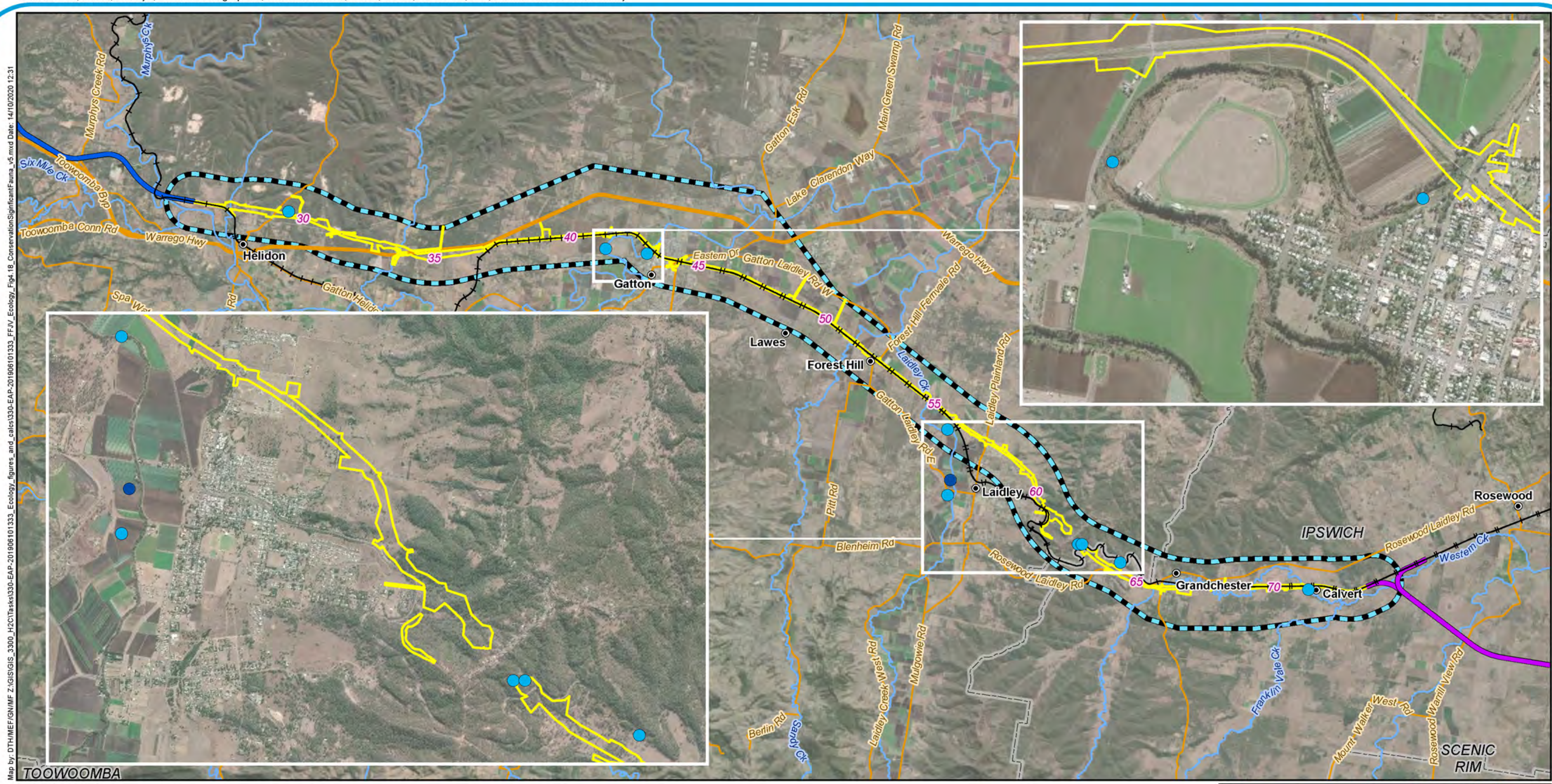
Photograph 4.5 **Laidley Creek, showing vegetation where the Black-faced monarch was observed (FFJV 2017)**

Photograph 4.6 **Laidley Creek, showing vegetation where the Spectacled monarch was observed (FFJV 2017)**

Field investigations also confirmed the presence of habitat (foraging and breeding), including:

- Suitable habitat for forest/woodland migratory species such as the Oriental cuckoo (Cuculus optatus), Satin flycatcher (*Myiagra cyanoleuca*),Rufous fantail (*Rhipidura rufifrons*), Black-faced monarch (*Monarcha melanopsis*) and Spectacled monarch (*Symposiachrus trivirgatus*) in the form of riparian forests and woodlands and larger open forest and woodland remnants associated with the Helidon Hills and the Little Liverpool Range
- Suitable habitat for wetland/Wader migratory species such as the Glossy ibis (*Plegadis falcinellus*) in the form or wetlands and farm dams
- Glossy-black cockatoo (*Calyptorhynchus lathami*) – presence of large hollows and foraging trees (i.e. *Allocasuarina torulosa* and *Allocasuarina littoralis*) within the Helidon Hills area and along road reserves.
- Powerful owl (Ninox strenua) – large tracts of forest or woodland within the Little Liverpool Range, and the Helidon Hills, and large hollows and foraging habitat within more fragmented landscapes
- Short-beaked echidna (*Tachyglossus aculeatus*) – occurrence of forests, woodlands and grasslands with areas suitable for breeding burrows
- Platypus (*Ornithorhynchus anatinus*) – occurrence of major drainage features with formed bank areas provide suitable for foraging and breeding areas.
- The availability of habitat types and their relevance to MSES fauna is discussed further in Section 4.4.4.
- This information was used, in addition to that contained within relevant conservation listing advice, to inform the predictive habitat modelling and mapping for each of the threatened and migratory fauna species (refer Appendix F for species habitat maps). Potential habitat for NC Act conservation significant and EPBC Act non-threatened migratory fauna species is spread throughout the Project alignment with a focus on those areas containing tracts of remnant vegetation.
- It is noted that whilst all areas of the ecology study area were not accessible, information derived from historic and concurrent surveys (refer Section 3.4.1.1) was used to inform the predictive mapping where applicable.
- Information related to the occurrence MNES fauna species (excluding migratory species) (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance Technical Report.

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

5 Chainage (km)
Localities
Existing rail
G2H project alignment
C2K project alignment
Defined watercourses
Major roads
Minor roads
EIS disturbance footprint
Ecology study area
Local Government Areas

Fauna observations

Black-faced monarch (*Monarcha melanopsis*)
Spectacled monarch (*Symposiachrus trivirgatus*)

A3 scale: 1:150,000

0 1 2 3 4 5km

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Helidon to Calvert

Figure 4.18: Observed NC Act conservation significant and EPBC Act listed migratory fauna species (excluding threatened MNES)

4.4.2.3 Invasive animals

A total of 12 introduced fauna species were recorded from the ecology study area, with five of these species declared as restricted matters (invasive animals) under the Biosecurity Act (refer Table 4.26 and Appendix E). These species were widespread across the entire ecology study area. Whilst not observed, it is noted that the Red imported fire ant (*Solenopsis invicta*) is known from the ecology study area (refer Section 4.3.4 for further details).

Table 4.26 Restricted matter fauna species identified within the ecology study area

Family name	Species name	Common name	Schedule 2 of the Biosecurity Act	Relative abundance within ecology study area
Bovidae	*Capra hircus*	Goat	Category 3	Uncommon
Canidae	*Canis familiaris*	Wild dog	Category 3	Common
Felidae	*Felis catus*	Cat	Category 3	Common
Leporidae	*Lepus europaeus*	European hare	Category 3	Very common
Leporidae	*Oryctolagus cuniculus*	European rabbit	Category 3	Uncommon

Table note:

Category 3 = includes noxious fish, weeds and pest animals. You must not distribute this restricted matter. This means it must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under permit.

4.4.2.4 Aquatic fauna

The Project EIS field assessments identified seven aquatic fauna species from the ecology study area (refer Table 4.27). The Mosquitofish (*Gambusia holbrooki*) was identified to be pervasive and extremely common within most waterways/water bodies assessed. This species is non-native and has been identified as a contributing factor to the decline of species diversity within areas to which it has been introduced.

Information related to the occurrence MNES fauna species (e.g. Australian lungfish (*Neoceratodus forsteri*)) (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance Technical Report.

Table 4.27 Aquatic fauna identified within the ecology study area

Family name	Species name	Common name	Native/non-native
Chelidae	*Chelodina longicollis*	Eastern snake-necked turtle	Native
Chelidae	*Emydura macquarii macquarii*	Murray turtle	Native
Cyprinidae	*Carassius auratus*	Goldfish koi	Non-native
Plotosidae	*Tandanus tandanus*	Eel-tailed catfish	Native
Eleotridae	*Gobiomorphus australis*	Striped gudgen	Native
Poeciliidae	*Gambusia holbrooki*	Mosquitofish	Non-native
Terapontidae	*Leiopotherapon unicolour*	Spangled perch	Native

4.4.3 Predicted habitat for conservation significant flora and fauna, migratory species and Special least concern fauna

Predictive habitat mapping for NC Act conservation significant species (Section 3.3.4.1 and Appendix A) indicates that potential habitat for seven conservation significant species (including two SLC mammal species) occurs within the ecology study area and six within the Project disturbance footprint (refer Table 4.28). Habitat mapping (Section 3.3.4.2 and Appendix A) indicates the potential for 22 EPBC Act listed migratory species to occur within the ecology study area and Project disturbance footprint (refer Table 4.29). Predicted habitat mapping for NC Act conservation significant and EPBC Act listed migratory species is presented Appendix F. Habitat Critical to the survival of the species has not been identified as occurring within the ecology study area for EPBC Act listed migratory species based on the migratory species referral guidelines.

Table 4.28 Predicted habitat for NC Act conservation significant flora and fauna species (excluding MNES) within the ecology study area

Species name	Common name	NC Act status	Predicted habitat within the ecology study area (ha)* (11,866.54 ha)*				Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)*			
			Total habitat	General	Essential	Core	Total habitat	General	Essential	Core
NC Act conservation significant flora										
Callitris baileyi	Bailey's cypress	NT	**1,399.47**	1,399.47	0.00	0.00	28.40	28.40	0.00	0.00
Eucalyptus taurina	Helidon ironbark	V	**3.18**	3.18	0.00	0.00	0.00	0.00	0.00	0.00
Melaleuca irbyana	Swamp tea-tree	E	**3,122.61**	2,914.01	208.6	0.00	128.78	124.35	4.43	0.00
NC Act conservation significant fauna										
Calyptorhynchus lathami lathami	Glossy black-cockatoo	V	**700.46**	700.46	0.00	0.00	45.11	45.11	0.00	0.00
Hemiaspis damelii	Grey snake	E	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ninox strenua	Powerful owl	V	**343.50**	343.50	0.00	0.00	**28.63**	28.63	0.00	0.00
NC Act special least concern animals										
Ornithorhynchus anatinus	Platypus	SLC	**1,217.28**	1,217.28	0.00	0.00	47.77	47.77	0.00	0.00
Tachyglossus aculeatus	Echidna	SLC	**2,486.69**	2,486.69	0.00	0.00	75.71	75.71	0.00	0.00

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special Least Concern

* = No value (i.e. 0) represents areas where habitat modelling has indicated that no predicted habitat has been identified within a particular area. For these species, impact assessment has not occurred although their habitat requirements and ecology has been considered through the modelling process (refer Appendices A, B and C)

Table 4.29 Predicted habitat for EPBC Act listed migratory species within the ecology study area

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the ecology study area (ha)* (11,866.54 ha)*			Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)*		
				Total habitat	Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat
EPBC Act migratory species									
Actitis hypoleucos	*Common sandpiper*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Apus pacificus	*Fork-tailed swift*	SLC	M	**11,866.54**	9,057.47	2,809.07	**634.58**	535.12	99.46
Calidris acuminata	*Sharp-tailed sandpiper*	SLC	M	**2,020.07**	757.71	1,262.36	**92.00**	26.85	65.15
Calidris melanotos	*Pectoral sandpiper*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Calidris ruficollis	*Red-necked stint*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Charadrius veredus	*Oriental dotterel*	SLC	M	**1,967.38**	694.62	1,272.75	**98.40**	33.25	65.15
Cuculus optatus	*Oriental cuckoo*	SLC	M	**95.41**	74.45	20.95	**0.52**	0.08	0.43
Gallinago hardwickii	*Latham's snipe*	SLC	M	**2,579.12**	1,359.30	1,219.82	**133.88**	68.73	65.15
Gelochelidon nilotica	*Gull-billed tern*	SLC	M	**502.98**	460.49	42.49	**15.43**	15.43	0.00
Hydroprogne caspia	*Caspian tern*	SLC	M	**708.09**	661.19	46.89	**20.51**	20.51	0.00
Limosa limosa	*Black-tailed godwit*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Monarcha melanopsis	*Black-faced monarch*	SLC	M	**275.52**	254.56	20.95	**6.07**	5.64	0.43
Motacilla flava	*Yellow wagtail*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Myiagra cyanoleuca	*Satin flycatcher*	SLC	M	**61.42**	40.47	20.95	**0.52**	0.08	0.43
Pandion haliaetus	*Eastern osprey*	SLC	M	**446.51**	404.02	42.49	**15.43**	15.43	0.00
Phalaropus lobatus	*Red-necked Phalarope*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Plegadis falcinellus	*Glossy ibis*	SLC	M	**4,224.33**	3,300.63	923.71	**184.68**	126.73	57.95
Pluvialis fulva	*Pacific golden plover*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Rhipidura rufifrons	*Rufous fantail*	SLC	M	**61.42**	40.47	20.95	**0.52**	0.08	0.43
Symposiachrus trivirgatus	*Spectacled monarch*	SLC	M	**61.42**	40.47	20.95	**0.52**	0.08	0.43

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the ecology study area (ha)* (11,866.54 ha)*			Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)*		
				Total habitat	Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat
Tringa nebularia	*Common greenshank*	SLC	M	**1,741.55**	446.51	1,295.04	**80.58**	15.43	65.15
Tringa stagnatilis	*Marsh sandpiper*	SLC	M	**2,027.97**	765.61	1,262.36	**92.22**	27.07	65.15

Table notes:

M = Migratory SLC = Special Least Concern

* = No value (i.e. 0) represents areas where habitat modelling has indicated that no predicted habitat has been identified within a particular area. For these species, impact assessment has not occurred although their habitat requirements and ecology has been considered through the modelling process (refer Appendices A, B and C)

4.4.4 Flora and fauna habitat located within the ecology study area

A total of nine broad fauna habitat types have been identified within the ecology study area. The broad habitat types were delineated by grouping vegetation communities according to their vegetative structure, composition, and geomorphological characteristics. The condition of the various habitat types was derived from aerial photograph interpretation, RE mapping, relevant database searches, field reconnaissance and previous experience within the ecology study area.

Discrete areas of remnant vegetation are scattered across the ecology study area, however, most of the area is characterised by non-remnant vegetation, particularly cleared agricultural areas, which provide grassland habitat to fauna species. Grassland is the dominant land cover in the ecology study area, other land cover types in order of decreasing extent include crops, forest/woodland, urban and quarry.

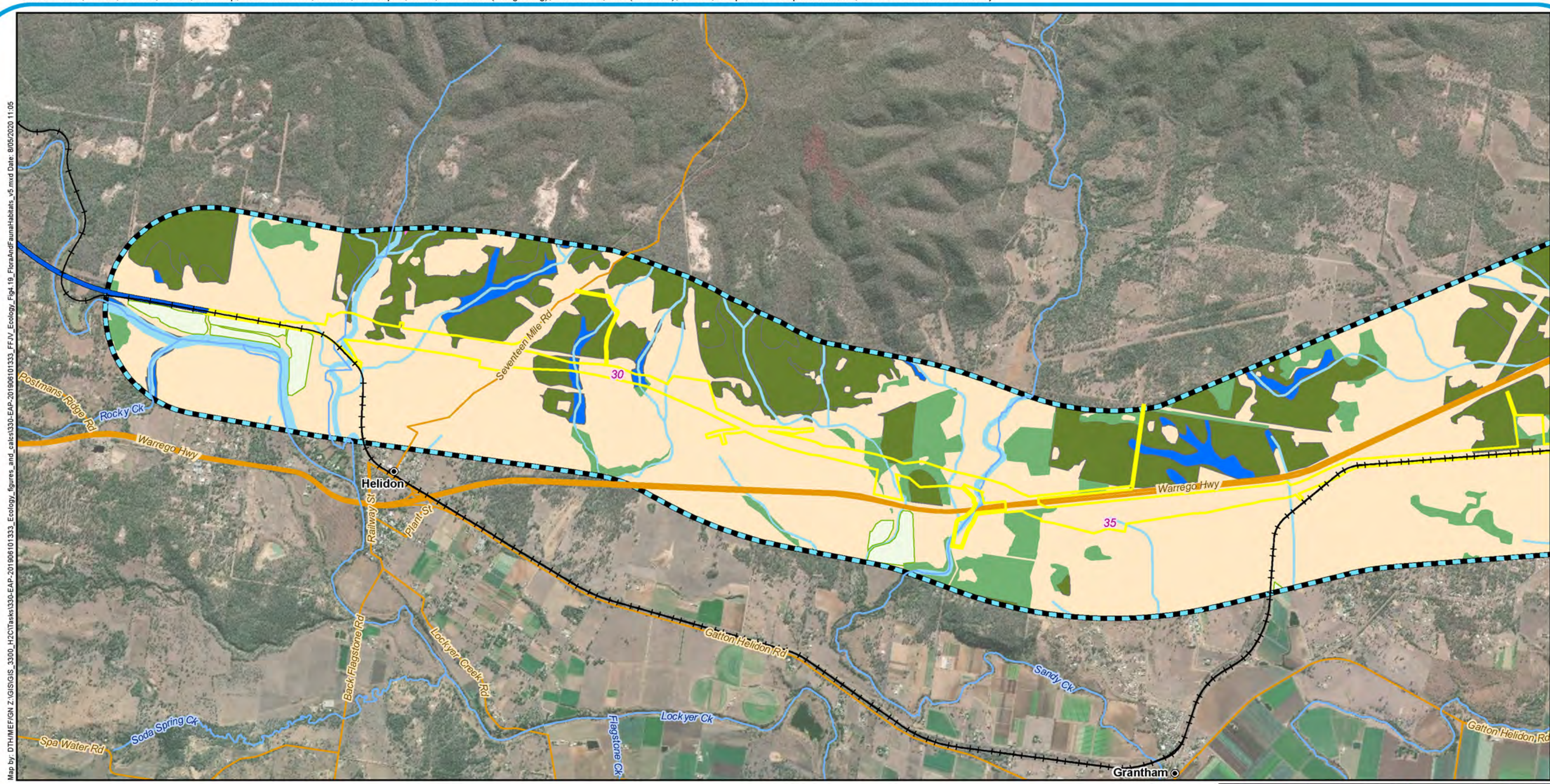
The majority of remnant and non-remnant native vegetation is clustered around the eastern and western extremities of the Ecology study area (i.e. Helidon and Calvert), in areas of higher elevation. The central portion of the Ecology study area (i.e. Gatton-Forest Hill) is extensively cleared and subject to high intensity irrigated horticulture. Non-remnant linear vegetation along roadsides and drainage lines, regrowth vegetation and isolated paddock trees form a variegated landscape mosaic in an otherwise fragmented environment. Drainage lines, waterways and wetlands are also important features in regards for the provision of habitat for MNES and are present within the ecology study area.

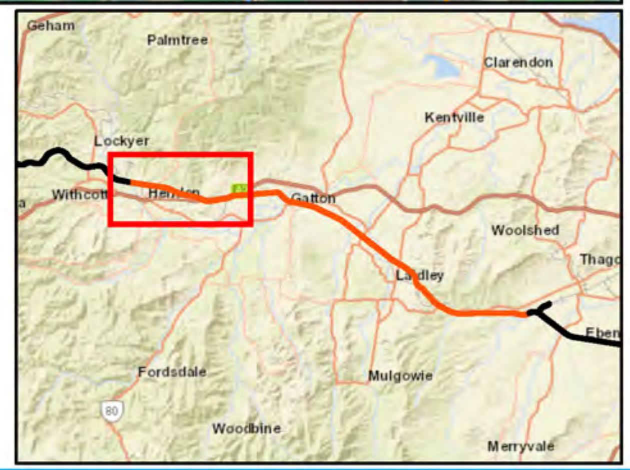
Each broad habitat type is discussed in further detail below and spatially represented in Figure 4.19. An analysis of the quantity of fauna habitat contained within the ecology study area and within the Project disturbance footprint is presented in Table 4.29.

Table 4.30 Extent of fauna habitat located within the ecology study area

Fauna habitat type (refer Figure 4.19a-)	Analogous Regional Ecosystems	Extent (ha)	
		Ecology study area	Project disturbance footprint
Mature eucalypt open forest and woodland	12.9-10.2, 12.9-10.3, 12.9-10.7, 12.9-10.17a, 12.9-10.19, 12.9-10.27, 12.3.2, 12.3.3, 12.3.3d and 12.3.19	1,529.81	29.63
Mature eucalypt riparian woodland	12.3.7	87.33	1.87
Acacia harpophylla-Casuarina cristata open forest subdominant community	12.9-10.6 and 12.3.10a (Category B and C)	6.11	0.00
Regrowth eucalypt communities	High value regrowth (Category C)	879.76	49.03
Melaleuca irbyana low open forest	12.3.18	5.77	0.00
Riparian zones/waterways	N/A	521.81	19.79
Wetlands	12.3.8 (also includes areas mapped as wetlands HES wetlands)	22.77	0.00
Grassland	N/A	6,986.46	490.70
Cultivated land	N/A	1,826.72	43.56
Total area of habitat		11,856.48	634.58

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community





Legend

- 5 Chainage (km)
- Localities
- Existing rail
- G2H project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Cultivated land
- Grassland
- Regrowth communities
- Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)
- Mature eucalypt riparian open forest and woodland
- Riparian zones / waterways
- Wetlands

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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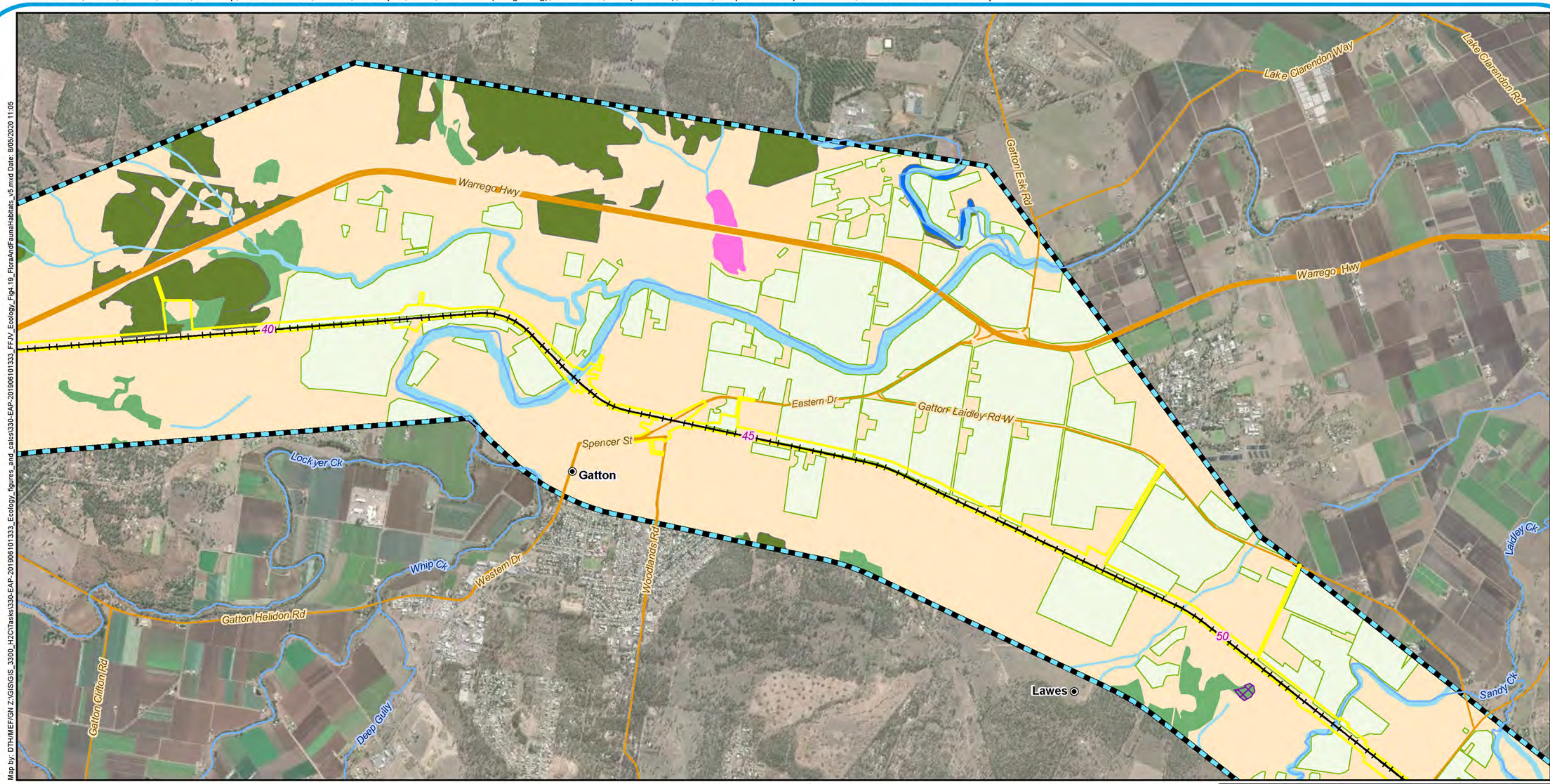
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.19a: Location of flora and fauna habitat types contained within the ecology study area

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



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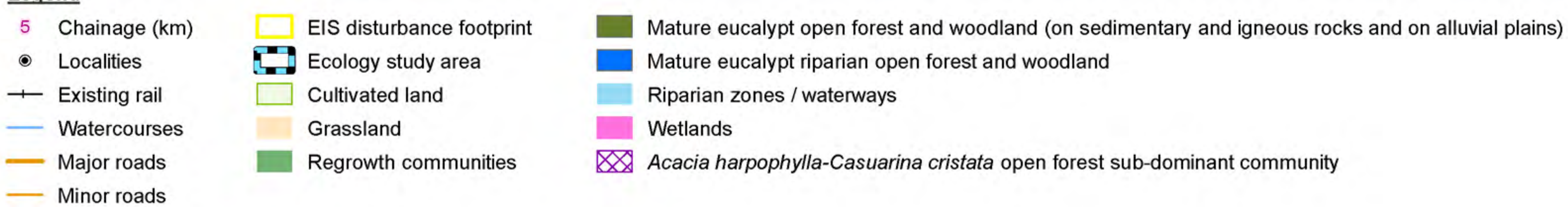

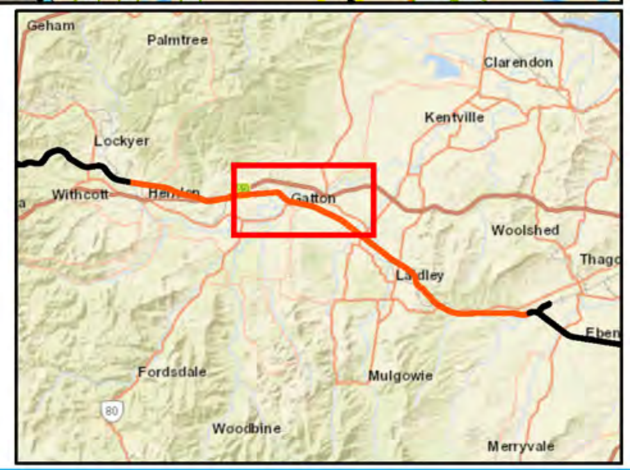

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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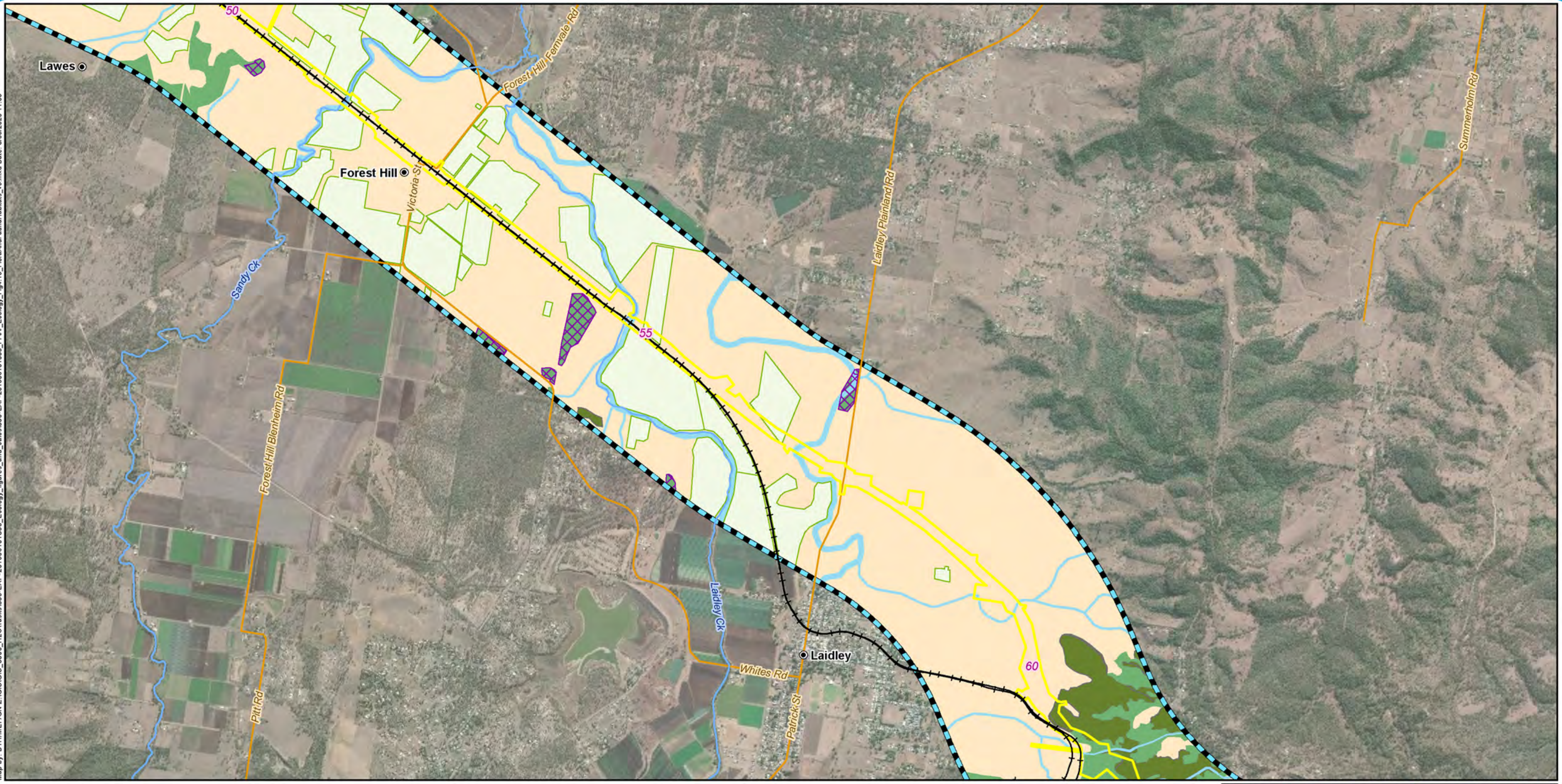
Coordinate System: GDA 1994 MGA Zone 56

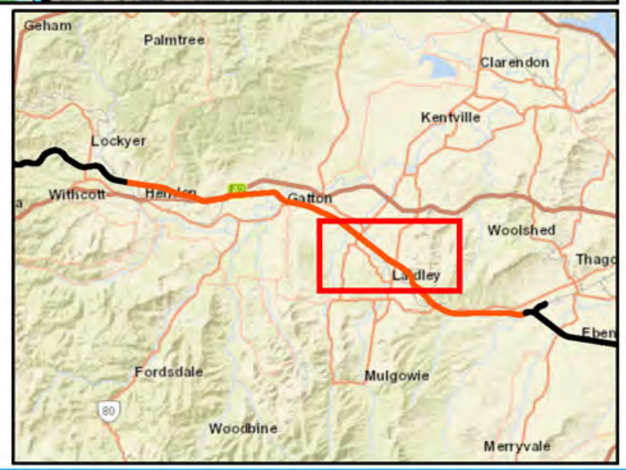
Helidon to Calvert

Figure 4.19b: Location of flora and fauna habitat types contained within the ecology study area

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.19_FloraAndFaunaHabitats_v5.mxd Date: 8/05/2020 11:05





Legend

- 5 Chainage (km)
- Localities
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Cultivated land
- Grassland
- Regrowth communities
- Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)
- Riparian zones / waterways
- *Acacia harpophylla-Casuarina cristata* open forest sub-dominant community

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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Integrating Community, Environment and Engineering

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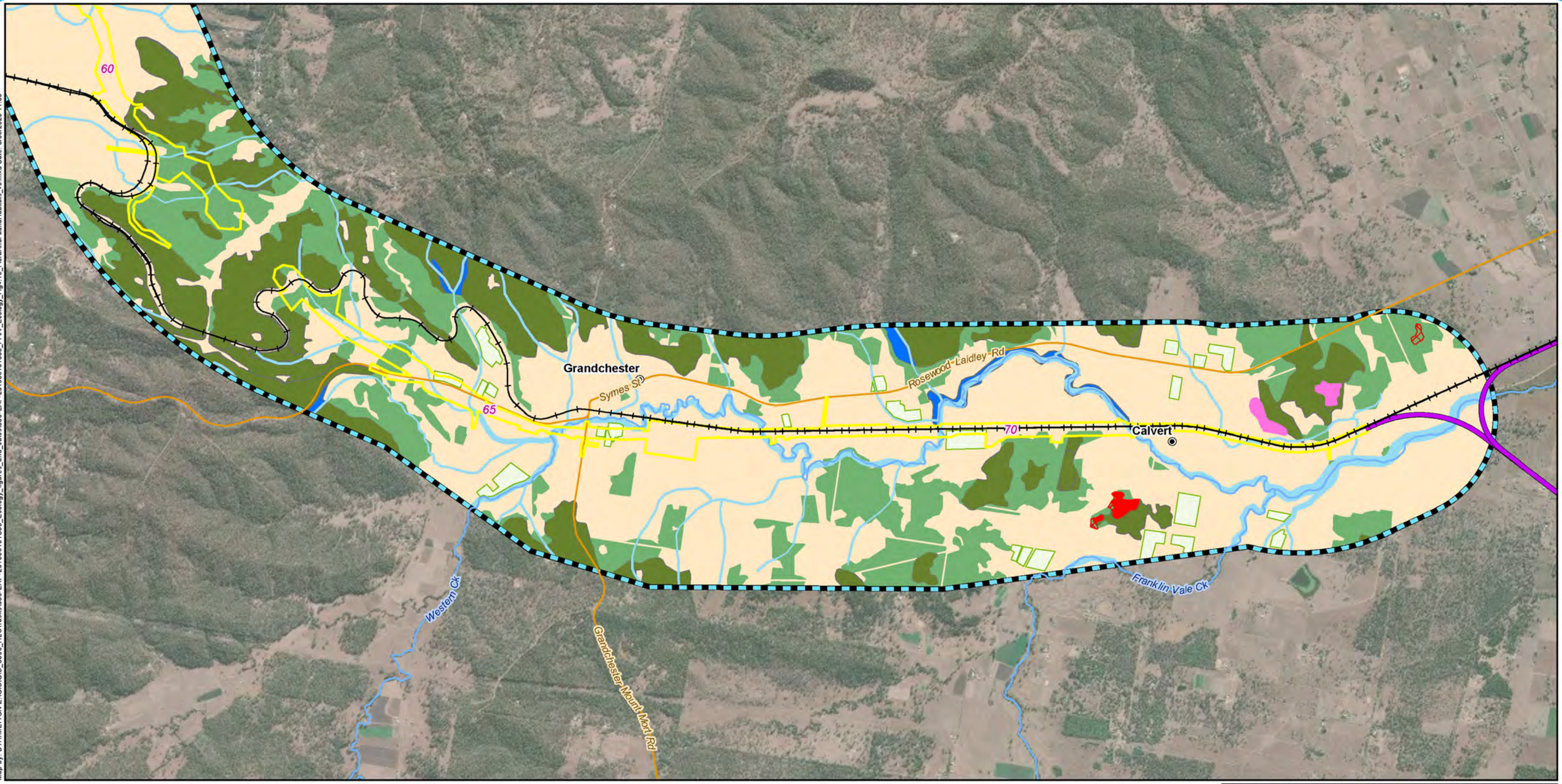
Coordinate System: GDA 1994 MGA Zone 56

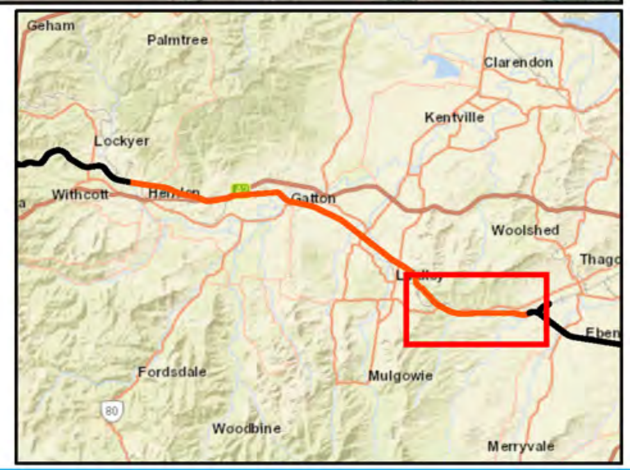
Helidon to Calvert

Figure 4.19c: Location of flora and fauna habitat types contained within the ecology study area

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: DTH/MEF/GN Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201906101333_Ecology_figures_and_calcs\330-EAP-201906101333_FFJV_Ecology_Fig4.19_FloraAndFaunaHabitats_v5.mxd Date: 8/05/2020 11:05





Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Cultivated land
- Grassland
- Regrowth communities
- Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)
- Mature eucalypt riparian open forest and woodland
- Melaleuca low open woodland
- Riparian zones / waterways
- Wetlands
- *Acacia harpophylla-Casuarina cristata* open forest sub-dominant community
- Regrowth Melaleuca low open woodland

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 08/05/2020 Version: 5
Coordinate System: GDA 1994 MGA Zone 56

Helidon to Calvert

Figure 4.19d: Location of flora and fauna habitat types contained within the ecology study area

4.4.4.1 Mature eucalypt open forest and woodland

On sedimentary rocks

This habitat is dominant in the Helidon Hills west to the Warrego Highway in the western portion of the Ecology study area and the elevated areas associated with the Little Liverpool Range in the east. Areas of remnant, mature eucalypt open forest and woodland within the Ecology study area are represented by REs 12.9-10.2, 12.9-10.3, 12.9-10.7 and 12.9-10.19. These communities are dominated by Spotted gum (*Corymbia citriodora*), Narrow-leaved ironbark (*Eucalyptus crebra*), Queensland bluegum (*Eucalyptus tereticornis*), Moreton Bay ash (*Corymbia tessellaris*), Silver-leaved ironbark (*Eucalyptus melanophloia*), Broad-leaved ironbark (*Eucalyptus fibrosa*), Gum-topped box (*Eucalyptus moluccana*) and *Angophora* spp. Spotted gum dominates the woodland in the Little Liverpool Range due to the poor soils in this area (refer Photograph 4.7), while woodlands in the Helidon Hills were more diverse.

The condition and structure of these habitats varies greatly across the ecology study area, ranging from a simplified structure with sparse shrub and/or ground strata reflective of past land use and current management practices (e.g. logging, cattle grazing and vegetation thinning), to a complex vegetation structure with all strata (i.e. canopy, mid-storey and understorey) essentially intact. Invasive weeds including Lantana (*Lantana camara* and *montevidensis*), and Prickly pear (*Opuntia sp.*) species were noted as commonly occurring in this habitat with dense infestations of *Lantana camara* observed in some areas. Important microhabitat refugia provided by this habitat type includes tree hollows, hollow logs and termitaria (arboreal and terrestrial).

Canopy species present in this habitat type provide a range of trunk and limb hollows (of a variety of size classes) which potentially provide suitable habitat for Microchiropteran bats, gliders, possums, birds (including parrots, cockatoos and owls), arboreal snakes and monitors. Standing dead trees (stags) also provide roosting sites, nesting dens and breeding locations for a similar range of species. Where mature eucalypt open forest and woodlands occur as fragmented/isolated patches in largely cleared agricultural landscapes, they are somewhat restricted in their capacity to support woodland and forest species and are more likely to offer habitat value to transitional species and support mammal and bird species typical of disturbed areas. Canopy arthropods are relatively abundant in eucalypt forest and woodlands and provide a valuable foraging resource to birds and mammals. Eucalypt forests and woodlands also provide an important source of nectar and pollen for birds (e.g. honeyeaters), and arboreal mammals (e.g. gliders).

Rocky areas of mature eucalypt open forest and woodland within the Helidon Hills may provide suitable habitat values for reptiles and mammals (eg. Macropods and gliders) (refer Photograph 4.8). The Little Liverpool Range provides similar habitat values and is expected to support a similar diversity of vertebrate species.

Photograph 4.7 **Spotted gum dominated woodland in Little Liverpool Range (2017)**

Photograph 4.8 **Rocky habitat in Helidon Hills area (2017)**

On alluvial plains

Areas of mature eucalypt open forest and woodland on alluvial plains within the Ecology study area include areas dominated by Queensland bluegum (*Eucalyptus tereticornis*) and Gum-topped box (*Eucalyptus moluccana*). Areas of remnant eucalypt open forest and woodland (on alluvial plains) within the Ecology study area are represented by RE 12.3.3 and 12.3.19. This habitat type exists on floodplains and creek flats within the Ecology study area and generally exhibits low structural complexity, particularly at lower strata levels. Ground cover is typically low due to the impacts of livestock use, and the understorey is also generally very sparse with an open canopy of large Queensland bluegum (refer Photograph 4.9). However, mature eucalypt trees on alluvial plains are known to provide important habitat, such as food and shelter (in the form of large tree hollows) (refer Photograph 4.10), for a range of fauna species, including birds, mammals, and reptiles.

Furthermore, during heavy rainfall periods this habitat type may flood temporarily, effectively becoming a wetland habitat (riverine wetland). When flooded this habitat type is suitable for a range of wetland bird species, including migratory species that may occasionally utilise flooded eucalypt open forest and woodland on alluvial plains where suitable cover may occur.

It is important to note that the definition of open forest and woodland habitats applied here excludes riparian vegetation along watercourses which has been classified as the habitat type; mature eucalypt riparian open forest and woodlands.

Photograph 4.9 Degraded floodplain woodland in Gatton area (2017)

Photograph 4.10 Example of large habitat tree (Queensland bluegum) in Ecology study area (2017)

4.4.4.2 Mature eucalypt riparian woodland

Eucalypt riparian open forest and woodlands within the Ecology study area include open forests and woodlands dominated by Queensland bluegum (*Eucalyptus tereticornis*) fringing drainage lines with associated species, including *Melaleuca* spp., Moreton Bay ash (*Corymbia tessellaris*), *Angophora* spp., and River she-oak (*Casuarina cunninghamiana*). Areas of remnant *Eucalypt* riparian open forest and woodland within the Ecology study area are represented by RE 12.3.7. This habitat type occurs exclusively along the edge of rivers, creeks and vegetated drainage lines within the ecology study area. Mature eucalypt riparian open forest and woodlands within the Ecology study area is generally in poor condition having been heavily impacted by adjacent land use. In most areas this habitat has been subject to clearing with few large trees present and substantial weed invasion (such as Laidley Creek and the mid-reaches of Lockyer Creek). Western Creek retains a narrow line of riparian vegetation along its length within the Ecology study area (refer Photograph 4.11), as does the upper reaches of Lockyer Creek (in the Helidon area).

Photograph 4.11 Western Creek in Grandchester area (2017)

Photograph 4.12 Regrowth Acacia woodland with Lantana camara dominant understorey (2017)

A range of fauna, including birds, mammals, and reptiles, may utilise this habitat type for foraging, breeding, and dispersal. The movement corridors provided by this habitat type are important for structural connectivity, in otherwise fragmented landscapes, although as noted, this connectivity is generally impaired within the ecology study area.

4.4.4.3 *Acacia harpophylla-Casuarina cristata* open forest subdominant community

Acacia harpophylla-Casurina cristata open forest on sedimentary rocks within the ecology study area is represented by mapped patches of mixed regrowth partially comprising RE 12.9-10.6. This habitat type is dominated by Brigalow (*Acacia harpophylla*) and/or Belah (*Casuarina cristata*), with a semi-evergreen vine thicket understorey. A prominent low tree or tall shrub layer may be present including species such as *Geijera parviflora* and *Eremophila mitchellii.* Vine thicket species potentially present include *Carissa ovata, Owenia acidula, Croton insularis, Denhamia oleaster* and *Notelaea microcarpa*. This habitat type typically occurs on cracking clays that are usually black or grey to brown or reddish-brown in colour and occurs in the Lockyer Valley and Boonah areas. RE 12.9-10.6 is considered to meet the conservation listing advice criteria for the Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC (refer EIS Appendix J: Matters of National Environmental Significance Technical Report).

Brigalow open forest/woodland on alluvial plains within the impact assessment area is represented by RE 11.3.10a. This habitat type is dominated by *Acacia harpophylla* forming a fairly continuous canopy with *Eucalyptus* spp. including *E. populnea and E. tereticornis* sometimes scattered through the canopy or occurring as emergents. This community occurs on Quaternary alluvial plains in the Lockyer Valley where small areas of cracking clay soils occur. This community is does not meet the conservation listing advice criteria for the Brigalow TEC (refer EIS Appendix J: Matters of National Environmental Significance Technical Report).

In the region both communities have been heavily impacted by land use activities associated with agriculture and cattle grazing. It is noted the areas where these communities are mapped as occurring are outside the Project disturbance footprint and have not been surveyed and confirmed as present.

4.4.4.4 Regrowth eucalypt communities

Areas of regrowth vegetation, largely represented by the Department of Resources (formerly the Department of Natural Resources, Mines and Energy) High Value Regrowth (HVR) vegetation mapping, are present throughout the ecology study area. A total of 1,159.79 ha of HVR is mapped within the ecology study area. The patches of regrowth vegetation within the Ecology study area are generally in poor condition, suffering from extensive weed invasion (refer Photograph 4.12) and disturbance from cattle grazing practices. Areas of regrowth habitat may provide foraging and perching habitat value for transitional fauna species and suitable microhabitats, including cracking clay soils for reptile species in floodplain areas. Transitional fauna species include migratory terrestrial bird species, moving between habitats.

4.4.4.5 *Melaleuca irbyana* low open forest

Melaleuca low open woodland within the Ecology study area includes small areas of low open woodland and tall shrubland dominated by *Melaleuca irbyana* (Swamp tea-tree). Areas of remnant *Melaleuca* low open woodland within the Ecology study area are represented by RE 12.3.18 on alluvial plains and are represented by three small patches in the western extent of the alignment. Within this habitat type *Melaleuca irbyana* forms a closed shrub layer or sub-canopy with a sparse understorey. An open canopy of emergent eucalypts (e.g. *Eucalyptus tereticornis*) is sometimes present. RE 12.3.18 is considered to meet the conservation listing advice for Swamp Tea-tree (*Melaleuca irbyana*) Forest of SEQ TEC.

This habitat type may provide foraging and nesting habitat for a limited range of bird and mammal species. Melaleuca low open woodland occurs on Mesozoic sediments where drainage is impeded, such as lower slopes and elevated flats. Ephemeral pools commonly occur, provided suitable breeding habitat for a range of frog species. During the wet season this habitat type commonly forms a palustrine wetland when flooded. Where Queensland bluegum (*Eucalyptus tereticornis*) is present, *M. irbyana* low open forest may provide abundant seasonal nectar resources.

4.4.4.6 Riparian zones/waterways

Riparian zones are an interface between terrestrial and aquatic ecosystems and also play a vital role supporting biodiversity. Healthy, native riparian vegetation reduces the water temperature of aquatic habitats by shading (as a buffer to thermal radiation). When water temperature increases poikilothermic aquatic organisms will experience physiological stress (Guschina and Harwood 2006), with expected reduced resilience to additional stressors (such as further degraded water quality parameters). More sunlight in the riparian zone also increases the growth of soft leaved vigorous weeds and algae that can choke the stream channel, reducing fish passage at lower hydrological flow.

In general, riparian zones within the Ecology study area are in poor condition with little taller vegetation present and heavy weed infestation in the shrub and ground layers. Where present, riparian forests dominated by Queensland bluegum (*Eucalyptus tereticornis*) provide seasonal nectar resources for birds and flying-foxes and mature specimens have large tree hollows suitable as shelter nesting sites for arboreal mammals and some bird species (particularly parrots). Proximity to permanent water sources also increases the importance of these areas as habitat. Riparian vegetation also contributes to in-stream habitat (e.g. large woody debris) considered important for fish species. Within these zones, aquatic fauna are considered to have potential to occur where large permanent waterholes occur (refer Photograph 4.13).

Within the ecology study area, habitats with permanent water are likely to support the most diverse and abundant aquatic communities, however areas with seasonal water provide periodically available habitat and act as pathways for fauna. Lockyer Creek was noted as retaining a large pool at the alignment crossing area during Project assessments despite dry conditions occurring at the time (refer Photograph 4.13). Mapping of risk to waterways from waterway barrier works currently indicates that eight major risk and two high risk waterways intersect the Project alignment. These crossings (and associated works within the riparian vegetation communities) coincide with medium aquatic conservation assessment scores indicating the value of riverine wetlands and associated habitat importance within the ecology study area.

Photograph 4.13 Lockyer Creek at alignment crossing point (2017)

Photograph 4.14 Lake Dyer (Bill Gunn Dam) near Laidley (2017) – note: this is outside of the ecology study area

4.4.4.7 Wetlands

Wetland habitats within the Ecology study area include dams and reservoirs (lacustrine), wetlands associated with the floodplains of major watercourses (riverine), and vegetated swamps (palustrine). It is noted no wetlands are mapped as occurring within the Project disturbance footprint (refer Table 4.9). Artificially created wetlands (i.e. farm and public dams (refer Photograph 4.14)), which are abundant across agricultural landscapes, are included as they potentially provide suitable wetland alternatives for vertebrate fauna. Artificial wetlands include typically small farm dams and much larger turkey-nest dams associated with irrigated cropping, as well as drinking water supply reservoirs. Riverine wetlands associated with floodplains are ephemeral and typically vegetated by a mixture of native and non-native grasses and grass-like plants, and Queensland bluegum (*Eucalyptus tereticornis*). All of the aquatic ecology monitoring sites at non-riverine wetlands had Aquascores (under ACA AquaBAMM assessment) of High to Very High indicating good conditions across the ecology study area.

Palustrine wetlands within the Ecology study area typically occur on alluvial floodplains and are dominated by *Poaceae* (grasses), *Restionaceae* (rushes) and *Cyperaceae* (sedges). Areas of remnant Palustrine wetland within the Ecology study area are represented by RE 12.3.8, although none occur within the Project disturbance footprint.

Wetland habitats within the Ecology study area are considered to provide suitable habitat for a variety of fish, amphibian, reptile (incl. turtles) and bird (i.e. migratory wetland species) species. Larger palustrine-wetlands potentially provide important refuge habitat for many bird species, including dispersive species. It is noted farm dams are less likely to provide these habitat elements and floodplain wetlands are highly ephemeral. At the time of the EIS field surveys the study region had undergone an extended dry period with no water available on floodplain wetlands. Migratory wetland species may occasionally occur on larger dams with shallow muddy areas (such as Lake Dyer near Laidley).

Of the 22.77 ha of HES wetland that occur within the ecology study area, 0 hectares lies within the current Project disturbance footprint and will not be directly impacted from activities associated with the Project. Two high ecological significance (HES) wetlands are located at the eastern end of the ecology study area, associated with the local hydrological catchment of Western Creek (Ch 72.40 km). There are also HEV wetlands areas mapped as occurring in the western extent of the ecological study area near Helidon. These are associated with tributaries of Lockyer Creek. The Project disturbance footprint will intersect the mapped HEV wetland areas.

Other wetland values within the Ecology study area are represented through aquatic conservation assessment modelling. The catchment aquatic conservation assessment indicates a skew towards higher value riverine wetlands throughout both the Lockyer Creek and Bremer River (including Western Creek in the ecology study area) catchments, indicating the presence of sensitive wetlands throughout both catchments. Noting this, aquatic assessment within the Ecology study area indicated areas of very low value (i.e. portions of Lockyer Creek catchment) and medium value (i.e. Lockyer Creek, Laidley Creek and Western Creek) (DEHP 2015). No springs mapped on the Queensland wetland mapping layer (Queensland Government 2020f) were identified within the ecology study area.

4.4.4.8 Grassland

Grassland habitats within the ecology study area include non-native grasslands and derived native grasslands. Non-native grasslands are dominated by exotic pasture grasses and are represented by areas of non-remnant vegetation (excluding cultivated land), previously cleared of native-vegetation for agriculture. Dominant pasture grasses include Rhodes grass (*Chloris gayana*), Pigeon grass (*Setaria sphacelate*), Green panic (*Megathyrsus maximus*), and Sabi grass (*Urochloa mosambicensis*). However, native grass species also occur, including Native rats-tail grass (*Sporobolus creber*), Forest bluegrass (*Bothriochloa bladhii*), Blue grass (*Dichanthium sericeum*), and Blady grass (*Imperata cylindrica*).

Derived native grasslands are dominated by native grass species and are represented by areas of non-remnant vegetation (excluding cultivated land), previously cleared of woody species (i.e. trees and shrubs) for agriculture. Dominant grass species include Queensland panic (*Panicum queenslandicum*), Forest bluegrass), Blue grass, Digitaria (*Digitaria divaricatissima*), and Pitted bluegrass (*Bothriochloa decipiens*). However, exotic pasture grasses sometimes occur, such as Rhodes grass.

Non-native and native derived grasslands are considered as one fauna habitat due to similarities in structure and floristics. Grassland within the ecology study area is typically located on alluvial floodplains and creek flats. These grassland habitats are commonly utilised for agricultural purposes including livestock grazing and fodder harvesting and are often in poor condition. Better grassland habitat condition may be found in road and rail reserves which are not impacted by grazing (refer Photograph 4.15).

Grassland within the ecology study area provides foraging habitat for granivorous bird species such as finches, parrots and pigeons. Grassland habitats also provide important microhabitat refugia (i.e. soil cracks) for small ground fauna such as native rodents, skinks, and snakes. Scattered paddock trees occur across many grassland habitats, providing fauna habitat and connectivity in otherwise cleared and fragmented landscapes. In general, the grasslands that dominate the Project disturbance footprint provide poor habitat value for MNES fauna species potentially occurring in the area, although grasslands may provide temporary habitat for wetland bird species when flooded.

Photograph 4.15 Grasslands in road/rail reserve in Laidley area (2017)

Photograph 4.16 Cultivated lands near Laidley (2017)

4.4.4.9 Cultivated land

Cultivated land within the ecology study area is extensive dominating the landscape between Gatton Laidley. This includes irrigated and dryland crops, stubble fields and fallow fields. Common crops include winter cereals, vegetables and legumes. The availability of soil cracks and other microhabitat refugia is greatly reduced by soil cultivation. Cultivated land typically occurs in low-lying areas on fertile clays and provides habitat for generalist bird species such as Torresian crow (*Corvus orru*), Australian magpie (*Gymnorhina tibicen*), and Little corella (*Cacatua sanguinea*). Non-native fauna species are typically abundant in cultivated land habitats, including restricted matters (Category 3 invasive animals) such as European red fox (*Vulpes vulpes*), Domestic dog (*Canis familiaris*), and Feral pig (*Sus scrofa*).

4.4.4.10 Cultivated land

Cultivated land within the ecology study area is extensive and includes irrigated and dryland crops, stubble fields and fallow fields. Common crops include winter cereals, vegetables and legumes. The availability of soil cracks and other microhabitat refugia is greatly reduced by soil cultivation.

4.4.5 Aquatic physical habitat values

The ecological site values at the 17 aquatic ecology survey locations were assessed using the AUSRIVAS Physical Assessment Protocol. The ecological site values were recorded across a 100 m assessment reach and have been summarised for each survey location in the sections below (refer Table 4.31). The habitat assessment scores noted that most of the aquatic habitat across the ecology study area was typically poor to fair. Typically, the un-named tributaries demonstrated the poorest physical habitat site condition while the higher physical habitat site condition were noted from Western Creek and Laidley Creek. Physical habitat assessments were used to further potential impact assessments and the resulting risk assessment of these impacts; however, inferences on habitat suitability for aquatic species were not made at a site-specific level, as assessment at this scale were expected to potentially result in false negatives (Type I error).

Table 4.31 Habitat assessment score summary

Location (Watercourse)	Relation of site to alignment waterway crossing	Habitat assessment score (%)	Category
H2C 1A (Sandy Creek)	Alignment waterway crossing	55	Good
H2C 2A (Un-named Tributary: Lockyer Creek)	Alignment waterway crossing	33.5	Fair
H2C 3A (Lockyer Creek)	Upstream of alignment	52	Good
H2C 4A (Lockyer Creek)	Alignment waterway crossing	47	Fair
H2C 5A (Sandy Creek)	Alignment waterway crossing	40.5	Fair
H2C 7A (Un-named Tributary: Lockyer Creek)	Alignment waterway crossing	44	Fair
H2C 8A (Un-named Tributary: Laidley Creek)	Alignment waterway crossing	33.5	Fair
H2C 9A (Western Creek)	Alignment waterway crossing	52.5	Good
H2C 10A (Western Creek)	Alignment waterway crossing	51	Good
H2C 11A (Lockyer Creek)	Downstream of alignment	41.5	Fair
H2C 12A (Lockyer Creek)	Downstream of alignment	43	Fair
H2C 13A (Laidley Creek)	Downstream of alignment	49	Fair
H2C 14A (Laidley Creek)	Upstream of alignment	51	Fair
H2C 15A (Un-named Tributary: Lockyer Creek)	Downstream of alignment	43.5	Fair
H2C 16A (Sandy Creek)	Upstream of alignment	44.5	Fair
H2C 17A (Laidley Creek)	Upstream of alignment	60	Good
H2C 18A (Western Creek)	Downstream of alignment	58.5	Good

A photographic record was taken at each sample location and is provided in Appendix G. The location of the aquatic sampling locations is shown in Figure 3.2.

A summary of the water quality results associated with each of the aquatic sampling locations is provided in Section 4.4.6 (refer Table 4.50, Table 4.51 and Table 4.52).

4.4.5.1 H2C 1A – Sandy Creek alignment waterway crossing

Overview

The H2C 1A sampling location is located on the Sandy Creek, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 1A, the site habitat assessment scored 55 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 1A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.32 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 1A.

Table 4.32 H2C 1A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	18
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	12
Pool variability	Fair: Shallow pools much more prevalent than deep pools.	8
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	16
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	10
Bank stability	Left bank: Fair: Moderately unstable; 30 to 60 per cent of bank in reach has areas of erosion; high erosion potential during floods Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over; 5-30 per cent of bank in reach has areas of erosion.	Left bank: 5 Right bank: 6
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Left bank: Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal. Right bank: Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 3 Right bank: 2
Total Low Gradient Stream Habitat Score		110/200 Good (55%)

Site characteristics

The H2C 1A assessment reach bedform features was defined by a dry bedform. The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left bank of the assessment reach had a convex shape with a steep bank slope (i.e. between 30° and 60°). The right bank of the assessment reach had a convex shape with a low bank slope (i.e. between 10° and 30°). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and a road bridge. Fence structures were present as artificial bank protection measures.

The creek bed within the assessment reach was considered to have a packed, unarmoured compaction, with an array of sediment sizes, overlapping, tightly packed but can be dislodged with moderate. The sediment was defined by an open framework, with 0 to 5 per cent fine sediment present with high availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have moderately restricted fish passage at low and base flow and considered likely to have a good passage at high flow. Barriers to fish movement include flood debris at approximately 1.5 m above the bed substrate.

The assessment reach for the site did not support macrophyte vegetation. Approximately 5 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was present in the riparian zone. Trees with a height greater than 10 m had approximately 40 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 70 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 10 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included cleared landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing pressures and a road bridge connected to the Warrego Highway.

4.4.5.2 H2C 2A – Western Creek alignment waterway crossing

Overview

The H2C 2A sampling location is located at Western Creek, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 2A, the site habitat assessment scored 33.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 2A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.33 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 2A.

Table 4.33 H2C 2A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Poor: Less than 10 per cent stable habitat; lack of habitat is obvious; substrate unstable or lacking.	1
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	6
Pool variability	Poor: Majority of pools small-shallow or pools absent.	1
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	1
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	15
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	6
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 3 Right bank: 3

Habitat variable	Condition category	Score
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 0 Right bank: 1
Total Low Gradient Stream Habitat Score		67/200 Fair (33.5%)

Site characteristics

Bedform features at the H2C 2A assessment reach were absent due to the creek being dry.

The assessment reach was characterised by a 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a convex shape with a low bank slope (i.e. between 10° and 30°). Bank stability was potentially affected by cleared vegetation, human access, road/rail bridge crossing and associated reinforced concrete pipe (RCP) and culverts. Fence structures were present as artificial bank protection measures.

The creek bed within the assessment reach was considered to have low compaction, with a loose array of fine sediments, no overlapping, no packing and structure and can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was absent but some fill material from the road containing cobble fractions was present.

At the time of assessment, no flow or pooled water was present.

The assessment reach had no fish passage present at low flow but was considered to have a partly restricted passage at high flow. Barriers to fish movement included the road crossing and RCP culvert, approximately 30 cm in diameter. A fence along the width of the drainage line was also present.

Macrophyte vegetation was absent from the assessment reach. Large woody debris such as logs and branches greater than 10 cm in diameter were also absent from the assessment reach.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'extreme disturbance'. Riparian vegetation (excluding grass cover) was absent from the left bank and occurred as isolated and scattered vegetation on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m and trees with a height less than 10 m were absent from the assessment reach. Shrubs had a vegetative cover of approximately 25 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 100 per cent exotic vegetation, with native vegetation absent. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included grazing and cropped irrigated areas along the left and right banks. Local impacts noted at the assessment site included grazing and the road/rail bridge crossing with one reinforced concrete pipe 30 cm in diameter present.

4.4.5.3 H2C 3A – Lockyer Creek downstream of alignment

Overview

H2C 3A sampling location is located at Lockyer Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 3A, the site habitat assessment scored 52 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 3A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.34 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 3A.

Table 4.34 H2C 3A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	12
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	12
Pool variability	Fair: Shallow pools much more prevalent than deep pools.	8
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	16
Channel flow status	Fair: Water fills 25-75 per cent of the available channel, and/or riffle substrates are mostly exposed.	8
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	8
Bank stability	Left bank: Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods. Right bank: Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 4 Right bank: 2
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 2 Right bank: 2
Total Low Gradient Stream Habitat Score		104/200 Good (52%)

Site characteristics

The H2C 3A assessment reach bedform features was defined by a pool area where the stream widens and deepens and current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with a steep bank slope (i.e. between 60◦ and 80◦). Bank stability was potentially affected by cleared vegetation and human access. No artificial bank protection measures were present.

The creek bed within the assessment reach was considered to have moderate compaction, with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment matrix was framework dilated, with 32 per cent to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was well rounded.

At the time of assessment, the water level was low. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was slightly turbid, with water clarity reduced by suspended material.

The assessment reach did not have fish passage at low flow but was considered likely to have good passage at high flow. Barriers to fish movement included sediment deposition in the creek bed that was approximately 1 m high.

Approximately 30 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Sedge *(Cyperus sp.),* Rush *(Juncus sp.)* and Cumbungi *(Typha sp.)*. Submerged macrophytes included Canadian Pondweed *(Elodea sp.)* and floating macrophytes included Starwart *(Callitriche sp.).* Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the left bank and as occasional clumps on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 10 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 15 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 15 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included cropped irrigated areas along the left and right banks, as well as a present RV Park. Local impacts noted at the assessment site included litter, recreational swimming and a road crossing bridge downstream.

4.4.5.4 H2C 4A – Lockyer Creek alignment waterway crossing

Overview

The H2C 4A sampling location is located on the Lockyer Creek, at the Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 4A, the site habitat assessment scored 47 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 4A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.35 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 4A.

Table 4.35 H2C 4A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	12
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	12
Pool variability	Fair: Shallow pools much more prevalent than deep pools.	10

Habitat variable	Condition category	Score
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	16
Channel flow status	Fair: Water fills 25-75 per cent of the available channel, and/or rifle substrates are mostly exposed.	7
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance.	5
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 2 Right bank: 2
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		94/200 Fair (47%)

Site characteristics

The H2C 4A assessment reach bedform features were defined by a run, with a gradient of 1 to 3◦ and a small but distinct uniform current with an unbroken surface.

The assessment reach was characterised by a wide box shaped channel which had channel modifications present, associated with a rail/road bridge abutment. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, stock access, human access and feral animals. There was also a rail bridge crossing and a road crossing present with associated storm water piping. Rip rap and blue rock lining was present along the bank at the bridge abutments as a bank protection measure. There were also fence structures present.

The creek bed within the assessment reach was considered to have a moderate compaction with an array of sediment sizes, little overlapping and some packing but can be dislodged with moderate. The sediment was defined by a framework dilated, with 32 per cent to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the water level was low. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach did not have potential fish passage, but at high flow there was likely to be a potentially partly restricted passage. Barriers to fish movement included the stormwater discharge associated with the rail bridge crossing.

Approximately 5 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Sedge *(Cyperus sp.).* Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated/scattered vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m were absent from the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 20 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 20 per cent native vegetation and 80 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included cleared landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included litter, grazing, rail bridge crossing and storm water pipes associated with the road crossing.

4.4.5.5 H2C 5A – Sandy Creek alignment waterway crossing

Overview

The H2C 5A sampling location is located on the Sandy Creek, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 5A, the site habitat assessment scored 40.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 5A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.36 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 5A.

Table 4.36 H2C 5A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Poor: Less than 10 per cent stable habitat; lack of habitat is obvious; substrate unstable or lacking.	5
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	8
Pool variability	Poor: Majority of pools small-shallow or pools absent.	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	6
Bank stability	Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30 per cent of bank in reach has areas of erosion.	Left bank: 7 Right bank: 7
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		81/200 Fair (40.5%)

Site characteristics

The H2C 5A assessment reach bedform feature was defined by a dry creek bed.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation and the road/rail crossing. Artificial bank protection measures include the concrete bridge abutments and associated fence structures.

The creek bed within the assessment reach was considered to have low compaction, with an array of fine sediments, no overlapping no packing and structure, and can be dislodged very easily. The sediment was defined by a matrix filled contact framework, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity was absent for cobble, pebble and gravel fractions within the assessment reach.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have a moderately restricted fish passage at low flow and minimal restriction to fish passage at high flow. Barriers to fish movement included the bridge abutments for the rail/road crossing.

Macrophyte vegetation was not present at the site. Approximately less than 5 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'extreme disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m were absent from the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 100 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 5 per cent native vegetation and 95 per cent exotic vegetation including lantana, guinea grass and castor oil plant. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included cropped irrigated areas along the left bank and grazing along the right bank. Local impacts noted at the assessment site included litter, agricultural crops and the rail/road crossing bridge.

4.4.5.6 H2C 7A – Laidley Creek downstream of alignment

Overview

The H2C 7A sampling location is located on the Laidley Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 7A, the site habitat assessment scored 44 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 7A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.37 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 7A.

Table 4.37 H2C 7A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Poor: Less than 10 per cent stable habitat; lack of habitat is obvious; substrate unstable or lacking.	5
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	8

Habitat variable	Condition category	Score
Pool variability	Poor: Majority of pools small-shallow or pools absent	3
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	3
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16
Channel sinuosity	Good: The bends in the stream length 2-3 times longer than if it was in a straight line.	12
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 5 Right bank: 5
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 0 Right bank: 1
Total Low Gradient Stream Habitat Score		88/200 Fair (44%)

Site characteristics

Approximately 10 per cent of the H2C 7A assessment reach bedform features was defined by a pool area where the steam widens or deepens and the current declines.

The assessment reach was characterised by a flat ‘U’ shaped channel which had channel modifications present, associated with a bridge and attributed culverts. The left and right banks of the assessment reach had a convex shape with a low bank slope (i.e. between 10◦ and 30◦). Bank stability was potentially affected by cleared vegetation, human access and the bridge and associated culverts. Artificial bank protection measures were present in the form of concrete bridge abutments and fence structures.

The creek bed within the assessment reach was considered to have low compaction, with a loose array of fine sediments, no overlapping, no packing and structure, and can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was absent.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have a very restricted fish passage at low flow that would progress to partly restricted at high flow. Barriers to fish movement included sediment deposition, flood debris and the road crossing bridge, which was comprised of five culverts, each approximately 2 m wide.

Approximately 5 per cent of the assessment reach was comprised of the emergent macrophyte Rush *(Juncus sp.).* Large woody debris such as logs and branches greater than 10 cm in diameter were absent from the assessment reach.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘extreme disturbance’. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the right bank of the assessment reach and was absent from the left bank. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m were absent from the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 5 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 5 per cent native vegetation and 95 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included cleared areas for grazing along the left and right banks. Local impacts noted at the assessment site included litter, grazing, overhead powerlines and the road crossing bridge.

4.4.5.7 H2C 8A – unnamed tributary alignment waterway crossing

Overview

The H2C 8A sampling location is located on an unnamed tributary, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 8A, the site habitat assessment scored 33.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 8A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.38 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 8A.

Table 4.38 H2C 8A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Poor: Less than 10 per cent stable habitat; lack of habitat is obvious; substrate unstable or lacking.	2
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	7
Pool variability	Poor: Majority of pools small-shallow or pools absent.	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration (Bridge)	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	8
Bank stability	Poor: Unstable; many eroded areas; ‘raw’ areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 1 Right bank: 1
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 1 Right bank: 1

Habitat variable	Condition category	Score
Total Low Gradient Stream Habitat Score		67/200 Fair (33.5%)

Site characteristics

H2C 8A is situated within the Lockyer Creek system.

The H2C 8A assessment reach was dry therefore no definitive bedform features were present.

The assessment reach was characterised by a ‘U’ shaped channel which had no channel modifications present. The left and right banks of the assessment reach had an undercut shape with a steep bank slope (i.e. between 60◦ and 80◦). Bank stability was potentially affected by cleared vegetation, stock and human access, feral animals and a bridge associated with a road crossing. Artificial bank protection measures were present with fence structures.

The creek bed within the assessment reach was considered to have low compaction, with a loose array of fine sediments, no overlapping, no packing and structure, and can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. Sediment angularity for cobble, pebble and gravel fractions within the assessment reach was absent.

At the time of assessment, no flow or pooled water was present.

The assessment reach did not have adequate fish passage at low flow and was considered likely to be moderately restricted at high flow. Barriers to fish movement present included RCP’s under the road approximately 1 m high from the creek bed. Soil erosion was also present under the culvert.

The assessment reach did not support macrophyte vegetation. Large woody debris such as logs and branches greater than 10 cm in diameter were absent from the site.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘extreme disturbance’. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the left and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m were not found within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 2 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 5 per cent native vegetation and 95 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

Local land use along the assessment reach included cleared areas for grazing along the left and right banks. Local impacts noted at the assessment site included litter and a bridge associated with the road crossing. The road crossing was comprised of 2 RCP’s, one approximately 30 cm in diameter and one approximately 10 cm. Both RCP’s were approximately 1 m high from the creek bed.

4.4.5.8 H2C 9A – Eastern Creek alignment waterway crossing

Overview

The H2C 9A sampling location is located on the Eastern Creek, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 9A, the site habitat assessment scored 52.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 9A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.39 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 9A.

Table 4.39 H2C 9A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	15
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	10
Pool variability	Poor: Majority of pools small-shallow or pools absent.	5
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	16
Channel flow status	Good: Water fill less than 75 per cent of the available channel; on more than 25 per cent of the channel substrate s exposed.	13
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	13
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance.	5
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 5 Right bank: 5
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 4 Right bank: 4
Total Low Gradient Stream Habitat Score		105/200 Good (52.5%)

Site characteristics

The H2C 9A assessment reach bedform features were defined by a pool area where the stream widens or deepens and the current declines.

The assessment reach was characterised by a flat ‘U’ shaped channel which had reinforced channel modifications present, associated with bridge abutments. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30° and 60°). At the time of assessment, the left and right banks of the assessment reach were demonstrating a moderate level of erosion. Bank stability was potentially affected by cleared vegetation, human access and a road crossing bridge.

The creek bed within the assessment reach was considered to have moderate compaction, with an array of sediment sizes, overlapping, some packing but can be dislodged with moderate. The sediment present was matrix dominated, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, the water level was low. There were no sediment oils, but water oils were present in the form of globs and sheen. Sediment odours or water odours were absent from the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach condition had a partially restricted fish passage at low flow and was considered adequate for passage at high flow. Barriers to fish movement included the road bridge, litter and sediment under the bridge. There were vegetated side/point bars present within the assessment reach.

Approximately 25 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Sedge *(Cyperus sp.)* and floating macrophytes included Starwart *(Callitriche sp.)*. Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'high disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 20 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 40 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 25 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 60 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 per cent and 75 per cent.

Local land use along the assessment reach included rural residential areas along the left and right banks. Local impacts noted at the assessment site included litter, road crossing and associated bridge. There was also a telecommunication cable and power lines present.

4.4.5.9 H2C 10A – Western Creek alignment waterway crossing

Overview

The H2C 10A sampling location is located at Western Creek, at the proposed Project alignment waterway crossing location.

Following assessment of the condition and extent of habitat variables present at H2C 10A, the site habitat assessment scored 51 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 10A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.40 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 10A.

Table 4.40 H2C 10A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	13
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	11
Pool variability	Poor: Majority of pools small-shallow or pools absent.	5
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	18
Channel flow status	Fair: Water fills 25-75 per cent of the available channel, and/or riffle substrates are mostly exposed.	6
Channel alteration (Bridge)	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	15
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	8
Bank stability	Left bank: Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods. Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30 per cent of bank in reach has areas of erosion.	Left bank: 5 Right bank: 7

Habitat variable	Condition category	Score
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 2 Right bank: 2
Total Low Gradient Stream Habitat Score		102/200 Good (51%)

Site characteristics

Approximately 80 per cent of the H2C 10A assessment reach bedform features were defined by a pool area where the stream widens or deepens and current declines.

The assessment reach was characterised by a flat ‘U’ shaped channel which had reinforced channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, human access and the road crossing bridge. Artificial bank protection measures include rip rap concrete and concrete abutments associated with the bridge.

The creek bed within the assessment reach was considered to have low compaction, with a loose array of fine sediments, no overlapping, no packing and structure, and can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was absent.

At the time of assessment, the water level was low. There were light sediment oils present and also water oils depicted by a visual sheen. Sediment odours and water odours were absent from the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach did not have fish passage at low flow but was considered likely to have a good passage at high flow. Barriers to fish movement included flood debris and sediment build up at the bridge location.

Approximately 10 per cent of the assessment reach supported submerged macrophytes. Macrophyte vegetation included Pondweed *(Potamogeton sp.).* Approximately 20 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as occasional clumps of vegetation on the left bank and as semi continuous vegetation on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 15 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 40 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 20 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 per cent and 75 per cent.

Local land use along the assessment reach included cleared landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included litter and the road crossing bridge.

4.4.5.10 H2C 11A – Lockyer Creel downstream of alignment

Overview

The H2C 11A sampling location is located on the Lockyer Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 11A, the site habitat assessment scored 41.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 11A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.41 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 11A.

Table 4.41 H2C 11A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10-30 per cent mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	8
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present.	13
Pool variability	Poor: Majority of pools small-shallow or pools absent.	3
Sediment deposition	Fair: Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80 per cent of the bottom affected; sediment deposits at obstructions, constructions and bends; moderate deposition in pools prevalent.	8
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	3
Channel alteration	Excellent: Artificial channelisation or dredging absent or minimal; stream with normal pattern.	20
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance.	5
Bank stability	Left bank: Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods Right bank: Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 5 Right bank: 2
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 3
Riparian zone score	Left bank: Good: width or riparian zone 12-18 m; human activities have impacted the riparian zone only minimally. Right bank: Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 5 Right bank: 3
Total Low Gradient Stream Habitat Score		83/200 Fair (41.5%)

Site characteristics

The H2C 11A assessment reach bedform features were defined by a pool area where the stream widens or deepens and the current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with the left bank having a moderate bank slope (i.e. between 30° - 60°) and the right bank having a steep slope (i.e. between 60 - 80°). Bank stability was potentially affected by cleared vegetation and a bed level crossing. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have low compaction with a loose array of fine sediments, no overlapping, no packing and structure and could be dislodged very easily. The sediment was defined by matrix dominated with less than 60 per cent fine sediment, interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was well-rounded.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have no fish passage at low and base flow with the exemption of being moderately restricted at high flow. Barriers to fish movement include rocks, earth material and a bed level road crossing. There were side/point bars that were vegetated present within the assessment reach.

Approximately 95 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Rush *(Juncus sp.),* Cumbungi *(Typha sp.)* and *Persicaria sp*. Approximately 5 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and as occasional clumps on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 15 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 25 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 60 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 60 per cent native vegetation and 40 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

Local land use along the assessment reach included cleared and modified landscapes along the left and right banks including rural residential and recreation areas. Local impacts noted at the assessment site included litter, bed level road crossing and recreational activities including an adjacent camp ground.

4.4.5.11 H2C 12A – Lockyer Creek upstream of alignment

Overview

The H2C 12A sampling location is located on the Lockyer Creek, upstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 12A, the site habitat assessment scored 43 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 12A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.42 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 12A.

Table 4.42 H2C 12A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10-30 per cent mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	6
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	11
Pool variability	Fair: Shallow pools much more prevalent than deep pools.	6
Sediment deposition	Good: Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50 per cent of the bottom affected; slight deposition in ponds	11
Channel flow status	Good: Water fills >75 per cent of the available channel; or <25 per cent of channel substrate is exposed.	15
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16

Habitat variable	Condition category	Score
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	6
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 1 Right bank: 1
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 1 Right bank: 2
Total Low Gradient Stream Habitat Score		86/200 Fair (43%)

Site characteristics

The H2C 12A assessment reach bedform features were defined by a pool area where the stream widens or deepens and current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, human access and the road bridge. Rip rap and concrete lining was present along the bank at the bridge abutments as a bank protection measure. The rip rap concrete consisted of blue asphalt and there was also a fence structure present as another bank protection measure.

The creek bed within the assessment reach was considered to have low compaction with a limited range of sediment sizes with a little overlapping, some packing and structure but can be dislodged very easily. The sediment was defined by a matrix dominated, less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was well-rounded.

At the time of assessment, no flow or pooled water was present.

The assessment reach had very restricted fish passage at low flow but was considered likely to have a good passage at high flow. Barriers to fish movement included sediment deposition where the unvegetated side/point bars had formed.

The majority of the assessment reach did not support macrophytes. A singular submerged macrophyte included a Pondweed *(Potamogeton sp.)*. Approximately 20 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter. The majority of the large woody debris was believed to be flood debris.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated/scattered vegetation on the left bank and as semi-continuous vegetation on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 10 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 40 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 5 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 90 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included a cleared landscape for grazing along the left and right banks. Local impacts noted at the assessment site included litter, grazing upstream, a road bridge and a power line crossing.

4.4.5.12 H2C 13A – Lockyer Creek upstream of alignment

Overview

The H2C 13A sampling location is located on the Lockyer Creek, upstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 13A, the site habitat assessment scored 49 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 13A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.43 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 13A.

Table 4.43 H2C 13A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	14
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	14
Pool variability	Poor: Majority of pools small-shallow or pools absent.	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration (Bridge)	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	8
Bank stability	Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30 per cent of bank in reach has areas of erosion.	Left bank: 6 Right bank: 6
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 2 Right bank: 2
Total Low Gradient Stream Habitat Score		98/200 Fair (49%)

Site characteristics

The H2C 13A assessment reach did not have any definitive bedform features as a result of the creek being dry.

The assessment reach was characterised by a flat ‘U’ shaped channel which had channel modifications present, associated with the bridge abutments. The left bank of the assessment reach had a concave shape with a steep bank slope (i.e. between 60◦ and 80◦). The right bank of the assessment reach had a convex shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and the road bridge. Rip rap and concrete lining was present along the bank at the bridge abutments as a bank protection measure. There was also concrete bridge abutments and a fence structure present.

The creek bed within the assessment reach was considered to have moderate compaction with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was defined by a framework dilated matrix with 32-60 per cent fine sediment with low availability for interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have a partially restricted fish passage that was considered likely good passage at high flow. Barriers to fish movement included flood debris and the road bridge. There were no bars present within the assessment reach.

The assessment reach did not support macrophyte vegetation. Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as occasional clumps of vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 50 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 30 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 70 per cent native vegetation and 30 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach included grazing along the left and right banks. Local impacts noted at the assessment site included litter, grazing and the road bridge.

4.4.5.13 H2C 14A – Laidley Creek downstream of alignment

Overview

The H2C 14A sampling location is located at Laidley Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 14A, the site habitat assessment scored 51 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 14A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.44 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 14A.

Table 4.44 H2C 14A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50 per cent of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	17

Habitat variable	Condition category	Score
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	12
Pool variability	Poor: Majority of pools small-shallow or pools absent.	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration (Bridge)	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	15
Channel sinuosity	Good: The bends in the stream length 2-3 times longer than if it was in a straight line.	12
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 5 Right bank: 5
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 3 Right bank: 3
Total Low Gradient Stream Habitat Score		102/200 Good (51%)

Site characteristics

The H2C 14A assessment reach bedform features were absent due to the creek bed being dry.

The assessment reach was characterised by a flat ‘U’ shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, stock access, human access and the present bridge. Rip rap and concrete lining was present along the bank at the bridge abutments as a bank protection measure.

The creek bed within the assessment reach was considered to have moderate compaction, with an array of sediment sizes present with little overlapping, some packing but can be dislodged with moderate. The sediment was framework dilated, with 32 per cent to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, no flow or pooled water was present.

The assessment reach did not have fish passage at low flow and was considered likely to be a moderately restricted passage at high flow. Barriers to fish movement included flood debris to approximately 1.5 m high and three concrete box culverts associated with the bridge. There were no bars present within the assessment reach.

The assessment reach did not support macrophytes vegetation. Approximately 50 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was present in the riparian zone. Trees with a height greater than 10 m had approximately 10 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 90 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 30 per cent native vegetation and 70 per cent exotic vegetation. Riparian shading of the assessment reach was between 26 per cent and 50 per cent.

Local land use along the assessment reach included cropped and irrigated areas along the left and right banks. Grazing was also present along the left and right bank. Local impacts noted at the assessment site included litter, grazing, crops and the road crossing bridge.

4.4.5.14 H2C 15A – Wrights Creek downstream of alignment

Overview

The H2C 15A sampling location is located at Wrights Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 15A, the site habitat assessment scored 43.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 15A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.45 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 15A.

Table 4.45 H2C 15A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30-50 per cent mix of stable habitat; well suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation (may rate at high end of scale).	11
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	8
Pool variability	Poor: Majority of pools small-shallow or pools absent.	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	0
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	13
Channel sinuosity	Good: The bends in the stream increase the stream length 2-3 times longer than if it was in a straight line.	15
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 3 Right bank: 3
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities.	Left bank: 2 Right bank: 2

Habitat variable	Condition category	Score
Total Low Gradient Stream Habitat Score		87/200 Fair (43.5%)

Site characteristics

The H2C 15A assessment reach did not have any bedform features present as the creek bed was dry.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, human access and the road/rail bridge and associated culverts. Rip rap and concrete lining was present along the bank at the bridge abutments as a bank protection measure. There was also timber slates present.

The creek bed within the assessment reach was considered to have a moderate compaction, with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was matrix dominated, with less than 60 per cent fine sediment with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have very restricted fish passage at low and base flow, which may be potentially partly restricted at high flow. Barriers to fish movement included four reinforced concrete pipes approximately 1.5 m in diameter, exotic vegetation and blue rock from the road/rail bridge.

Approximately 5 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Juncus (*Juncus usitatus*). Less than 5 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'high disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 25 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 2 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 60 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 25 per cent native vegetation and 75 per cent exotic vegetation. Riparian shading of the assessment reach was between 26 per cent and 50 per cent.

Local land use along the assessment reach included modified landscapes with non-remnant vegetation along the left and right banks. Local impacts noted at the assessment site included the rail/road crossing bridge and associated culvert 0.5 m diameter. Artificial structures (power lines and blue rock from the rail/road crossing) were present at the site.

4.4.5.15 H2C 16A – Sandy Creek downstream of alignment

Overview

The H2C 16A sampling location is located on Sandy Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 16A, the site habitat assessment scored 44.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 16A was comprised by disturbance to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.46 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 16A.

Table 4.46 H2C 16A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10-30 per cent mix of stable habitat; habitat availability less than desirable, substrate frequently disturbed or removed.	10
Pool substrate characterisation	Fair: all mud or clay or sand bottom; little or no root mat; no submerged vegetation.	8
Pool variability	Poor: majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: little or no enlargement of islands or point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Poor: very little water in channel and mostly present as standing pools.	0
Channel alteration	Good: some channelisation present, usually in areas of bridge abutments, evidence of past channelisation.	15
Channel sinuosity	Good: the bends in the steams increase the stream length 2-3 times longer than if it was in a straight line.	15
Bank stability	Fair: moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 5 Right bank: 3
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone	Poor: width of riparian zone <6 m; little or no riparian vegetation is present because of human activities.	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		88/200 Fair (44.5%)

Site characteristics

The H2C 16A assessment reach bedform features was defined by a dry bedform.

The assessment reach was characterized by a 'U' shaped channel which had channel modifications present, associated with a 2 RCPs. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30° and 60°). Bank stability was potentially affected by cleared vegetation, human access and bridge and culvert. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have moderate compaction with array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was defined as matrix dominant with less than 60 per cent fine sediment present with interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, there was no water flow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have moderately restricted passage at low flow and considered likely to be good passage at high flow. Barriers to fish movement include the road crossing with 2 RCPs.

The assessment reach for the site did not support macrophytes vegetation.

The riparian zone of the assessment reach has a vegetation disturbance rating of 'extreme disturbance'. The riparian vegetation (excluding grass cover) occurred as occasional clumps of vegetation on the right bank and isolated/scattered on the left bank. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 20 per cent vegetation cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetation cover of approximately 10 per cent within the riparian zone along the assessment reach and shrubs had a vegetation cover of approximately 40 per cent. Ground cover vegetation, including grass species, had a vegetation cover of approximately 95 per cent within the riparian zone of assessment reach. The riparian zone was defined by approximately 10 per cent native vegetation and 90 per cent exotic vegetation. Riparian shading of the assessment reach was between 6–25 per cent.

Local land uses along the assessment reach include cropped (irrigated) along the left and right banks. Local impacts notes at the assessment site include road, bridge/culvert and litter.

4.4.5.16 H2C 17A – Laidley Creek downstream of alignment

Overview

H2C 17A sampling location is located at Laidley Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 17A, the site habitat assessment scored 60 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 17A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.47 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 17A.

Table 4.47 H2C 17A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50 per cent of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient).	16
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present.	15
Pool variability	Good: Majority of pools large-deep; very few shallow.	12
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Fair: Water fills 25-75 per cent of the available channel, and/or riffle substrates are mostly exposed.	8
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelisation, i.e. dredging (greater than 20 years) may be present, but recent channelisation is not present.	15
Channel sinuosity	Good: The bends in the stream increase the stream length 2-3 times longer than if it was in a straight line.	11
Bank stability	Left bank: Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods. Right bank: Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 3 Right bank: 2
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5

Habitat variable	Condition category	Score
Riparian zone score	Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 4 Right bank: 4
Total Low Gradient Stream Habitat Score		120/200 Good (60%)

Site characteristics

The H2C 17A assessment reach bedform features were defined by a pool area where the stream widens and deepens and current declines.

The assessment reach was characterised by a flat ‘U’ shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a concave shape with a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, human access and the road crossing bridge. Rip rap and concrete lining was present along the bank at the bridge abutments as a bank protection measure. A concrete discharge pipe from the adjacent cropland was also present.

The creek bed within the assessment reach was considered to have low compaction, with a limited range of sediment sizes, little overlapping, some packing and structure but can be easily dislodged with moderate. The sediment was matrix dominated, with less than 60 per cent fine sediment and low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was absent.

At the time of assessment, the water level was low. There were no sediment oils, but water oils were present from a visible sheen on the surface. Sediment odours or water odours present within the assessment reach. Water within the assessment reach was slightly turbid, with water clarity reduced by dissolved material.

The assessment reach had a highly restricted fish passage at low flow however was expected to have adequate passage at high flow. Barriers to fish movement included imported blue rock and sediment deposition at the bridge.

Approximately 45 per cent of the assessment reach supported macrophytes. Approximately 40 per cent of the macrophyte vegetation was submerged and included ribbon weed *(Vallisneria sp.)* and Canadian pondweed (E*lodea sp.*). The other 5 per cent of the macrophyte vegetation was floating duckweed (*Lemna aequinoctialis)*. Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘high disturbance’. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 50 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 30 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 20 per cent native vegetation and 80 per cent exotic vegetation.

Local land use along the assessment reach included irrigated cropping along the left and right banks. Local impacts noted at the assessment site included the road crossing bridge.

4.4.5.17 H2C 18A – Western Creek downstream of alignment

Overview

H2C 18A sampling location is located at Western Creek, downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 18A, the site habitat assessment scored 58.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 18A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.48 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 18A.

Table 4.48 H2C 18A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10-30 per cent mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	8
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	16
Pool variability	Good: Majority of pools large-deep; very few shallow.	11
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20 per cent of the bottom affected by sediment deposition.	20
Channel flow status	Fair: Water fills 25-75 per cent of the available channel, and/or riffle substrates are mostly exposed.	8
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern.	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1-2 times longer than if it was in a straight line.	8
Bank stability	Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods.	Left bank: 4 Right bank: 4
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 5
Riparian zone score	Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 4 Right bank: 4
Total Low Gradient Stream Habitat Score		117/200 Good (58.5%)

Site characteristics

The H2C 18A assessment reach bedform features were defined by a pool area where the stream widens and deepens and current declines.

The assessment reach was characterised by a flat ‘U’ shaped channel which no channel modifications present. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30◦ and 60◦). Bank stability was potentially affected by cleared vegetation, stock access and human access. There was no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have moderate compaction, with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment matrix was framework dilated, with 32 per cent to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the creek bed was dry. There were no sediment oils present, but water oils were visible with oil sheen. Sediment odours and water odours were absent from the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have no fish passage at low flow, and partially restricted passage at high flow. The principle barriers to fish movement included sediment deposition.

Approximately 25 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included sedge (*Cypress sp.)* and submerged macrophyte vegetation included ribbon weed *(Vallisneria sp.)* and Canadian pondweed (E*lodea sp.*). Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 20 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 10 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 20 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 90 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

Local land use along the assessment reach along the left bank included grazing and along the right bank included rural residential. Local impacts noted at the assessment site included litter, recreational activities and the downstream rail/road crossing.

4.4.6 Surface water quality (field and laboratory results)

Due to the lack of water within some of the watercourses, water quality data was not collected from all sites, assessed for aquatic ecological values. The baseline water quality results and laboratory analysis results for the two sampling events are provided in Table 4.49, Table 4.50 and Table 4.51.

Table 4.49 Water quality data measured *in-situ* from waterways within the ecology study area

Site	Date	pH	EC	Temperature	Turbidity	Salinity	Dissolved oxygen	Dissolved oxygen
units	-	-	**(µscm^{-1})**	**(°C)**	**(NTU)**	**(ppt)**	**(mgL^{-1})**	**(%)**
Lockyer Creek catchment								
Lockyer Creek WQO	**-**	**6.5 – 8.0**	**< 520**	**n/a**	**< 6**	**n/a**	**n/a**	**85 – 110**
H2C 2A Un-named	11/10/2017	Dry at time of sampling						
	01/03/2018	7.39	3600	32.8	5.4	2.08	4.8	69.3
	11/03/2019	Dry at time of sampling						
H2C 3A Lockyer Creek	12/10/2017	7.52	870	24.3	0.2	7.44	3.32	41.5
	01/03/2018	Dry at time of sampling						
	12/03/2019	9.21	1065	29.4	13.5	0.48	15.55	205.4
H2C 4A Lockyer Creek	09/10/2017	7.5	510	23.9	2.7	1.04	4.56	54
	01/03/2018	Dry at time of sampling						
	12/03/2019	8.94	866	29.2	62	0.39	13.54	176.6
H2C 7A Un-named	11/10/2017	7.0	740	22.9	6.6	1.54	2.35	27.0
	02/03/2018	Dry at time of sampling						
	12/03/2019	No access at time of sample						
H2C 11A Lockyer Creek	09/10/2017	9.32	1400	26.7	46.1	1.24	9.61	120.8
	01/03/2018	8.44	1100	24.7	53.5	0.65	5.1	61.4
	11/03/2019	Dry at time of sampling						
H2C 12A Lockyer Creek	10/10/2017	8.33	970	24.7	33.8	1.56	6.35	76.0
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 13A Laidley Creek	13/10/2017	Dry at time of sampling						
	02/03/2018	7.96	310	25.2	24	0.16	5.15	63
	12/03/2019	Dry at time of sampling						

Site	Date	pH	EC	Temperature	Turbidity	Salinity	Dissolved oxygen	Dissolved oxygen
units	**-**	**-**	**(μscm^{-1})**	**(°C)**	**(NTU)**	**(ppt)**	**(mgL^{-1})**	**(%)**
H2C 14A Laidley Creek	13/10/2017	Dry at time of sampling						
	02/03/2018	8.14	300	24.7	19.7	0.16	4.9	60
	12/03/2019	Dry at time of sampling						
H2C 17A Laidley Creek	13/01/2017	7.62	850	23.5	0.1	5.86	3.02	32.5
	02/03/2018	8.05	340	25.1	13.7	0.18	7.32	86.5
	12/03/2019	Dry at time of sampling						
Bremer River catchment								
Western Creek WQO	**-**	**6.5 – 8.0**	**< 770**	**n/a**	**< 17**	**n/a**	**n/a**	**85 – 110**
H2C 9A Western Creek	11/10/2017	7.52	2200	21.9	6.6	2.03	0	0.2
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 10A Western Creek	11/10/2017	7.62	3800	21.2	6.7	6.95	0.90	11.8
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 18A Western Creek	13/10/2017	7.45	2300	23.2	2.0	6.89	3.03	37.0
	01/03/2018	Dry at time of sampling						
	12/03/2019	6.43	3,381	28.9	13.7	1.63	6.45	85.1

Table note:

Highlighted colour where value is above WQO or outside WQO range where applicable
Ppt = parts per thousand
Source: DERM (2010b, 2010c)

Table 4.50 Water quality (nutrients) laboratory results for water quality monitoring sites

Site	Date	pH	Chlorophyll a	Total P	Suspended solids	Filtered Reactive Phosphorus	Turbidity	Ammonia	Nitrate	Nitrite	Organic nitrogen	Total kjeldahl nitrogen	Total nitrogen
units	**-**	**-**	**(mgL^{-1})**	**(mgL^{-1})**	**(mgL^{-1})**	**(mgL^{-1})**	**(NTU)**	**(mgL^{-1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**
Lockyer Creek catchment													
Lockyer Creek WQO	**-**	**6.5 – 8.0**	**< 5**	**< 0.03**	**<6**	**<0.015**	**<5**	**< 0.01**	**-**	**-**	**< 0.2**	**-**	**< 0.25**
H2C 2A Un-named	11/10/2017		Dry at time of sampling										
	01/03/2018	7.9	< 5	0.32	2.8	0.13	1.7	0.03	37	0.34	1.9	1.9	43
	11/03/2019		Dry at time of sampling										
H2C 3A Lockyer Creek	12/10/2017	8.3	< 10	< 0.05	1.6	<0.05	< 1	0.03	< 0.02	<0.02	0.3	0.3	0.3
	01/03/2018		Dry at time of sampling										
	12/03/2019	9.1	<5	0.06	11	0.05	2.9	0.18	<0.02	<0.02	0.7	0.9	0.88
H2C 4A Lockyer Creek	09/10/2017	8.1	< 10	0.10	< 1	0.1	2.3	0.13	0.43	0.04	< 0.2	0.2	0.7
	01/03/2018		Dry at time of sampling										
	12/03/2019	8.7	6.4	0.10	67	0.01	42	<0.01	<0.02	<0.02	0.67	0.7	0.67
H2C 7A Un-named	11/10/2017	8.1	< 10	0.13	4.4	0.11	1.7	0.13	0.19	< 0.02	0.5	0.6	0.8
	02/03/2018		Dry at time of sampling										
	12/03/2019		No access at time of sample										
H2C 11A Lockyer Creek	09/10/2017	9.3	< 10	0.10	47	<0.05	36	0.11	< 0.02	< 0.02	0.49	0.6	0.6
	01/03/2018	8.5	29	0.19	53		32	< 0.01	< 0.02	< 0.02	0.7	0.7	0.7
	11/03/2019		Dry at time of sampling										
H2C 12A Lockyer Creek	10/10/2017	8.4	87	0.10	19	<0.05	9.6	<0.01	<0.02	<0.02	0.4	0.4	0.4
	01/03/2018		Dry at time of sampling										
	12/03/2019		Dry at time of sampling										
H2C 13A Laidley Creek	13/10/2017		Dry at time of sampling										
	02/03/2018	8.0	< 5	0.44	13		17	0.04	0.13	< 0.02	0.6	0.6	0.74
	12/03/2019		Dry at time of sampling										

Site	Date	pH	Chlorophyll a	Total P	Suspended solids	Filtered Reactive Phosphorus	Turbidity	Ammonia	Nitrate	Nitrite	Organic nitrogen	Total kjeldahl nitrogen	Total nitrogen
units	**-**	**-**	**(mgL^{-1})**	**(mgL^{-1})**	**(mgL^{-1})**	**(mgL^{-1})**	**(NTU)**	**(mgL^{-1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**
H2C 14A Laidley Creek	13/10/2017		Dry at time of sampling										
	02/03/2018	8.1	< 5	0.40	11		14	0.02	0.20	< 0.02	0.5	0.5	0.72
	12/03/2019		Dry at time of sampling										
H2C 17A Laidley Creek	11/10/2017	8.2	< 10	0.27	7.0	0.21	2.1	0.02	0.03	< 0.02	0.3	0.3	0.3
	02/03/2018	8.3	6.0	0.39	21		8.4	0.02	0.16	0.03	0.3	0.3	0.49
	12/03/2019		Dry at time of sampling										
Bremer River catchment													
Western Creek WQO	**-**	**6.5 – 8.0**	**<17**	**< 0.05**	**<6**	**<0.02**	**< 17**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**<0.5**
H2C 9A Western Creek	11/10/2017	8.2	< 10	0.15	11	<0.05	4.8	< 0.01	0.03	< 0.02	0.2	0.2	0.2
	01/03/2018		Dry at time of sampling										
	12/03/2019		Dry at time of sampling										
H2C 10A Western Creek	11/10/2017	8.4	< 5	0.06	7.2	<0.05	3.3	< 0.01	0.05	<0.02	0.4	0.4	0.4
	01/03/2018		Dry at time of sampling										
	12/03/2019		Dry at time of sampling										
H2C 18A Western Creek	11/10/2017	8.1	< 5	0.05	2.5	<0.05	2.6	0.02	< 0.02	< 0.02	0.6	0.6	0.6
	01/03/2018		Dry at time of sampling										
	12/03/2019	6.3	18	0.01	21	0.01	18	0.2	<0.02	<0.02	1.3	1.3	1.3

Table note:

Highlighted colour where value is above WQO or outside WQO range where applicable

Source: (DERM 2010b, 2010c)

Table 4.51 Dissolved metal and indicative PAH laboratory results for water quality monitoring sites

Site	Date	Arsenic (III)	Cadmium	Chromium (VI)	Copper	Lead	Mercury	Nickel	Zinc	Naphthalene (PAH)
units	**-**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**
Lockyer Creek catchment										
Lockyer Creek WQO	**-**	**0.024**	**0.0002**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
H2C 2A Un-named	11/10/2017	Dry at time of sampling								
	01/03/2018	<0.001	<0.0002	<0.001	0.004	<0.001	<0.0001	0.006	<0.005	<0.001
	11/03/2019	Dry at time of sampling								
H2C 3A Lockyer Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	0.002	<0.0002	<0.001	0.002	<0.001	<0.0001	0.001	0.005	<0.001
H2C 4A Lockyer Creek	09/10/2017	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	0.011	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
H2C 7A Un-named	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	02/03/2018	Dry at time of sampling								
	12/03/2019	No access at time of sample								
H2C 11A Lockyer Creek	09/10/2017	0.002	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	11/03/2019	Dry at time of sampling								
H2C 12A Lockyer Creek	10/10/2017	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.005	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 13A Laidley Creek	13/10/2017	Dry at time of sampling								
	02/03/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.006	<0.005	<0.001
	12/03/2019	Dry at time of sampling								

Site	Date	Arsenic (III)	Cadmium	Chromium (VI)	Copper	Lead	Mercury	Nickel	Zinc	Naphthalene (PAH)
units	**-**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**	**(mgL^{1})**
H2C 14A Laidley Creek	13/10/2017	Dry at time of sampling								
	02/03/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.002	0.012	<0.001
	12/03/2019	Dry at time of sampling								
H2C 17A Laidley Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	02/03/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.001	<0.005	<0.001
	12/03/2019	Dry at time of sampling								
Bremer River catchment										
Bremer - Western Creek	**-**	**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
H2C 9A Western Creek	11/10/2017	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 10A Western Creek	11/10/2017	<0.001	<0.002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 18A Western Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.004	<0.005	<0.001

Table note:

Highlighted colour where value is above WQO or outside WQO range where applicable

Source: DERM (2010b, 2010c)

4.4.7 Springs and groundwater dependent ecosystems

No springs were observed during field assessments associated with surface water or identified from the Groundwater Dependant Ecosystems Atlas (BoM 2018) within the ecology study area. Noting this, several first order stream intersect the Project alignment and may be associated with natural springs.

As no field-truthing of these particular environments were undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted as true presence, and thus form a potentially sensitive environmental receptor.

4.4.8 Wetlands

No HES wetland occur within the Project disturbance footprint. However, HEV wetlands (MSES wetlands) are present within Project disturbance footprint (refer Section 4.3.8. In addition, anthropogenic wetlands in the form of farm dams were prevalent within the ecology study area, although none occur within the Project disturbance footprint. These areas have the potential to act as important resources for local faunal species.

4.5 Environmental values and Sensitive environmental receptors

4.5.1 Environmental values

Consistent with the relevant legislation as stated in Section 2, the overarching ecological values adopted for the ecology study area were:

- Queensland's natural environmental and native flora and fauna
- Finite natural resources, including conservations parks, and wetlands
- Land conducive to the maintenance of existing land forms, ecological health, biodiversity, riverine and wetland areas
- Biodiversity.

4.5.2 Sensitive environmental receptors

A sensitive environmental receptor is a feature, area or structure that may be affected by direct or indirect changes to the environment. For conservation significant flora and fauna species, predictive habitat mapping has been used to assess the species potential to occur within the ecology study area (refer Appendix A). Mapping associated with this process is presented in Appendix F and the area of predicted habitat contained within the ecology study area is provided in Table 4.29. In instances where species/communities did not have potential habitat contained within the ecology study area, these species were not subject to impact assessment and were no longer considered to constitute sensitive environmental receptors as the risk of impacts to any of these species was considered low. The sensitive environmental receptors identified for terrestrial and aquatic ecology within the ecology study area are identified in Table 4.52 along with their assigned sensitivity value as determined by Table 3.7.

Table 4.52 Identified sensitive environmental receptors within the ecology study area

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
▪ Queensland's natural environment and native flora and fauna ▪ Land conducive to the maintenance of existing land forms, ecological health, connectivity, riverine and wetland areas ▪ Biodiversity	Protected areas: ▪ Bowman Park Koala Refuge	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impacts
▪ Queensland's natural environment and native flora and fauna ▪ Biodiversity	Category B Regulated vegetation - Endangered REs: ▪ 12.3.3 ▪ 12.3.3d ▪ 12.3.19 ▪ 12.3.18 ▪ 12.9-10.27	High	▪ Protected by State legislation ▪ Important for biodiversity ▪ Rare ▪ High sensitivity, high exposure to impacts
	Category B Regulated vegetation - Of concern REs: ▪ 12.3.2 ▪ 12.3.8 ▪ 12.9-10.3 ▪ 12.9-10.7	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Category B Regulated vegetation - Least concern REs: ▪ 12.3.7 ▪ 12.9-10.2 ▪ 12.9-10.5 ▪ 12.9-10.5a ▪ 12.9-10.19	Low	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Category C Regulated vegetation - High Value Regrowth (HVR) vegetation	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Migratory fauna species listed under the provisions of the EPBC Act (including habitat): ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Fork-tailed swift (*Apus pacificus*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Pectoral sandpiper (*Calidris melanotos*) ▪ Red-necked stint (*Calidris ruficollis*) ▪ Oriental dotterel (*Charadrius veredus*) ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Gull-billed tern (*Gelochelidon nilotica*)	High	▪ Protected by Commonwealth legislation

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
	▪ Caspian tern (*Hydroprogne caspia*) ▪ Black-tailed godwit (*Limosa limosa*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Yellow wagtail (*Motacilla flava*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Eastern osprey (*Pandion haliaetus*) ▪ Red-necked phalarope (*Phalaropus lobatus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Pacific golden plover (*Pluvialis fulva*) ▪ Rufous fantail (*Rhipidura rufifrons*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) ▪ Common greenshank (*Tringa nebularia*) ▪ Marsh sandpiper (*Tringa stagnatilis*)		
	Conservation significant terrestrial flora and fauna species listed under the provisions of the NC Act (including habitat): ▪ Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) ▪ Powerful owl (*Ninox strenua*) ▪ Bailey's cypress pine (*Callitris baileyi*) ▪ Swamp tea-tree (*Melaleuca irbyana*) ▪ Helidon ironbark (*Eucalyptus taurina*)	High	▪ Protected by State legislation ▪ Rare ▪ High sensitivity, high vulnerability
	Priority Back on Track flora and fauna species (that are not listed under as threatened under the provisions of the EPBC Act or NC Act)	Low	▪ Protected by State legislation ▪ A common feature of the landscape, not facing endangerment, not rare, low extinction risk ▪ Low sensitivity, high exposure to impact
	Flora and fauna species not listed under the EPBC Act but listed as Least concern under the provisions of the NC Act and flora that is listed as Special least concern under the provisions of the NC Act	Low	▪ Protected by State legislation ▪ A common feature of the landscape, not facing endangerment, not rare, low extinction risk ▪ Low sensitivity, high exposure to impact
▪ Queensland's natural environment and native flora and fauna ▪ Land conducive to the maintenance of existing land forms, ecological health, connectivity, riverine and wetland areas ▪ Biodiversity	MSES wildlife habitat, Essential habitat, State significant vegetation and bioregional corridors, Mapping associated with the *Nature Conservation (Koala) Conservation Plan 2017*	High	▪ Important for biodiversity ▪ High sensitivity, high exposure to impact
	Regionally significant vegetation, bioregional corridors and wildlife refugia	Moderate	▪ Identified as sensitive by State policy ▪ Important for biodiversity ▪ High exposure to impact

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
	Locally significant vegetation, bioregional corridors and wildlife refugia	Low	▪ Identified as sensitive by local policy ▪ Important for biodiversity ▪ High exposure to impact
	Natural wetlands and watercourses, including: ▪ Nationally significant wetlands ▪ State significant wetlands (HES) ▪ State significant waters (HEV) ▪ MSES Watercourses ▪ Groundwater dependent ecosystems ▪ Waterway barriers for fish passage	High	▪ Protected by State legislation ▪ Important for biodiversity ▪ High sensitivity, high exposure to impacts

5 Potential impacts and impact mitigation

Potential Project related impacts are described in the sections below. These impacts are then assessed against the identified sensitive environmental receptors, with initial mitigation considered as part of 'initial impact mitigation' impact assessment. Project mitigation measures are then used to re-assess the significance of impact to determine any residual risk of impact with all mitigation measures in place is also provided within this section. In instances where preliminary assessment indicate that there is any potential for a residual impact significant with the potential to result in a significant residual impact to an MNES (i.e. migratory species listed under the EPBC Act) or to an MSES (no matter how slight) (refer Section 5.3.2), these sensitive environmental receptors have been assessed under the relevant State or Commonwealth significant impact guidelines (refer Sections 5.3.3 and 5.3.4).

Through information gathered during the Project EIS process, sensitive environmental receptors within the receiving environment which have the potential to be subject to significant impacts, have been identified. Mitigation measures have been developed to reduce the potential magnitude of impacts. Impact assessment methods to be adopted, depending on the nature of the environmental value being assessed, are described in Section 5.1.3.

5.1 Description of potential impacts

5.1.1 Project activities

Infrastructure activities proposed as part of the Project have been categorised into four phases; construction, commissioning and reinstatement, operation and decommissioning. A description of Project related activities and the duration of their disturbance is provided in Table 5.1.

Table 5.1 Description of Project related activities associated with construction, commissioning and reinstatement, operation, and decommissioning phase

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
Construction	Site preparation	Vegetation clearing	Permanent
		Topsoil stripping	Medium term/ Permanent
		Construction of temporary site compounds	Medium term
		Construction of rail access roads	Permanent
		Installation of boreholes and construction water	Medium term
		Installation of offices, hardstands	Medium term
		Stockpiling	Medium term
	Utility diversions	Excavation	Permanent
		Trenching	Short term
		Modification, diversion and realignment of utilities and associated infrastructure	Short term/Medium term
	Drainage	Culvert installation	Permanent
	Structures	Construction of bridges over main waterways	Medium term
		Road/rail bridge construction	Medium term
	Civil works	Cutting construction	Medium term
		Embankment construction using cut to fill from rail alignment from external sources, where required	Medium term

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
		Construction of temporary haul roads	Medium term
		Drainage controls	Medium term
	Road works	Road realignment	Permanent
		Construction of permanent rail maintenance access roads	Permanent
	Rail logistics	Sleeper stockpiling	Medium term
		Rail stockpiling	Medium term
	Rail construction	Drilling	Temporary
		Blasting	Temporary
		Ballast installation	Short term
		Sleeper placement	Short term
		Rail placement	Short term
		Installation of train signals and communications infrastructure	Short term
		Demobilising site compounds	Short term
	Tunnel construction	Removal of construction material and waste	Temporary
		Roadheader excavation	Short term
		Removal of redundant structures	Temporary
		Decommissioning work site signs	Temporary
		Decommissioning access roads	Short term
		Forming and stabilising of spoil mounds	Short term
	Signals and communications installation	Removal of temporary fencing	Temporary
Commissioning and reinstatement	Demobilisation/ Decommissioning	Establish permanent fencing	Temporary
		Restoration of disturbed areas, including revegetation where required	Short term
	Spoil mounds	Conversion of haul roads and construction access roads into permanent roads	Medium term
	Fencing	Train services	Permanent
	Restoration	Minor maintenance works	Temporary
	Road works	Bridge and culvert inspections	Temporary
		Sleeper replacement	Temporary
		Rail welding	Temporary
		Rail grinding	Temporary
		Ballast dropping	Temporary
		Track tamping	Temporary
		Major periodic maintenance	Temporary
Operation	Train operations	Train movement along rail	Permanent
	Operational maintenance	Ongoing vehicle movement within rail corridor	Permanent
Decommissioning	Trains decommissioned	Increased vehicle movement within rail corridor	Short term

5.1.2 Potential impacts to terrestrial and aquatic ecology

5.1.2.1 Habitat loss from vegetation clearing/removal

The removal of vegetation and construction of linear infrastructure resulting in habitat loss is likely to pose the largest risk of adverse impacts for biodiversity arising from the Project. The impact may be direct in the form of vegetation and habitat removal, or indirect, as fauna and flora diversity may become reduced due to shortages in available habitat resources. Habitat loss and degradation can also occur due to the increased risk of fire during construction and maintenance activities. Small-scale clearing within largely intact patches of vegetation can cause localised depletion of some species (Kutt et al. 2012). Vegetation clearing, and habitat loss are likely to occur during the construction phase activities. Habitat loss and degradation has the potential to impact upon all threatened and migratory species (including their associated habitats) identified in this assessment (refer Table 5.3 and Table 5.4).

For aerial foraging bird species (Forked-tail swift) that do not require forested areas to occur these areas represent the entire Project disturbance footprint. Given the species occurs transiently across a broad swathe of eastern Australia the impact from the Project is considered negligible at worst and impacts on this species are not considered further.

Of the Projects disturbance footprint of 634.58 ha, 32.26 ha of remnant vegetation (i.e. Category B regulated vegetation) and 66.39 ha of regrowth vegetation (HVR) (i.e. Category C regulated vegetation). The remaining 535.93 ha (84.5 per cent of the Project disturbance footprint) has largely been heavily modified through anthropogenic activities (clearing for agriculture/cattle grazing).

Whilst it is acknowledged that the SEQ bioregion exists in a highly modified state and potential vegetation removal associated with the Project is considered to be relatively small when compared to historical broad scale vegetation clearing that has occurred in the region for agricultural purposes, this does not diminish the significance of such loss, as the existing clearing makes the significance of any further clearing even more pronounced. Vegetation clearing and habitat loss that cannot be avoided, particularly in high constraint areas is likely to result in permanent impacts to threatened biodiversity values.

5.1.2.2 Fauna species injury or mortality

Physical trauma to fauna is a direct impact that has the potential to reduce local population size and has the potential to create ’source/sink’ dynamic, but this may not necessarily alter population size. However, changes in the mortality rate can affect population viability and may be a critical factor in a fragmented landscape where population sizes are fairly small and/or poorly connected. The impact of mortality on population viability is particularly pronounced for longer-lived, slow breeding species, such as the Koala (i.e. K-selected species) and is less pronounces in those that are R-selected (e.g. those species with high fecundity and shorter lifespans).

Physical trauma to fauna is a direct impact that reduces local population numbers and has the highest likelihood to occur during vegetation removal associated with the Project activities. Physical trauma to fauna has the potential to occur during all phases of the Project with the highest potential likelihood during construction activities that involve vegetation clearing, earthworks, trenching and increased labour force in the area (through the movement of vehicles). This potential impact will be proportionate to the extent of vegetation and habitat potential for species that is removed and has the potential to impact sensitive environmental receptors, including conservation significant and migratory species listed under the provisions of the EPBC Act and/or NC Act.

Some diurnal (active during the day) and mobile species, such as listed bird species, including migratory species, may move away from areas being disturbed (i.e. vegetation removal) and may not be adversely impacted in terms of direct physical trauma unless breeding is occurring. However, other species that are less mobile (i.e. ground-dwelling reptile, mammal species and aquatic species), or those that are nocturnal and nest or roost in tree hollows during the day (i.e. arboreal mammals such as possums and Microchiropteran bat species), may find it difficult to move away from roosts.

There is the potential for fauna injury or mortality during all phases of the Project through vehicle collision, but particularly when high volumes of vehicle activity (i.e. vehicle movement to facilitate construction) occur or during the operational stages of the rail. Vehicle collision is a direct impact that reduces local population numbers and is a common occurrence in Australia (Coffin 2007; Rowden et al 2008). The construction of tracks, as well as the general use of access tracks and roads across the Project disturbance footprint will result in increased vehicle movements that may cause injury or death to fauna by vehicle strike. In addition, once operational, train strike may also occur. As described in Section 1, during the operational phase double-stacked trains (6.5 m high) will use the tracks at speeds of 80 to 115km per hour, at a rate of 23 to 33 per day. Mammals, reptiles, amphibians and birds are all at risk of vehicle/train strike, particularly common species (e.g. macropods) that are tolerant of disturbance and/or those species that can utilise roads and easements for movement pathways or as foraging habitat. The height of the double-stacked trains (when not within cuttings or on embankments/bridges) increases the risk to gliding possums (i.e. Greater glider), some of which are threatened species.

In addition, entrapment of wildlife in utility diversions (e.g. trenches) or other excavations associated with the Project may also cause physical trauma to fauna. For example, open trenches for underground utilities, or other pits are known to be effective at trapping a wide variety of wildlife and often result in mortality (Ayers and Wallace 1997; Doody et al 2003; Woinarski et al 2006). Species most likely to become trapped in pits or other excavations during construction of the Project are ground dwelling species that are capable of moving across modified areas in the absence of woodland or forest habitat such as mammals, amphibians, and reptiles.

Aquatic fauna may be injured or killed during construction within waterways, such as the construction of culverts and bridges. Species most susceptible to death or injury include smaller and/or sessile species such as freshwater invertebrates.

The unmitigated potential occurrence of fauna species injuries or mortalities resulting from the Project can be short term and permanent, where mortality to the species occurs, or temporary where the species is rehabilitated and re-released.

5.1.2.3 Reduction in biological viability of soil to support plant growth due to soil compaction

Compaction of soil as a result of the Project activities may result in direct impacts to soil consistence (i.e. the strength and coherence of a soil) and soil structure (i.e. the arrangement of soil particles). Changes to soil consistence and structure can affect the productive capacity of the soil for agricultural practices, the suitability of the soils for various land uses, how the soil and landscape will respond to management practices, and the flow paths by which water moves within the soil and landscape (Fitzpatrick et al 1999).

Reduction in soil viability may negatively impact threatened flora such as Bailey’s cypress pine (*Callitris baileyi*), Helidon ironbark (*Eucalyptus taurina*) and Swamp tea-tree (*Melaleuca irbyana*). Impacts to soil may also have flow on effects to other threatened and migratory fauna species though degradation of their associated habitat.

The most direct effect of soil compaction is an increase in the bulk density of soil which can restrict plant root growth and function. Due to the increase in bulk density, large pores essential for water and air movement in soil are primarily affected. This influence over water and air movement can impact root penetration, seedling emergence and plant growth (Fitzpatrick et al 1999; Duiker 2004).

Soil biota may also be affected by compaction, for example earthworm numbers and activity can be reduced in compacted soils. In addition, water infiltration and percolation are slower in compacted soils, thereby inhibiting root growth, leading to the potential reduced uptake of immobile nutrients such as phosphorus and potassium; and increased nitrogen losses can be expected because of prolonged periods of saturated conditions in compacted soils.

Larger non-burrowing soil animals such as mites, springtails, and fly larvae may also be affected by soil compaction. Burrowing animals such as earthworms, termites, ants, and beetles can defend themselves better but may still suffer negative effects.

The unmitigated potential impacts of soil compaction resulting from the Project are generally short term and temporary.

5.1.2.4 Displacement of flora and fauna species by invasion of weed and pest species

Weed and pest species have the potential to impact on terrestrial and aquatic biodiversity as native species can become displaced through predation and competition. Pest species can also damage native vegetation by grazing and trampling (Adair and Groves 1998; Clarke et al 2000; Thorp and Lynch 2011) or though direction competition/predation (e.g. *Gambusia holbrooki* within aquatic ecosystems). Therefore, weed and pest species may reduce the extent of available habitat and hence population size for specific species. This may have the effect of increasing mortality and reducing the size and viability of population sizes though resource limitation and associated stresses.

Proliferation of weed and pest species is an indirect impact (i.e. not a direct result of the Project activities) that may have cumulative effects as each Project activity, as well as agricultural practices and other resource Project activities, may act in conjunction to increase the chances of weed and pest proliferation throughout the Project disturbance footprint and adjoining areas. Proliferation of weed and pest species has the potential to occur during all phases of the Project, especially during the construction phase, however the highest likelihood of weed and pest species occurring is from vegetation clearing and soil disturbance from earthworks, with aquatic impact through transport along discharge lines into local watercourses.

Invasive aquatic faunal species are currently present within watercourses assessed within the Project disturbance footprint and are likely already impacting flora and fauna species. Noting this, it is expected that potential impact from invasive fauna on aquatic values is expected to be low, with transporting of invasive fauna species unlikely within each phase. However, the potential impact from aquatic invasive flora has potential to occur at greater frequency and magnitude.

The effects of proliferation of weed and pest species may not be noticeable immediately or even in the short term, as visible signs may take several months or seasons to impact on sensitive environmental receptors. These potential impacts are likely to be long term and affect all sensitive environmental receptors in the Project disturbance footprint, including affecting the quality and integrity of, remnant vegetation, habitat for conservation significant species, wetlands and watercourses.

Numerous non-native species have been recorded in the ecology study area. Of these, five fauna species and 13 flora species were restricted matters, listed under the provisions of the Biosecurity Act, were recorded. Without appropriate management strategies, the Project activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited or occur in low densities.

Project activities also have the potential to introduce new weed species into the ecology study area. The most likely causes of weed dispersal and introduction associated with the Project include earthworks, movement and disturbance of soil, and attachment of seed (and other propagules) to vehicles and machinery during all phases. Weed dispersal by vehicles along access tracks and roads is a key source of weed invasion (Birdsall et al 2012). Weed invasion is an indirect impact that may degrade the quality of habitats, potentially resulting in habitat loss.

Soil disturbance during construction may increase the risk of invasion from weed and/or pest species, which can further reduce habitat quality and compromise the integrity of adjacent areas such as remnant vegetation.

Large areas of the ecology study area have significant weed growth, particularly non-native grasses, which have been introduced as part of historic agricultural land use of the area. Therefore, the potential for habitat modification from weed invasion resulting from the Project is highest where Project activities take place in relatively intact areas, such as those identified as containing in-tact remnant vegetation that currently has low weed diversity and abundance.

Seven pest animal species have been recorded in the ecology study area. These include species listed as restricted matters under the Biosecurity Act.

Unmitigated Project activities have the potential to disperse pest (animal) species from the Project disturbance footprint into the surrounding landscape, due to habitat removal, noise disturbance, and human presence during the construction and operational phases of the Project. Construction of access tracks and the rail infrastructure through large patches of intact vegetation may result in the establishment of pest species (particularly predators such as foxes and cats) into areas where they are currently absent or in low numbers. Therefore, unmitigated potential impacts of the displacement of native species through the invasion of non-native may be temporary or irreversible.

5.1.2.5 Reduction in the connectivity of biodiversity corridors

Biodiversity corridors (including those associated with drainage features and watercourses) can be defined as systems of linear habitat which enhance the connectivity of wildlife populations and may help to overcome the main consequences of habitat fragmentation (Wilson and Lindenmayer 1995). Corridors can assist ecological functioning at a variety of spatial and temporal scales from daily foraging movements of individuals, to broad-scale genetic gradients across biogeographical regions.

The Queensland corridor mapping for SEQ (Version 4.1, 2016) depicts regional corridors within the ecology study area along the Little Liverpool Range, which portrays vegetation that is significant for the spread and movement of flora and fauna, including both threatened and migratory species. Connectivity is present north and south of the ecology study area in the range, and is evident in areas associated with steep topography.

Most of the ecology study area exists in a generally fragmented environment. However, functional connectivity is retained through local linkages of remnant and regrowth vegetation, associated with roadside and riparian corridors linking larger patches of vegetation on private land. These linkages are likely to provide landscape permeability for mobile species such as birds and bats. Select fauna species such as birds, bats and koalas may also utilise isolation paddock trees as ‘stepping stones’ when traversing open habitat types (Fischer & Lindenmayer 2002).

The potential impacts of linear infrastructure traversing these biodiversity corridors include habitat fragmentation, edge effects and barrier effects. These potential impacts are discussed further in the sections below. An additional potential impact upon biodiversity corridors resulting from the Project is the proliferation of weeds and pest species, as mentioned previously. Sensitive environmental receptors involving conservation significant and migratory species listed under the provisions of the EPBC Act (non-threatened migratory species) and/or NC Act, bioregional corridors and wildlife refugia are likely to be impacted the most from these potential impacts due to the importance of habitat quality and linkages for species at a local scale and the cumulative impacts at a regional landscape scale.

The unmitigated potential impacts to biodiversity corridors resulting from the Project are likely to be long term and irreversible.

5.1.2.6 Edge effects

Edge effects refer to the changes in environmental conditions (e.g. altered light levels, wind speed, temperature) that occur along the edges of habitats. These new environmental conditions along the habitat edges can promote the growth of different vegetation types (including weed species), promote invasion by pest animals specialising in edge habitats, or change the behaviour of resident native animals (Moenting and Morris 2006). Edge zones can be subject to higher levels of predation by introduced mammalian and native avian predators. The distance of edge effect influences can vary and has been previously recorded from 50 m to greater than 1 km from an edge (Forman et al 2000; Bali 2005).

Within the ecology study area, many patches of vegetation are small, irregularly shaped, and fragmented, and as such are already subject to considerable edge effects. Therefore, it is unlikely that the Project would increase the overall extent of edge effects in these areas, however for very small patches any further fragmentation may decrease the extent of core habitat that is undisturbed by edge effects. However, in large habitat patches with low edge to area ratios, Project activities may create edge effects resulting in habitat degradation and a reduction of the habitat available for a range of species.

Edge effects have the potential to impact on the range of flora and fauna species identified as potentially occurring in the ecology study area, especially upon the species with specific micro-habitat requirements that are less tolerant to disturbance (e.g. some ground-dwelling reptiles and mammals, smaller birds and some plants). Conversely, some conservation significant plant species appear to respond positively to edge effects, particularly ground disturbance, and colonise these edge areas reasonably quickly.

It is anticipated that significant environmental receptors involving conservation significant species and wetland and waterway habitat may be impacted greatest from edge effects, where avoidance of vegetated areas is not practicable.

The unmitigated potential impacts of edge effects resulting from the Project are considered to be short term and irreversible.

5.1.2.7 Habitat fragmentation

Habitat fragmentation relates to the physical dividing up of a continuous habitat into separate smaller fragments (Fahrig 2002). The habitat fragments tend to be smaller and separated from each other by a matrix of less suitable habitat. The new habitat type situated between fragments is often artificial and less suitable to the species remaining within these newly created fragments (Bennett 1990) or is generally only used by adaptive and aggressive generalist species (i.e. Noisy miners) (Loyn et al 1983) which further decreases population levels of other species remaining in the fragments.

The landscape in which the Project is situated is highly fragmented with most vegetation occurring as small fragments due to agricultural practices such as pasture, cropping and horticulture. The Project activities will contribute to further fragmentation along with the associated edge effects and reduction in habitat. This effect will largely impact habitat associated with the area between Helidon and Gatton, and the Little Liverpool Range (i.e. greenfield sections of the Project). Outside of these areas the Project is co-located with the existing West Moreton System avoiding further fragmentation though it is noted that the width of existing barrier will increase which will impact on some species behaviour.

Habitat fragmentation has been identified as an important threatening process to several threatened. This is due to the importance of connectivity, dispersal opportunities and habitat quality for species at a local scale and the cumulative impacts at a regional scale. In some instances, the Project may not result in significant fragmentation of populations identified as relevant to the area, given the capacity of the species to disperse widely across the landscape and vagile species such as birds and bats).

Linear Project activities may however result in some small-scale localised fragmentation which has the potential to be detrimental to the dispersal of relatively sedentary species, such as small mammals, frogs, and reptiles which can lead to crowding effects and increased competition within habitat patches. Mobile species such as larger mammals, birds, and bats may not be affected by this small-scale fragmentation, as the landscape in which they currently exist is fragmented. The predicted level of fragmentation would not be enough to restrict their dispersal between habitat patches providing that mitigation measures are in place to facilitate dispersal in these species.

The unmitigated potential impacts of habitat fragmentation resulting from the Project are considered to be long term and irreversible (refer Table 3.6 for definitions associated with timeframes).

5.1.2.8 Barrier effects

Barrier effects (permanent and/or temporary) occur where particular species are either unable or are unwilling to move between suitable areas of habitat due to the imposition of a barrier. This can include a habitat type that has become unsuitable (e.g. cleared areas devoid of vegetation or structure) or a physical barrier such as a fence, alteration to a waterway or a culvert that that does not provide movement opportunities. As noted in the previous section (fragmentation) this is only considered a potential impact in the Helidon area due to the highly modified nature of much of the landscape and the use of the tunnel through the Little Liverpool Range. Species most vulnerable to barrier effects include uncommon species, smaller ground-dwelling species, and relatively sessile species with smaller home ranges.

Various Project activities may create barrier effects, particularly those that may create a hard barrier that restricts fauna movement (e.g. access tracks, easements, operational rail track). This impact may affect small mammals, frogs, reptiles. Mobile species such as larger mammals, birds, and bats may not be affected to the same extent.

Human activity and infrastructure are likely to create a barrier as many species are known to avoid areas of human activity resulting in indirect habitat loss. Human presence may affect species in different ways. Some species display avoidance behaviour while others may habituate and become attracted to areas of human activity. Predators and prey may respond differentially to human activity, causing a disruption of community interaction and potentially disrupting ecological processes (Caro 2005). Human presence and activity is likely to produce avoidance responses in larger mammalian predators that are sensitive to disturbance (i.e. Quolls), while species such as macropods (i.e. kangaroos and wallabies) and smaller amphibian and reptile species are more likely to habituate to human presence.

Waterway barrier works have the potential to impair movement of fish species across the works area, decreasing connectivity of habitat and overall ecological service. Although waterway barrier works for the Project are expected to be restricted to bridge infrastructure works within the construction phase, these works will occur along major watercourses and therefore have the potential to cause major (although temporary during the construction period) impacts to waterways. However, it is proposed that bridge construction activities will incorporate locating piers for the bridge structures outside the low-flow areas of the watercourses thereby avoiding further unmitigated impacts to instream habitat.

Similarly, barrier effects may be experienced by native animals in the form of increased patrolling and predation by pest animals along barriers, such as a cleared corridor. Foxes and wild dogs target these barrier areas as prey becomes more exposed and easier to detect and catch.

The unmitigated potential impacts of barrier effects resulting from the Project are considered to be in most cases short term and temporary (i.e. in instances where fauna passaged measured are provided) but may in some cases be long term and irreversible (refer Table 3.6 for definitions associated with timeframes).

5.1.2.9 Noise, dust, and light impacts

Noise, dust, and light are direct impacts that have the potential to occur as a result from the Project activities during all phases and may also have cumulative effects. Understanding of the impacts of noise on fauna is limited. There are no current State or Commonwealth government policies or guidelines that recommend noise thresholds or limits associated impacts to fauna. Noise may adversely affect wildlife by interfering with communication, masking the sound of predators and prey, causing stress or avoidance reactions, and in some cases, may lead to changes in reproductive or nesting behaviour. Excessive noise may lead some species to avoid noisy areas, potentially resulting in the fragmentation of species habitat. On the other hand, many animals react to new noise initially as a potential threat, but quickly ‘learn’ that the noise is not associated with a threat (Radle 2007).

The Project may lead to localised increases of airborne dust levels during construction. Increased dust can result in respiratory issues in fauna, adverse impacts on plant photosynthesis and productivity (Chaston and Doley 2006), changes in soil properties ultimately impacting plant species assemblages’ (Farmer 1993), and mortality and/or decrease in aquatic health on aquatic communities from the toxicity of poor water quality. Evidence of potential impacts on entire vegetation communities is scarce. Many studies focus on specific impacts to single species. Recent research on threatened flora in a semi-arid environment in Western Australia found no significant impact on plant health as a result of a range of dust accumulation loads caused by vehicle movements (Matsuki *et al*. 2016). The deposition of (unpaved) road dust on nearby freshwater wetlands caused by heavy traffic increases due to energy development projects found minimal impact on water quality or soils (Creuzer *et al*. 2016).

Artificial lighting may have a range of impacts across different groups of taxa and between species within these groups. Rodents may avoid brightly lit areas at night. Frogs and nocturnal reptiles may congregate at artificial lights to feed on insects attracted to light (Perry et al. 2008). Similarly, many microbat species may congregate at artificial lighting (Rich and Longcore, 2006), although other species may avoid well-lit areas (Threlfall *et al*. 2013).

The likelihood of potential impacts is anticipated to be greatest where Project activities take place near vegetated areas and known habitat, during construction, decommissioning and rehabilitation phases. Operating rail lines will generate noise and vibration and it is likely that many species will habituate as a result of the regularity of generated noise.

The Project will result in minor light spill (i.e. 'warm light' at level crossings and around the tunnel portals) into adjacent receiving environments (e.g. fauna habitat) due to the operation of plant and equipment throughout the construction phase of the Project and installation of lighting on infrastructure required for the operation of the Project. Impacts associated with light spill may include direct impacts (e.g. increased susceptibility to predation from increased light) or indirect impacts related to altered foraging and habituation in areas exposed to increased lighting. Light impacts associated with construction will be temporary in nature, however operational lighting impacts will be long term and localised (e.g. infrastructure) or transient in nature (i.e. vehicle movement). Whist light spill may impact negatively on many species, it may positively impact upon species such as microbats by attracting nocturnally flying insects upon which this species feeds.

Sensitive environmental receptors affected from these potential impacts include all threatened flora (impact associated with dust) and terrestrial fauna species (impact associated with noise and vibration). These types of impacts are likely to be short-term in duration and localised.

5.1.2.10 Increase in litter (waste)

The act of littering has the potential to impact the surrounding environment by causing injury to wildlife. When discarded as litter, human-made materials such as plastic, glass and aluminium have the potential to cause external injury to wildlife, entanglement, and if accidentally ingested, may cause starvation or suffocation. Littered objects may also provide suitable habitat for disease-spreading insects, such as flies and mosquitoes (Healthy Land and Water 2019; Western Australian Government undated).

According to the National Litter Index, across Australia the most littered items are cigarette butts; and plastic objects are the most littered by volume of material. Cigarette butts and small plastic items are often mistaken for food resources and have been found in the stomachs of juvenile birds. In addition, littering of cigarette butts also poses a bushfire risk (Healthy Land and Water 2019b; Western Australian Government n.d.).

Sensitive environmental receptors affected from this potential impact include all threatened flora (through alterations in recruitment and nutrient cycles) and fauna species (direct consumption, declines in habitat suitability and entanglement). This type of impact has the potential to be long in duration due to the varying times of decomposition; however, it is likely to be localised and manageable.

5.1.2.11 Aquatic habitat degradation

Activities related to the construction and operation of the Project are likely to impacts to water quality, thereby degrading habitats for aquatic fauna and flora. Erosion and sedimentation (refer Section 5.1.2.12), contamination and an increase in litter (refer Section 5.1.2.10) are all potential mechanisms that will adversely impact aquatic habitat. In addition, direct loss of waterway habitat may occur though activities associated with waterway crossings during construction and operation.

Physical habitat modification due to hydrological regime change may degrade current habitat morphological features including substrate composition, channel form and bank stability which may reduce aquatic ecological values. Further loss of ecological services may occur from a removal of riparian vegetation required for both watercourse and drainage feature infrastructure (within construction and operation phases), which may compound physical habitat modification from any changes to hydrological regimes. It is noted most waterways intersected by the Project are already subject to significant habitat modification due to adjacent land use. GDEs may be disturbed by potential impacts from tunnel construction.

The transport of sediment and eroded material can be washed off areas of exposed soil, stockpile locations, or localised areas in proximity to Project infrastructure (e.g. culverts and bridges) during rainfall events and thus may also affect terrestrial habitats. This in turn may lead to increased sediment loads and turbidity within waterways and potentially increase nutrient loads. In addition to direct impacts to aquatic habitat degradation associated with erosion and sedimentation, flow on effects from increased sedimentation may impair the functioning of culverts should deposition be too high, exacerbating barrier effects (refer Section 5.1.2.8).

There is potential for contaminants and pollutants associated with construction and operation of the Project to enter aquatic environments, resulting in the alteration or loss of potential habitat for terrestrial and aquatic species. Concrete, oil and grease and other chemicals associated with construction and operation may result in localised run-off into adjacent watercourses and waterbodies following rainfall events. There is the potential to increase exposure of sensitive environmental receptors to contaminants or bio-accumulation of contaminants. Refer EIS Chapter 9: Land resources and EIS Chapter 13: Surface water and hydrology for discussion on contaminants on land and in aquatic environments.

The disturbance and modification of some riparian zones and works within watercourses/wetlands during the construction phase of the project has the potential to reduce the ecological integrity of the watercourse thereby impacting on structural aspects that support breeding and foraging requirements of aquatic species.

Potential threats are more likely to be realised through impacted water quality (e.g. increased turbidity) at the site localised to construction works although this is only expected to be temporary in nature.

5.1.2.12 Erosion and sedimentation

Terrestrial impacts associated with erosion and sedimentation include compaction of soil, loss of soil structure, nutrient degradation, and increased soil salinity all of which can lead to reductions in the carrying capacity of the terrestrial environment as a result of decreasing habitat value.

Erosion and subsequent sedimentation can be damaging to the ecological health of waterways and the surrounding terrestrial environment and may be a proximate cause of environmental degradation. Mobilised course sandy sediment tends to accumulate in areas of slow-flow and may smother bottom-dwelling organisms and their habitats. Deep permanent river pools, that are valuable habitats for aquatic fauna and refuges for wildlife during summer and drought, may become filled by course sediments, which may render them ineffective in relation to their ability to support aquatic and terrestrial species.

Large sediment accumulations can cause upstream flooding or deflect the flow into the adjacent stream bank or even onto adjacent land, causing further erosion and transported sediments can fill the deep permanent pools of rivers to ruin this critical refuge habitat.

In addition to the secondary impact of erosion and sedimentation on aquatic habitats, the primary impact of erosion on terrestrial habitat has potential to occur in relation to Project activities. As indicated above, these would be expected to occur within areas of exposed soil, stockpile locations, or localised areas in proximity to Project infrastructure (e.g. culverts and bridges) during rainfall events. The changes to overland flow paths from erosion have the potential to have a localised direct impact on terrestrial habitats. These impacts are principally associated with a loss of substrate stability around vegetation and may result in a loss of vegetation quality and cover.

5.1.2.13 Tunnelling impacts – Little Liverpool Range

The construction and operation of the proposed tunnel through the Little Liverpool Range may have potential to cause a number of localised impacts to habitats located above the tunnel such as subsidence, groundwater drawdown, and vibrations caused by the tunnel construction. The tunnel is proposed to be 850 m long with an excavated cross-section of approximately 142 m² (internal space dimensions are driven by ventilation requirements).

The tunnel intersects the Koukandowie Formation (part of the Marburg Subgroup), which is a sedimentary rock comprising cross bedded sandstone and shale layers of weak to medium strength (refer EIS Chapter 9: Land resources for further detail). Aboveground subsidence may result from both the tunnelling process itself, or as a result of settlement caused by subsequent groundwater drawdown processes caused by the tunnel. Impacts to native vegetation from potential subsidence will be localised and are therefore difficult to predict beforehand. Potential impacts on remnant vegetation may include the following: trees may become destabilised by surface movement causing tree falls and slumping; surface or tension cracking may sever or damage vegetation root systems causing tree death; ground fracturing and surface cracking may cause localised changes to soil hydrology with follow-on adverse impacts to surface vegetation.

Geotechnical survey works within the tunnel area have so far been limited (refer Golder 2019). Nevertheless, initial interpretation of results indicate the potential for settlement and therefore damage to vegetation communities due to subsidence from the tunnel appears to be low. Ongoing geotechnical investigations will assess the potential for settlement/subsidence and will inform the final design of the tunnel.

Groundwater monitoring in the Little Liverpool Range area indicates groundwater levels range from 13 metres below ground level (mbgl) (east of the east portal of the tunnel), 15 mbgl (west of the west portal) and up to 82 mbgl along the ridgeline (at Ch 62.2) (Golder 2019). The vegetation in the range at the tunnel area comprises eucalypt open forest dominated by species such as Spotted gum (*Corymbia citriodora*), Grey gum (*Eucalyptus major*), and Narrow-leaf ironbark (*E. crebra*). None of these species are known to require access to groundwater. Indeed, the depth to groundwater in the higher elevations of the range preclude vegetation accessing this water source.

Lowered groundwater levels due to long-term seepage into the tunnel has the potential to impact groundwater users and vegetation such as deep-rooted trees (GDEs). Mapping of GDEs (from the BoM GDE Atlas) indicates the potential presence of 'low potential' GDEs associated with local gully lines in the range area, the nearest of which lies to the north side of the east portal of the tunnel. It is noted the mapped GDEs have not been confirmed as present. Vegetation in these areas includes Queensland blue gum (*E. tereticornis*) which may access groundwater. Preliminary predictive numerical modelling of the drained tunnel through the Little Liverpool Range was carried out to estimate potential groundwater drawdown impacts (Golder 2019). Drawdown is assumed to be ongoing and long-term. Under the base case scenario (estimated typical groundwater levels and no structural features) drawdown impacts were limited in magnitude and lateral extent, and no potential GDEs were within the predicted 1 m drawdown extent and no unacceptable adverse impacts would be anticipated (refer EIS Chapter 14: Groundwater for further information).

Potential ground-borne vibration and associated ground-borne noise due to tunnel construction works has been assessed in a conservative fashion relying on technical assumptions for the vibration emitted by the excavation activity and the surrounding geotechnical conditions (refer EIS Chapter 15: Noise and vibration for further information). The assessment considered the closest 70 sensitive (human) receivers to the tunnel as properties beyond this distance were not expected to experience vibration levels that could trigger the assessment criteria. It is noted there are no guidelines regarding potential impacts to fauna. Vibration levels are predicted to be above the lower guideline limit for dwellings during non-standard working criteria (0.3 mm/s) at approximately 10 properties along the top of the range above the tunnel. Nevertheless, it is noted there are no guidelines regarding potential impacts of ground vibration to fauna. Vibration impacts are very likely to be similar to those described for noise. In addition, vibration impacts will be restricted to the construction period. As such, any potential impact on fauna is likely to be minor at worst and temporary.

5.2 Impact mitigation

This section outlines both the flora and fauna impact mitigation measures included as part of the Project design and the mitigation measures that are proposed for the Project to manage predicted environmental impacts. The impacts are initially assessed with consideration of the design mitigation measures and then reassessed to determine residual risk after the inclusion of the proposed mitigation measures.

5.2.1 Design considerations

Development of the design has progressed in parallel with the impact assessment process. Design solutions for avoiding, minimising or mitigating impacts have therefore been incorporated into the Project as appropriate and where possible.

Mitigation measures and controls that have been factored into the design for the Project are as follows:

- The Project is partially located within the existing QR West Moreton System rail corridor, as well as within the Gowrie to Grandchester future State transport corridor. As noted previously, the Gowrie to Grandchester rail corridor was assessed in detail in 2003 with analysis of the potential environmental impacts posed by the Project. The Project design has been developed to utilise the existing rail corridor system and minimise land severance and impacts to natural and rural landscapes to the greatest extent possible.
- The Project disturbance footprint has been restricted to what is anticipated to be required to construct and operate the works in a safe and efficient manner. Restricting the temporary construction disturbance footprint and the permanent operational disturbance footprint minimises the extent of disturbance required to vegetation and habitats during construction and operation.
- Avoidance of natural movement corridors will maintain connectivity for terrestrial species which have potential habitat with the broader region. For example, the rail tunnel (approximately 850 m in length) occurs where the alignment crosses a higher point in the mapped regional corridor in the Little Liverpool Range. Fauna will be able to utilise the unimpacted section of the range over the tunnel as a movement corridor.
- The Project has avoided direct impacts on nationally or regionally protected areas such as the Lockyer Resources Reserve, Lockyer State Forest or Lockyer National Park. The Project has also avoided direct impacts to sections of the Little Liverpool Range subject to Little Liverpool Range Initiative.
- Clearing of vegetation will be restricted to the minimum required to enable the safe construction, operation and maintenance of the rail corridor, including minimising the disturbance of sensitive areas such as:
  - Habitat for critically endangered, endangered and vulnerable flora and fauna species
  - Critically endangered and endangered TECs
  - Riparian vegetation
  - Steep slopes and
  - Instream habitats.
- Watercourse crossing structures (including culverts and bridges) have been designed to maintain aquatic fauna passage and minimise the risk of blockages in reference to the accepted development requirements for operational work that is constructing or raising waterway barrier works (1 October 2018; DAF 2018)
- The Project incorporates bridge and culvert structures to maintain existing flow paths and flood flow distributions. These have been located and sized to minimise increases in peak water levels, velocities and duration of inundation
- Bridges have been designed to minimise impacts to the bed, banks and environmental flows of watercourses in accordance with requirements of the Fisheries Act 1994 (Qld)
- The Project has been developed to minimise impacts to watercourses, riparian vegetation and instream flora and habitats by adopting a crossing structure hierarchy where bridges are preferred to culverts to maintain connectivity for MNES and MSES species and riparian fauna conduits that are important to MNES and MSES species
- Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments

- The nominated rail corridor has been restricted to the land required to accommodate permanent infrastructure components of the railway, including earthworks, cross drainage and rail maintenance access roads. Habitat for MNES and MSES species has been avoided wherever possible.
- Fauna crossing opportunities for species such as Koala, have been located to align with mapped regionally significant fauna movement corridors and areas of important fauna habitat. Crossing one (Ch 29.7 km) is at natural ground level north-west of Helidon and represents a likely choice for fauna to cross with minimal guidance. Crossings two and three (Ch 32.6 km and Ch 65.7 km) are located with bridge crossings south of the Helidon Hills area and east of Grandchester respectively. The three locations have been assessed as providing movement opportunities for the greatest number of species. Opportunities to incorporate fauna infrastructure at other potential crossing points (such as large culverts) will be considered during detailed design.
- Opportunities for the provision of fauna exclusion fencing and fauna movement solutions have been identified. These include fencing strategies to guide terrestrial species to safe movement opportunities including the proposed fauna crossing locations. These opportunities will be refined through the detailed design process and incorporated where appropriate.
- Avoidance of natural movement corridors will maintain connectivity for species such as the Brush-tailed rock-wallaby, Koala and Greater Glider, which have potential habitat with the broader region. For example, the Little Liverpool Range tunnel (850 m long) occurs where the Project crosses a higher point in the mapped regional corridor in the Little Liverpool Range. Fauna will be able to use the unimpacted section of the range over the tunnel as a movement corridor, with impacts from the tunnel's construction and operation not anticipated (e.g. subsidence and settlement) or are likely to be negligible (e.g. ground-borne noise).

5.2.2 Proposed mitigation measures

To manage Project risks, a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as presented in Table 5.2. Mitigation measures have been recommended to address Project specific issues and opportunities. Legislative requirements and accepted government plans, policies and practices have been met. Information related to government threat abatement plans and recovery plans has been incorporated into the identified mitigation measures wherever applicable. Mitigation measures have been selected based on the best available information including government guidelines (e.g. DTMR's Fauna Sensitive Road Design Manual (DTMR 2010)) and the appropriateness and effectiveness in managing the identified impacts including mitigation measures used on similar projects that have been subject to legislative approval. It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis.

ARTC has reviewed a cross-section of available published literature on effectiveness of mitigation measures used on linear infrastructure. There is significant literature which corroborates ARTC's proposed mitigation measures as being effective:

- Installation and regular maintenance of fauna exclusion fences can help reduce wildlife mortality during construction. Wildlife crossing structures (underpasses and overpasses) have been constructed around the world and are used by many species to safely cross linear infrastructure (Bond and Jones 2008; VicRoads 2012; van der Grift et al. 2015; van der Ree et al. 2015a; Weller 2015)
- Wildlife crossing structures also improve traffic safety and contribute to the conservation of biodiversity by allowing animals to move safely across roads, thereby reducing the risk of collision (Smith et al. 2015)
- Wildlife crossing structures are the most effective approach to mitigate the barrier effect of linear infrastructure on wildlife movement (Taylor and Goldingay 2010; Smith et al. 2015)
- The combination of exclusion fencing with wildlife passes are complementary, with the ability to avoid animal collisions and maintain infrastructure permeability (VicRoads 2012; Carvalho et al. 2017; Ghent 2018; Barrientos et al. 2019).
- VicRoads (2012) corroborates the use of bridge underpasses for the effective use of koala crossings

- The most effective stream crossings for fish, when long-span bridges are not an option, are culverts or shorter span bridges that simulate the natural channel (Offburg and Blank 2015).
- Use of planting native species to the region was validated by Milton, et al. (2015).

ARTC is committed to implementing ongoing monitoring of the effectiveness of the measures with contingency (under an adaptive management framework) to change/improve management strategies where deleterious impacts to the identified environmental values are observed, or are not minimised, as per the objectives of the proposed mitigation measures.

Literature is in agreement that monitoring is a critical component of quantifying effectiveness of a specific mitigation measure (van der Ree et al. 2008; van der Grift et al. 2015). This is because the success of mitigation measures are heavily reliant on factors such as existing environment, potential habitat, species, climate, design components of the linear infrastructure, and operational frequency of the transport; due to these factors it is not feasible to be able to provide a quantification of effectiveness of the Project's mitigation measures (Ghent 2018).

For example, a comprehensive evaluation of the effectiveness of wildlife crossing structures requires a clear definition of success. Effectiveness is defined as the extent to which the goals of mitigation are reached. However, it is difficult to assess effectiveness without a specific and measurable goal. Therefore, ARTC recommends the SMART approach, that is, goals that are Specific, Measurable, Achievable, Realistic and Time framed (van der Ree et al. 2008; van der Ree et al. 2015b and 2015c; van der Grift et al. 2015). Van der Ree et al. (2007) proposed that the overall objective of wildlife crossing structures is to 'increase the permeability of a road corridor'. Criteria that can be used to measure effectiveness include:

- Rates of road-kill
- Habitat connectivity
- Biological requirements are met
- Allowance for dispersal and re-colonisation
- Maintenance of meta-population processes and ecosystem services.

It is also recommended that goals should be set for individual projects that are specific to species, location and the nature of the conflict. For example, a specific goal might be to ensure more than 90 per cent of individuals that approach a crossing structure successfully cross it, or to maintain the risk of extinction of a population to less than 5 per cent over the next 100 years.

Additional strategies as identified by the relevant threat abatement plan/recovery plans will be incorporated into the Project's mitigation strategies following the primary approval phase of the Project as part of detailed design.

Table 5.2 identifies the relevant delivery phase, the aspect to be managed, and the proposed mitigation measure which are directly applicable to sensitive environmental receptors or their associated habitat, which is then factored into the initial impact assessment (refer Section 5.3.2).

In addition, it is recognised that targeted surveys for some of the MSES fauna species has not been carried out in accordance with the State based fauna survey Guidelines within the Project disturbance footprint as part of Project surveys detailed in this report. ARTC will undertake additional ecological surveys in accordance with relevant Commonwealth and/or State surveys guidelines to verify and further refine the habitat mapping and extent of local populations (where applicable). These additional works will inform relevant approvals and management plans, along with necessary offset requirements and disturbance limits.

EIS Chapter 23: Outline Environmental Management Plan provides further context and the framework for implementation of these proposed mitigation and management measures.

Table 5.2 Project impact mitigation measures

Delivery phase	Environmental value impacted	Mitigation and management measures
Detailed design	Flora and fauna	While the assessment assumes the entire Project disturbance footprint will be cleared, the disturbance footprint will be refined through detailed design as far as practical, to that required to safely and efficiently construct and operate the Project. This will avoid unnecessary clearing and require inputs from the design team, construction contractor, and where applicable, the constructing authority.
		Flora and fauna surveys to be undertaken where required to verify prior surveys and assessments, refine potential offsets, inform micro-siting of infrastructure, support secondary approvals and establish baseline conditions against which relevant outcomes of the Reinstatement and Rehabilitation Plan can be compared. Methods and sequencing of surveys, including seasonal timing, will be in accordance with the relevant published State and Commonwealth survey guidelines and conservation advices for each target species, such as the *Protected Plants Survey Guidelines* (DES 2020a). Flora species to be targeted through these surveys include, but are not limited to the following species: ▪ Bailey's cypress pine (*Callitris baileyi*) ▪ Swamp tea-tree (*Melaleuca irbyana*) ▪ Helidon ironbark (*Eucalyptus taurina*) Fauna surveys, including terrestrial, aquatic habitats and breeding habitats (including burrows and hollow bearing trees/logs, wetlands, existing culverts and structures) will include the following target species: ▪ Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) ▪ Powerful owl (*Ninox stren*ua) ▪ Platypus (*Ornithorhynchus anatinus*) ▪ Short-beaked echidna (*Tachyglossus aculeatus*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Eastern osprey (*Pandion haliaetus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Rufous fantail (*Rhipidura rufifrons*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) Where a species is detected this will be reported to the relevant agencies along with information on the species habitat, habitat in which the species was identified and where possible population size and local threatening processes. The information will be used to refine the predictive habitat mapping, significant residual impact assessment, disturbance limits, mitigation measures and offsets. Surveys of representative remnant and regrowth vegetation communities that will be impacted by the Project will be undertaken during the detailed design phase in accordance with the *Guide to determining terrestrial habitat quality - Methods for assessing habitat quality under the Queensland Environmental Offsets Policy Version 1.3* (DES 2020b) to enable a condition assessment of vegetation communities that require offset for the Project.

<table>
<tr><th>Delivery phase</th><th>Environmental value impacted</th><th>Mitigation and management measures</th></tr>
<tr><td></td><td></td><td>Based on the outcome of flora, fauna and MNES habitat surveys:
▪ Work with the design team and construction team to implement measures to avoid and/or further minimise the extent of impacts (i.e. designate no-go zones, reduce the construction or operational footprint within or adjacent to communities or habitat for MSES, define clearing limits)
▪ This information will inform staged and sequential clearing (i.e. clearing of non-habitat trees in area, then a wait period and then the clearing of the remaining habitat)
Identify suitable locations for the release of fauna that may be encountered during pre-clearing or clearing or for the salvaging of microhabitats.</td></tr>
<tr><td></td><td></td><td>For any threatened flora species identified through surveys within the disturbance footprint, consult with relevant specialist to determine the feasibility of translocating or propagating specimens in accordance with relevant guidelines (e.g. Guidelines for the Translocation of Threatened Plants in Australia (Commander et al. 2018)), including the collection of seed. Feasibility will be assessed noting that not all species can be translocated or propagated and that for the majority of the species identified as potentially occurring there is limited evidence of these species being successfully translocated, even though some are used in the horticultural industry.</td></tr>
<tr><td></td><td></td><td>The potential for Project works to impact ecological receptors through erosion, soil loss, land degradation, sedimentation or decreased surface water or groundwater quality or availability will be managed through the implementation of:
▪ Soil surveys to further characterise soil conditions across the disturbance footprint at a suitable scale to inform detailed design, including appropriate design responses where reactive or problem soils are present or suspected
▪ Contaminated land surveys to inform detailed design and subsequent contaminated land strategy
▪ A Soil Management Plan will be developed to provide the framework for the stripping, storage, treatment and reuse of topsoil
▪ An Erosion and Sediment Control Plan (ESCP) will be developed as part of the CEMP, in accordance with the International Erosion Control Association's Best Practice Erosion and Sediment Control (IECA, 2008). It will include:
– Soil/land conservation objectives for the Project
– Management of problem soils
– Temporary/permanent drainage, erosion and sediment control measures
– Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material
– Vehicle, machinery and imported fill hygiene protocols and documentation
– Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction
– Where practical and or in accordance with specific flora and fauna management plans, vegetation clearing and ground disturbing works will be staged sequentially across the Project to minimise areas exposed to erosion and sediment risk of receiving waterways and drainage lines in accordance with the general environmental duty of the Environmental Protection Act 1994 (Qld)
– Measures for minimising the exposure time of unprotected materials to prevent sedimentation of receiving waterways and subsequent impacts to ecological receptors
– A process for site- and activity-specific preparation when forecast large or high-intensity wet weather events are predicted. This may include, but not be limited to, removing equipment out of riparian zones, stabilising/covering live work areas, additional application of soil binders/veneers and pre event treatment and dewatering of sediment basins.
– Process for the continuous review of effectiveness of erosion and sediment controls</td></tr>
</table>

<table>
<tr><th>Delivery phase</th><th>Environmental value impacted</th><th>Mitigation and management measures</th></tr>
<tr><td></td><td></td><td>Water quality monitoring requirements as defined in the Surface Water Sub-plan to assess the effectiveness of erosion and sediment controls and reinstatement and rehabilitation programs
The ESCP will align with the Reinstatement and Rehabilitation Plan and will include progressive stabilisation of earth materials and soil consolidation to prevent erosion and sedimentation in areas within the disturbance footprint that do not form part of the permanent works (e.g. temporary construction compounds, temporary waterway barrier works and laydown areas etc.).
A surface water monitoring framework, which will inform the development of the CEMP Surface Water Sub-plan and construction water quality monitoring program. It will identify monitoring locations including upstream, downstream and at the intersection of the Project disturbance footprint and watercourse. It will include the relevant water quality objectives, parameters, criteria and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality.
The Surface Water Sub-plan will establish the construction water quality monitoring program which will include (as a minimum):
Analysis of the representative background monitoring dataset
Identification of Project works and activities during construction and operation, including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points)
A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures.
Potential aquatic and terrestrial Groundwater Dependent Ecosystems will be field-truthed to confirm presence
Further geotechnical investigations will be undertaken at deep cut sections to inform design and location-specific construction management of groundwater.
Risks associated with dewatering (i.e. water table lowering) and environmental management requirements during construction will be identified through appropriate baseline groundwater monitoring, modelling and analysis and incorporated into the CEMP.</td></tr>
<tr><td></td><td>Riparian vegetation and aquatic habitats</td><td>Project design minimises impacts to waterways, riparian vegetation and in-stream flora and habitats by:
Adopting a waterway crossing structure hierarchy: bridges preferred to culverts, to maintain infrastructure permeability for fauna at identified habitat connectivity points, however local conditions and constructability impacts must be considered when determining the preferred environmental solution
Avoiding, then minimising the extent and duration of temporary waterway diversions. Where unavoidable, implement water quality, erosion and sediment control measures to minimise impacts to downstream environments and water users.
Continuing to refine Project design in response to hydraulic modelling outcomes. This includes addressing flood impact objectives which include consideration of peak water levels, flow distribution, velocities, and duration of inundation, and implications for fish passage. This will confirm bridge lengths, culvert sizing and numbers, localised scour and erosion protection measures for both rail, road and other permanent Project infrastructure.
Avoiding, then minimising the extent of permanent waterway diversions. Where unavoidable, waterway diversion design to include simulation of natural features e.g. meanders, pools, riffles, shaded and open sections, deep and shallow sections and different types of sub-strata, depending on the pre-disturbance environmental values, as per requirements of relevant and applicable conditions of approval, legislation, regulations and industry guidelines. Maintenance activity locations, construction compounds and storage areas will be defined as part of Project detailed design and positioned away from waterways.</td></tr>
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<table>
<tr><th>Delivery phase</th><th>Environmental value impacted</th><th>Mitigation and management measures</th></tr>
<tr><td></td><td></td><td>Stormwater controls, such as scour protection, are to be further developed and incorporated where necessary to achieve compliance with established water quality objectives. Temporary and permanent measures must be appropriate to the site conditions, responding to the erosion risk assessment, environmental receptors, climatic zone and seasonal factors. The ESCP will establish and specify the monitoring and performance objectives for handover to operational management on completion of construction.
Ensuring the Project disturbance footprint extents allow sufficient space for provision of the required temporary and permanent erosion and sediment control measures/pollution control measures defined during detailed design
Developing ESCPs for implementation during pre-construction, construction and commissioning.</td></tr>
<tr><td></td><td>Fauna passage[1,2]</td><td>Refine fauna passage locations and associated rehabilitation areas in the design to maintain infrastructure permeability, particularly at the key locations identified as part of the EIS assessment process to maintain and/or re-establish habitat connectivity for the targeted local species.
Design of fauna passage structures and associated rehabilitation areas will respond to local topographical and hydrological context, with consideration of safety requirements for the rail corridor and adjoining properties.
Design of bridges and culverts to accommodate terrestrial fauna passage where assessed as appropriate, in addition to fish passage design requirements.
Fauna passage design will be consistent with the intent of DTMR’s Fauna Sensitive Road Design Manual (DTMR 2000) and where applicable species-specific requirements.</td></tr>
<tr><td></td><td>Fauna fencing</td><td>Fauna fencing opportunities will be further assessed and, where appropriate, developed during detailed design to limit fauna strike and fauna mortality risk and/ or maintain habitat connectivity. This will include:
Assessment of the compatibility of each approach for the targeted local species with the general fencing principles at each proposed fencing location
Consideration of safety requirements for the rail corridor and adjoining properties
Consultation with adjoining landholders
Requirements for maintaining an appropriate clearance buffer between adjacent vegetation and fauna fences
Consideration for maintenance constraints and responsibilities that a fauna connectivity or fencing opportunity may introduce to operations.
Fauna fencing will be designed with reference to DTMR’s Fauna Sensitive Road Design Manual (DTMR 2000). Additional expert guidance in relation to specific design features will be sought during the detailed design process.
Aim to maximise infrastructure permeability by connecting fauna fencing with safe crossing opportunities.</td></tr>
<tr><td></td><td>Aquatic fauna</td><td>Design watercourse crossing structures (including culverts and bridges) to maintain fish passage where applicable in accordance with Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works. Detailed design to minimise the need for ongoing maintenance and inspection to maintain fish passage.
The design will aim to minimise the need for ongoing maintenance and inspection to maintain fish passage.
Develop a dewatering strategy in accordance with the Biosecurity Act 2014 (Qld), providing reasonable measures to avoid the spread of pest species and in accordance with any required aquatic fauna species management plans and water quality objectives defined in the outline CEMP.
Where a temporary impoundment or diversion is required for construction purposes and the species is found to be present, the Flora and Fauna Sub-plan will include requirements for an appropriately qualified person to be consulted to make an assessment on the method of recovery, transport and release of fish. The Flora and Fauna Sub-plan will include requirements for the application of follow relevant State (DAF) fish salvage guidelines during construction activities.</td></tr>
</table>

Delivery phase	Environmental value impacted	Mitigation and management measures
		The Biosecurity Management Sub-plan will include measures to manage the risk of translocating non-endemic flora and fauna through dewatering and fish salvage activities
	Flora	Where feasible and practicable, locate construction areas including compounds, stockpiles, fuel storage, laydown areas and staff parking outside the tree protection zone as defined in *AS4970-2009 Protection of trees on development sites.* Where practical, existing tracks will be used and the design for new access tracks (permanent and temporary) will be undertaken with the aim of minimising disturbance of substrate and vegetation
	Landscape, rehabilitation and stabilisation	Landscape design establishes the requirements for rehabilitation of disturbed areas for habitat re-creation, landscaping and stabilisation, including for riparian zones and informs the development of the Rehabilitation and Reinstatement Plan and the Landscape and Rehabilitation Management Plan. This should also include criteria for retrieval of potential habitat elements (loose surface rock, large fallen timber) during vegetation clearing for habitat recreation where appropriate. Develop a Reinstatement and Rehabilitation Plan for areas within the disturbance footprint that do not form part of the permanent works (e.g. construction compounds, laydown areas, temporary access tracks etc). The Plan will include and clearly identify: ▪ Location of areas subject to rehabilitation and/or reinstatement/stabilisation, in accordance with the landscape and rehabilitation design developed during detailed design, including operational rail safety considerations ▪ Objectives and timeframes for rehabilitation and/or reinstatement/stabilisation works (including biodiversity, vegetation establishment and erosion and sediment control outcomes to be achieved) ▪ Where appropriate, the plan describes how the objectives align with relevant recovery plans, threat abatement plans, conservation advices or policy guidance for target species in areas identified for rehabilitation ▪ Details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas, consistent with the objectives ▪ Native flora species endemic to the Scenic Rim and Ipswich regions or other suitable species appropriate to the landscape context and nursery/seed stock sources ▪ Incorporate koala trees in landscape design and rehabilitation works, especially along existing corridors which are to be retained (e.g. riparian corridors) ▪ Procedures, timeframes, measurable performance objectives and responsibilities for monitoring the success of rehabilitation and/or reinstatement/stabilisation areas ▪ Corrective actions if the outcomes of rehabilitation and/or reinstatement/stabilisation are not achieved. A Landscape and Rehabilitation Management Plan must be developed to define post construction maintenance requirements, monitoring requirements and completion criteria for areas defined in the landscape design and/or identified in the Reinstatement and Rehabilitation Plan.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Flora and fauna	Develop the Flora and Fauna Sub-plan to include appropriate criteria, directives and procedures in relation to: ▪ Requirements for pre-clearing surveys in areas immediately adjacent to the Project disturbance footprint, including terrestrial, aquatic and wetland habitats, protected plants, breeding habitats (including burrows and hollow bearing trees/logs, existing culverts and structures, riparian habitat identified as potential roost sites) for both threatened and non-threatened species by suitably qualified persons. The pre-clearing surveys will be used for the following: – Identifying and documenting large tree hollows potentially used for breeding by threatened species (eg. Glossy black-cockatoo and Powerful owl) – Sighting infrastructure to avoid potential breeding hollows and known feeding trees of Glossy black-cockatoo – Investigate measures to remove, relocate and where possible compensate (nest boxes) for the loss of hollows – Where active nests of threatened species are recorded (ie. Glossy black-cockatoo and Powerful owl) nests will be left until chicks have fledged with exclusion zones placed around nest ▪ Staged and sequential clearing protocols ▪ Signage requirements for the delineation of no-go areas and clearing extents, including avoiding works above the tunnel as this area is a key corridor to maintain movement during construction and operation of the project ▪ Animal handling protocols, including relocation and emergency care. For example, consideration of chytrid fungus for frogs, and koalas subject to handling will be examined and if suspected of Chlamydia infection will be taken to a predesignated veterinarian/wildlife care facility for treatment prior to release. ▪ Works protocols to allow safe movement away from works area, should other fauna be observed within or adjacent to the works area ▪ Relocation of plants and micro-habitats (such as hollow bearing logs) where applicable ▪ Requirements for inspections and corrective actions during construction and rehabilitation activities ▪ Fauna and flora management actions, including those required under secondary approvals to be undertaken by suitably qualified persons ▪ Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction.
	Weeds and pests	Develop the CEMP Biosecurity Management Plan[1,2,3] to include: ▪ Requirements for pre-clearing surveys in areas immediately adjacent to the Project disturbance footprint to determine the risk of environmental weeds and pests including prohibited and restricted matters prescribed under the *Biosecurity Act 2014* (Qld) and Biosecurity Regulation 2016 being present ▪ Relevant guidelines to control potential deleterious pathogens including *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015f) associated with Project activities both of which may impact Melaleuca species ▪ Revegetation species to be obtained from source certified free of *Phytophthora cinnamomi* ▪ Mapping the existing extent and severity of any weed infestation and weed management requirements in the disturbance footprint or on adjacent land ▪ Pest animal management, including Red Imported fire ants management within the Biosecurity Zones 1 and 2 as per current DAF advice ▪ Weed surveillance and treatment during construction and rehabilitation activities ▪ Vehicle and plant washdown protocols when traversing properties via temporary access tracks or if any high-risk areas are identified during the Project construction

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Requirements in relation to pesticide and herbicide use and documentation, recognising ACDC Act requirements including any limitations on use, such as, restrictions on use in sensitive environmental areas, drainage lines that flow to waterways and aquatic habitats, and ensuring that broad scale use does not result in an increased erosion and sediment risk ■ Vehicle and plant equipment and imported fill hygiene protocols and documentation ■ Erosion and sediment control risks associated with broad scale weed removal or treatment ■ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material ■ Consideration of current local government Biosecurity Plans (City of Ipswich Biosecurity Plan 2018-2023 and Lockyer Valley Pest Management Plan 2013-2017) ■ Dewatering and fish salvage requirements to manage the risk of translocating non-endemic flora and fauna ■ Requirements for monitoring the effectiveness of weed hygiene measures.
		Develop the Community Engagement Sub-plan in the CEMP, to enable members of the public to assist with weed surveillance in the vicinity of Project works.
	Offsets[1,2]	Restriction of the Project disturbance footprint through detail design as far as practical to that required to safely and efficiently construct and operate the Project[1,2,3]. In doing so, areas of MNES, MSES and their associated habitat will be avoided, thereby minimising significant adverse residual impacts to MNES. Significant adverse residual impact to habitat for MNES and MSES will be re-calculated to confirm the Project's offset obligations under Australian Government and State requirements based on the outcomes of the Flora, fauna and MNES habitat surveys. A Project offset delivery plan and Offsets management plans will be developed to provide for the staged delivery of offsets, where appropriate, ahead of relevant clearing works being undertaken and finalised in consultation with relevant Australian Government and State regulatory agencies.
Pre-construction	Flora and fauna	Implement the Flora and Fauna Sub-plan. Undertake pre-clearing surveys in any areas to be cleared to enable pre-construction activities and confirm the species-specific works protocols to be implemented. Document the area and type of vegetation cleared in a post clearance summary, including MNES and MSES for offsetting and compliance purposes.
	Landscape, rehabilitation and stabilisation	The Reinstatement and Rehabilitation Plan will guide the approach to rehabilitation and be implemented progressively during pre-construction and construction phase activities.
	Weeds and pests	Implement the Biosecurity Management Plan during pre-construction to reduce the potential for the spread of weeds and pests into the surrounding environments and land uses.
	Erosion and sediment control	Implement appropriate site stabilisation treatments, including seeding and planting requirements, in the ESCPs and Reinstatement and Rehabilitation Plan.

Delivery phase	Environmental value impacted	Mitigation and management measures
Construction and commissioning	Flora and fauna	Project clearing extents are limited to that which is required to safely construct, operate and maintain the Project, in accordance with the approved Project disturbance footprint. Locate temporary construction facilities compounds, stockpiles, fuel storage, laydown areas, temporary access roads and staff parking to minimise the extent of disturbance on existing habitat and significant vegetation (i.e. undertake micro-siting of these temporary activities and facilities). Appropriate construction traffic speed limits will be established and managed to minimise vehicle strike risk. Clearly define clearing boundaries associated with the construction disturbance footprint with flagging or marking tape, signage or other suitable means to delineate no go areas. Undertake this delineation and marking process in a manner that is consistent with the Project flagging/marking tape process and specifications, to ensure that it is consistent with the wider Project control processes and does not conflict or contradict any other demarcation practices. Staged and sequence clearing where feasible to minimise the extent of exposed areas. Where possible, minimise loss of canopy vegetation and works that will lead to the proliferation of weed species. A qualified Fauna Spotter Catcher will undertake pre-clearance surveys of habitats and vegetation. The Fauna Spotter Catcher will supervise the subsequent clearing. The area and type of vegetation cleared will be documented where required for compliance with secondary approvals and offset purposes[1,2,3]. Implement the Air Quality Sub-plan to minimise dust impacts including dust monitoring and suppression methods.
	Riparian vegetation and aquatic habitats	Locate construction areas including compounds, stockpiles, fuel storage, laydown areas, temporary and permanent access roads within the Project disturbance footprint. Undertake a flood/drainage assessment to inform the siting and scale of temporary construction areas (including stockpiles, construction compounds, fuel storage and laydown areas etc). Locate these areas on land that is not subject to flooding to the extent possible. Siting of plant and equipment and refuelling facilities to be undertaken in accordance with *AS1940:2017 The storage and handling of flammable and combustible liquids.* Implement the site-specific ESCPs. Works within or adjacent to watercourses will be conducted in accordance with relevant secondary approvals including: ■ *Riverine protection permit exemption requirements* (WSS/2013/726) or conditions of a riverine protection permit issued for the Project ■ *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works. Dewatering/extraction of water from artificial impoundments will be undertaken after consultation with relevant stakeholders. Dewatering strategies will be required to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measures to avoid the spread of pest species (with capacity to affect water quality) and in accordance with any required aquatic fauna species management plans. The salvage and relocation of fish within isolated aquatic environments will be managed in accordance with DAF Guidelines for Fish Salvage An appropriately qualified person will be consulted to make an assessment on the method of recovery, transport and release of fish and other aquatic fauna, as required. As a minimum, the following will be implemented: ■ Relocation will be undertaken by a suitably qualified person ■ Dewatering pumps will have an intake screen ■ Records of all fish recovered, and the location of their release will be maintained.

Delivery phase	Environmental value impacted	Mitigation and management measures
		In the event of a spill incident during construction, any impacted aquatic environments will be assessed for the presence of fauna. If necessary, salvage and recovery efforts will be undertaken[1].
	Fauna passage	Prioritise bridge structures/culverts construction where practical and feasible, particularly in the key locations identified as part of the EIS assessment process to maintain and/or re-establish habitat connectivity as soon as possible and minimise the disruption to waterways. Stage the implementation of the Reinstatement and Rehabilitation Plan in locations associated with fauna passage structures.
	Flora	Minimise clearance of remnant vegetation to that necessary for construction and safe operation, and in accordance with the Project disturbance footprint and secondary approvals[1,2,3]. Where practicable and feasible, locate construction areas including compounds, stockpiles, fuel storage, laydown areas, staff parking outside the tree protection zone as defined in *AS4970-2009 Protection of trees on development sites.* Where possible, minimise loss of canopy vegetation and works that will lead to the proliferation of weed species. Implement the Soil Management Plan as part of the CEMP, guiding the stripping, stockpiling and management of topsoil where it has the potential to contain seedbank or weed material[1]. Topsoil stockpiles will be managed to maintain the viability of soil seed banks. Plan and implement revegetation and rehabilitation works so that they do not create safety, maintenance or performance issues e.g. vegetation does not grow and obscure signals or impact longevity of rail infrastructure.
	Aquatic fauna	Construct temporary and permanent watercourse crossing structures in accordance with the detailed design and *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier. This is required to minimise impacts to aquatic fauna (i.e. fish passage) and hydrology during construction and operation.
	Fauna fencing	Install fauna exclusion fencing in accordance with detailed design and fencing hierarchy especially in conjunction with the identified fauna passages/creek crossing locations for the Project to maintain permeability in the alignment[1,2].
	Weeds and pests	Implement the Biosecurity Management Plan during construction to reduce the potential for the spread of weeds and pests into the surrounding environments and land uses. The effectiveness of weed hygiene measures will be monitored as a component of the environmental monitoring procedure for the Project. Any vegetated material containing, or with the potential to contain, weed seed material will not be used for on-site mulching or erosion protection[1,2] Implement the Community Engagement Sub-plan in the CEMP, to enable members of the public to assist with weed surveillance in the vicinity of Project works.
	Landscape, rehabilitation and stabilisation	Construct landscaping treatments in accordance with the landscape design. Implement the Soil Management Plan. Undertake progressive rehabilitation and reinstatement of disturbed areas in accordance with the Reinstatement and Rehabilitation Plan and the Landscape and Rehabilitation Management Plan.
	Erosion and sediment control	Vegetation clearing and ground disturbing activities will be supplemented by the progressive installation of erosion and sediment controls including stabilisation works to minimise areas exposed to erosion and sediment risk. Implement site stabilisation treatments in accordance with: ▪ ESCP

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Air Quality Sub-plan ■ Reinstatement and Rehabilitation Plan. Assess the suitability of cleared vegetation for mulching/erosion protection on a case by case basis. Any vegetated material containing or with the potential to contain weed seed material will not be used for on-site mulching or erosion protection without prior treatment. For any unsuitable material i.e. noxious weeds etc, the cleared and grubbed material shall be removed from the site and disposed of in accordance with relevant statutory requirements and the Biosecurity Management Plan. Re-use suitable mulch generated by construction of the Project within appropriate timeframes and manner as specified in the ESCP and the Reinstatement and Rehabilitation Plan.
Operation	Riparian vegetation and aquatic habitats	Undertake maintenance activities and refuelling facilities in accordance with *AS1940:2017 The storage and handling of flammable and combustible liquids.* Where maintenance activities within or adjacent to watercourses are required these will be undertaken in accordance with: ■ *Riverine protection permit exemption requirements* (WSS/2013/726) or conditions of a riverine protection permit issued for the works ■ *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works.
	Weeds and pests	Undertake weed and biosecurity management within the rail corridor or at ARTC facilities, including equipment hygiene procedures and reasonable measures to avoid the spread of pest species. ARTC's Enviroline will be advertised for the Project to enable members of the public to notify ARTC of issues, including concerns regarding weeds and pests.
	Fauna passage	Cross drainage structures (including culverts and bridges) will be inspected to assess physical condition and performance, structural integrity and corrective measures in accordance with ARTC's *Structures Inspection Engineering Code of Practice* (ETE-09-01)[1,2]. Inspection of cross drainage structures will ensure fish passage/flow hydrology is being maintained where applicable (i.e. watercourses) Fauna passages will be maintained and where applicable monitored during the operational life of the Project (design life of 100-years
	Fauna fencing	Inspect and maintain fauna fencing in accordance with ARTC *Engineering (Track and Civil) Code of Practice – Section 17 Right of Way: Inspection and Assessment.* Fauna fencing will be maintained and where applicable monitored during the operational life of the Project (design life of 100-years) Record vehicle strikes with koalas and Greater gliders and investigate potential source of the issue Where applicable implement corrective measures (e.g. erect fauna friendly fencing, glider poles etc).

Table notes:

1 Mitigation measure successfully implemented as part of the Toowoomba Second Range Crossing Project.

2 Mitigation measure approved by the Commonwealth as part of the rail component for the Carmichael Coal Mine and Rail Project (EPBC 2013/6885) (refer measures within *Species Management Plans. Carmichael Rail Project* (CRN 2019)).

3 Mitigation measure commonly applied across other projects as approved by the Commonwealth in central and southern Queensland e.g. *Santos Significant Species Management Plan – GFD Project* (Santos 2016), *Anya Significant Species Management Plans* (Shell 2017), *Species Management Plans - Carmichael Rail Project* (CRN 2019).

5.2.3 Flora and fauna management and monitoring

Mitigation measures have been selected based on the best available information including government guidelines (eg. DTMR's Fauna Sensitive Road Design Manual (DTMR 2010)) and mitigation measures used on similar projects that have been subject to legislative approval. It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis. ARTC is committed to implementing ongoing monitoring of the effectiveness of the measures with contingency (under an adaptive management framework) to change/improve management strategies where deleterious impacts to the identified environmental values are observed, or are not minimised, as per the objectives of the proposed measures.

In addition, as the Project moves into the detailed design and construction phases, more focused and comprehensive ecological surveys in accordance with the Commonwealth's survey guidelines and relevant State survey guidelines will be undertaken. The surveys will aim to address any changes to the Project design and footprint and limitations associated with the existing surveys (e.g. access constraints during previous surveys, relevance of the surveys (i.e. some surveys area over four years old or were during sub-optimal periods due to the dry conditions), along with informing the design and construction, including specific measures to avoid, mitigate, minimise impacts on a particular species, along with ongoing monitoring activities.

The surveys will also have the added benefit in addressing some of the recommendations in conservation advices, recovery plans and threat abatement plans (where they exist) including:

- Surveys may identify extent and quality of habitat
- Identify new populations and knowledge of the species ecology
- Surveys may be designed to monitor known populations for certain species
- The Project is also a mechanism to engage the public about a species.

As part of these surveys, ARTC will look to collaborate and supplement existing studies being undertaken by local councils, environmental groups and government agencies.

Chapter 23: Draft Outline Environmental Management Plan of the EIS provides further context and the framework for implementation of these proposed mitigation and management measures.

ARTC is committed to implementing ongoing monitoring of the effectiveness of the measures with contingency (under an adaptive management framework) to change/improve management strategies where deleterious impacts to the identified environmental values are observed, or are not minimised, as per the objectives of the proposed mitigation measures.

5.3 Significant impact assessment

Quantitative estimations of the potential magnitude of disturbance was undertaken for each of the environmental receptors identified during the desktop and field components of the Project EIS using predictive habitat modelling. The Project disturbance footprint was used to calculate the 'unmitigated' disturbance area as a percentage of the extent of the occurrence of the Sensitive environmental receptor within the broader Project context (i.e. the ecology study area).

Calculated estimates of potential disturbance magnitudes for each of the sensitive environmental receptors is provided in Table 5.3.

The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the extent, duration and frequency of the impacts as described in Table 3.5 and Table 3.6.

5.3.1 Quantification of potential magnitude of impacts

Quantitative estimations of the potential magnitude of disturbance was undertaken for each of the Sensitive environmental receptors identified during the desktop and field components of the Project EIS using predictive habitat modelling. The Project disturbance footprint was used to calculate the 'unmitigated' disturbance area as a percentage of the extent of the occurrence of the ecological sensitive environmental receptor within the broader Project context (i.e. the ecology study area).

Calculated estimates of potential disturbance magnitudes for each of the ecological sensitive environmental receptors is provided in the following tables:

- EPBC Act listed migratory birds (i.e. species that are not a controlling provision of the project under the EPBC Act – Table 5.3
- NC Act listed conservation significant species – Table 5.4
- Other MSES – Table 5.5

The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the **extent**, **duration** and **frequency** of the impacts as described in Table 3.5 and Table 3.6.

It is noted there are matters/receptors that cannot be quantified in the following tables but may be subject to impacts from the Project. This refers to potential 'waterway barriers to fish passage' as addressed in Section 4.3.7. The Project will require crossing structures at 26 mapped waterways along the alignment. Impacts to fish passage will be mitigated during the final design/approval phase of the Project. While these impacts are unable to be quantified on this receptor, an assessment of significant residual impacts is addressed in Section 5.3.4.1.

Table 5.3 Estimation of potential magnitude of disturbance for each EPBC Act listed migratory species within the ecology study area

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)			Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance			Magnitude of disturbance area (based on total habitat available) (refer Table 3.5 for magnitude criteria)#
				Total habitat	Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat	
EPBC Act migratory species										
Actitis hypoleucos	Common sandpiper	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Apus pacificus	Fork-tailed swift	SLC	M	**634.58**	535.12	99.46	**5.35**	5.91	3.54	Moderate
Calidris acuminata	Sharp-tailed sandpiper	SLC	M	**92.00**	26.85	65.15	**4.55**	3.54	5.16	Moderate
Calidris melanotos	Pectoral sandpiper	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Calidris ruficollis	Red-necked stint	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Charadrius veredus	Oriental dotterel	SLC	M	**98.40**	33.25	65.15	**5.00**	4.79	5.12	Moderate
Cuculus optatus	Oriental cuckoo	SLC	M	**0.52**	0.08	0.43	**0.55**	0.11	2.05	Negligible
Gallinago hardwickii	Latham's snipe	SLC	M	**133.88**	68.73	65.15	**5.19**	5.06	5.34	Moderate
Gelochelidon nilotica	Gull-billed tern	SLC	M	**15.43**	15.43	0.00	**3.07**	3.35	0.00	Moderate
Hydroprogne caspia	Caspian tern	SLC	M	**20.51**	20.51	0.00	**2.90**	3.10	0.00	Moderate
Limosa limosa	Black-tailed godwit	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Monarcha melanopsis	Black-faced monarch	SLC	M	**6.07**	5.64	0.43	**2.20**	2.22	2.05	Moderate
Monarcha trivirgatus	Spectacled monarch	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Motacilla flava	Yellow wagtail	SLC	M	**0.52**	0.08	0.43	**0.85**	0.20	2.05	Negligible
Myiagra cyanoleuca	Satin flycatcher	SLC	M	**15.43**	15.43	0.00	**3.46**	3.82	0.00	Moderate
Pandion haliaetus	Eastern osprey	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Phalarops lobatus	Red-necked phalarope	SLC	M	**184.68**	126.73	57.95	**4.37**	3.84	6.27	Moderate
Plegadis falcinellus	Glossy ibis	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Pluvialis fulva	Pacific golden plover	SLC	M	**0.52**	0.08	0.43	**0.85**	0.20	2.05	Negligible
Rhipidura rufifrons	Rufous fantail	SLC	M	**0.52**	0.08	0.43	**0.85**	0.20	2.05	Negligible

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)			Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance			Magnitude of disturbance area (based on total habitat available) (refer Table 3.5 for magnitude criteria)#
				Total habitat	Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat	
Tringa nebularia	Common greenshank	SLC	M	**80.58**	15.43	65.15	**4.63**	3.46	5.03	Moderate
Tringa stagnatilis	Marsh sandpiper	SLC	M	**92.22**	27.07	65.15	**4.55**	3.54	5.16	Moderate

Table notes:

M = Migratory SLC = Special Least Concern

* There is potential for each of the sensitive environmental receptor impacts to overlap spatially. As a result, addition of disturbance values presented in the above table would not represent a true reflection of the total Project disturbance footprint.

\# Sensitive environmental receptors that recorded a magnitude of 'N/A' were not subject to an assessment of impact significance (refer Table 5.5) as the sensitive environmental receptor was not subject to impacts.

Table 5.4 **Estimation of potential magnitude of disturbance for each NC Act conservation significant flora and fauna species (excluding matters of national environmental significance) within the ecology study area**

Species name	Common name	NC Act status	Predicted habitat within the Project disturbance footprint (ha)* (634.58 ha)				Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance				Magnitude of total habitat disturbance area (refer Table 3.5 for magnitude criteria)#
			Total habitat	General	Essential	Core	Total habitat	General	Essential	Core	
NC Act conservation significant flora											
Callitris baileyi	Bailey's cypress	NT	**28.40**	28.40	0.00	0.00	**2.03**	2.03	0.00	0.00	Moderate
Eucalyptus taurina	Helidon ironbark	V	**0.00**	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	Absent - Not applicable
Melaleuca irbyana	Swamp tea-tree	E	**128.78**	124.35	4.43	0.00	**4.12**	4.27	2.12	0.00	Moderate
NC Act conservation significant fauna											
Calyptorhynchus lathami	Glossy-black cockatoo	V	**45.11**	45.11	0.00	0.00	**6.44**	6.44	0.00	0.00	Moderate
Hemiaspis damelii	Grey snake	E	**0.00**	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	Absent - Not applicable
Ninox strenua	Powerful owl	V	**28.63**	28.63	0.00	0.00	8.33	8.33	0.00	0.00	Moderate
NC Act special least concern animals											
Ornithorhynchus anatinus	Platypus	SLC	**47.77**	47.77	0.00	0.00	**3.92**	3.92	0.00	0.00	Moderate
Tachyglossus aculeatus	Short-beaked echidna	SLC	**75.71**	75.71	0.00	0.00	**3.04**	3.04	0.00	0.00	Moderate

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special Least Concern

* There is potential for each of the sensitive environmental receptor impacts to overlap spatially. As a result, addition of disturbance values presented in the above table would not represent a true reflection of the total Project disturbance footprint.

\# Sensitive environmental receptors that recorded a magnitude of 'N/A' were not subject to an assessment of impact significance (refer Table 5.5) as the sensitive environmental receptor was not subject to impacts.

Table 5.5 Estimation of potential magnitude of disturbance for each of the environmental sensitive environmental receptors (excluding threatened and migratory species) identified for the Project

Sensitive environmental receptor	Total coverage of environmental sensitive environmental receptor within the ecology study area (ha) (11,866.54 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (634.58 ha)	Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.5 for magnitude criteria)#
State significant environmental constraints (MSES)				
Protected areas (i.e. Bowman Park Koala Nature Refuge)	9.97	0.00	**0.00**	Negligible
Regulated vegetation (VM Act)				
Endangered remnant vegetation (REs) (Category B)	114.73	1.62	**1.41**	Low
Of concern remnant vegetation (REs) (Category B)	437.06	2.35	**0.54**	Negligible
Least concern remnant vegetation (REs) (Category B)	1151.53	28.29	**2.46**	Moderate
High value regrowth vegetation (HVR) (Category C)	1093.72	66.39	**6.07**	Moderate
Regulated vegetation (Category B) intersecting watercourses and wetlands	63.45	0.77	**1.21**	Low
Regulated vegetation (Category C) intersecting watercourses and wetlands	30.71	1.52	**4.95**	Moderate
MSES wildlife habitat	2940.06	19.84	**0.67**	Negligible
Essential habitat mapping	2679.75	95.66	**3.57**	Moderate
Nature Conservation (Koala) Conservation Plan 2017 mapping				
Koala Priority Areas	4407.30	193.49	**4.39**	Moderate
Koala Habitat Areas	2649.01	95.62	**3.61**	Moderate
Wetlands				
State significant wetlands (HES)	22.77	0.00	**0.00**	Negligible
State significant waters (HEV)	64.57	6.44	**9.97**	Moderate
Least concern flora and fauna* (NC Act) and Priority Back on Track flora and fauna species				
Least concern flora and fauna	11861.94	638.28	**5.38**	Moderate
Priority Back on Track species (not listed under the EPBC Act or NC Act)	11861.94	638.28	**5.38**	Moderate

Sensitive environmental receptor	Total coverage of environmental sensitive environmental receptor within the ecology study area (ha) (11,866.54 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (634.58 ha)	Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.5 for magnitude criteria)#
Biodiversity Planning Assessment (BPA)				
Local or Other Habitat Values	277.44	10.65	**3.84**	Moderate
Regional Habitat Values	667.14	9.10	**1.36**	Low
State Habitat values	635.09	9.61	**1.51**	Low
State Habitat for EVNT taxa	155.12	2.90	**1.87**	Low
Regional Terrestrial Corridor	1805.81	140.81	**7.80**	Moderate
State Riparian Corridor	720.47	22.52	**3.13**	Moderate
State Riparian/Terrestrial Corridor	2.54	0.00	**0.00**	Negligible

Table note:

* There is potential for each of the Sensitive environmental receptor impacts to overlap spatially. As a result, addition of disturbance values presented in the above table would not represent a true reflection of the total Project disturbance footprint

5.3.2 Initial significance of potential impacts

Following the assessment of the sensitivity of Sensitive environmental receptors, identification of the potential impacts to these receptors and the assessment of the magnitude of impact, an assessment of the impact of the Project on each Sensitive environmental receptor was undertaken (refer Table 5.6).

The magnitude of impacts presented in Table 5.6, takes into consideration direct impacts associated with the direct removal of habitat and also considers indirect impacts associated with air quality (refer EIS Chapter 12), surface water and hydrology (refer EIS Chapter 13), groundwater (refer EIS Chapter 14) and noise and vibration (refer EIS Chapter 15). The impact assessment of the Project on sensitive environmental receptors is provided in Table 5.6, presenting an initial assessment significance of impact (i.e. application of mitigation measures already incorporated into the design) for each sensitive environmental receptor, as well as the residual impact following the application of Project's mitigation measures.

In addition to the mitigation measures presented in Table 5.6, rehabilitation works may also be an effective mitigation measure to minimise potential impacts over time. However, the effectiveness of this solution has been excluded from the assessment given the uncertainty around the final use of the land being cleared for construction use only.

Significance ratings of Low, Moderate, High and Major constitute a potential significant residual impact to an MNES (migratory species) or MSES, and were subsequently re-assessed against the MNES significant impact guidelines (for migratory species) or MSES significant impact to confirm the initial impact assessment results (refer Sections 5.3.3 and 5.3.4 respectively).

Table 5.6 Initial assessment of significance of impacts of the Project upon identified Sensitive environmental receptors

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
Commonwealth receptors (EPBC Act listed migratory species)								
Commonwealth Significant Ecological Constraint (Species listed as migratory under the EPBC Act): ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Yellow wagtail (*Motacilla flava*) ▪ Pacific golden plover (*Pluvialis fulva*) ▪ Rufous fantail (*Rhipidura rufifrons*)	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**B**) Fauna species injury or mortality (**D**) Displacement of fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	Low	Moderate	Flora and fauna (design, preconstruction and construction proposed mitigation measures) Weeds and pests (preconstruction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Negligible	Low (refer to Section 5.3.3 for assessment against MNES Significant Impact guidelines for migratory species)
		Commissioning and reinstatement	(**B**) Fauna species injury or mortality (**D**) Displacement of fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Low	Moderate	Flora and fauna (design, preconstruction and construction proposed mitigation measures) Weeds and pests (preconstruction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Low	Moderate	Weeds and Pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Low
Commonwealth Significant Ecological Constraint (Species listed as migratory under the EPBC Act): - Common sandpiper (*Actitis hypoleucos*) - Fork-tailed swift (*Apus pacificus*) - Sharp-tailed sandpiper (*Calidris acuminata*) - Pectoral sandpiper (*Calidris melanotos*) - Red-necked stint (*Calidris ruficollis*)	High	Construction	(clearing/removal (**B**) Fauna species injury or mortality (**D**) Displacement of fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	Major	Flora and fauna (design, preconstruction and construction proposed mitigation measures) Weeds and pests (preconstruction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Moderate	High (refer to Section 5.3.3 for assessment against MNES Significant Impact guidelines for migratory species)

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
■ Oriental dotterel (*Charadrius veredus*) ■ Oriental cuckoo (*Cuculus optatus*) ■ Latham's snipe (*Gallinago hardwickii*) ■ Gull-billed tern (*Gelochelidon nilotica*) ■ Caspian tern (*Hydroprogne caspia*) ■ Black-tailed godwit (*Limosa limosa*) ■ Black-faced monarch (*Monarcha melanopsis*) ■ Spectacled monarch (*Monarcha trivirgatus*) ■ Satin flycatcher (*Myiagra cyanoleuca*) ■ Eastern osprey (*Pandion haliaetus*) ■ Red-necked phalarope (*Phalarops lobatus*) ■ Glossy ibis (*Plegadis falcinellus*) ■ Common greenshank (*Tringa nebularia*) ■ Marsh sandpiper (*Tringa stagnatilis*)		Commissioning and reinstatement	(**B**) Fauna species injury or mortality (**D**) Displacement of fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Low	Moderate	Flora and fauna (design, preconstruction and construction proposed mitigation measures) Weeds and pests (preconstruction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Low	Moderate	Weeds and Pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State receptors								
State Significant Ecological Constraint (VM Act): - Endangered remnant vegetation (REs) (Category B)	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	Moderate	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Low	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (preconstruction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ Of concern remnant vegetation (REs) (Category B)	Moderate	Construction	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Negligible	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ Least concern remnant vegetation (REs) (Category B)	Low	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	High	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Moderate	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Low	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Low	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (VM Act): ▪ High value regrowth vegetation (Category C)	Moderate	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Moderate	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Low	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	Weeds and Pests (operations) Riparian vegetation and aquatic habitats (operations)	Low	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (VM Act): ▪ Regulated vegetation (Category B) intersecting watercourses and wetlands	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	Moderate	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Low	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (preconstruction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations)	Negligible	Low

<table>
<tr><th rowspan="2">Sensitive environmental receptor(s)</th><th rowspan="2">Sensitivity[1]</th><th rowspan="2">Phase</th><th rowspan="2">Potential impacts [2]</th><th colspan="2">Initial significance (application of initial mitigation measures presented in Section 5.2.1)</th><th rowspan="2">Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'</th><th colspan="2">Residual significance following the application of Project mitigation measures presented in Table 5.2[3]</th></tr>
<tr><th>Magnitude[1]</th><th>Significance</th><th>Magnitude</th><th>Significance[4]</th></tr>
<tr><td rowspan="3">State Significant Ecological Constraint (VM Act):
- Regulated vegetation (Category C) intersecting watercourses and wetlands</td><td rowspan="3">Moderate</td><td>Construction</td><td>(A) Habitat loss from vegetation clearing/removal
(C) Reduction in biological viability of soil to support plant growth due to soil compaction
(D) Displacement of flora and fauna species from invasion of weed and pest species
(F) Edge effects
(G) Habitat fragmentation
(H) Barrier effects
(J) Increase in litter (waste)
(K) Aquatic habitat degradation</td><td>High</td><td>High</td><td>Flora and fauna (design, pre-construction and construction proposed mitigation measures)
Weeds and pests (pre-construction and construction mitigation measures)
Erosion and sediment control (pre-construction and construction)
Riparian vegetation and aquatic habitats (construction)</td><td>Moderate</td><td>Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)</td></tr>
<tr><td>Commissioning and reinstatement</td><td>(D) Displacement of flora and fauna species from invasion of weed and pest species</td><td>Moderate</td><td>Moderate</td><td>Flora and fauna (design, pre-construction and construction proposed mitigation measures)
Weeds and pests (pre-construction and construction mitigation measures)
Erosion and sediment control (pre-construction and construction)
Riparian vegetation and aquatic habitats (construction)
Landscape, rehabilitation and stabilisation (design, pre-construction, construction)</td><td>Low</td><td>Low</td></tr>
<tr><td>Operation</td><td>(D) Displacement of flora and fauna species from invasion of weed and pest species</td><td>Moderate</td><td>Moderate</td><td>Weeds and Pests (operations)
Riparian vegetation and aquatic habitats (operations)</td><td>Low</td><td>Low</td></tr>
</table>

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ MSES wildlife habitat	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Fauna passage (design, construction)	Negligible	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species;	Low	Moderate	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations) Fauna fencing (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ Essential habitat	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	High	Major	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Fauna passage (design, construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species;	Low	Moderate	Weeds and pests (operations) Riparian vegetation and aquatic habitats (operations) Fauna fencing (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
Nature Conservation (Koala) Conservation Plan 2017 mapping, including: ▪ Koala Priority Areas ▪ Koala Habitat Areas	High	Construction	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**H**) Barrier effects (**I**) Noise, dust, and light impacts	High	Major	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts	Low	Moderate	Weeds and pests (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
Mapped wetland areas ▪ State significant wetlands (HES) ▪ State significant waters (HEV)	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**K**) Aquatic habitat degradation (**I**) Erosion and sedimentation	High	Major	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**K**) Aquatic habitat degradation (**I**) Erosion and sedimentation	Low	Moderate	Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**K**) Aquatic habitat degradation (**I**) Erosion and sedimentation	Low	Moderate	Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Riparian vegetation and aquatic habitats (construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (species listed as threatened under the NC Act): **Flora**: - Bailey's cypress (*Callitris baileyi*) - Swamp tea-tree (*Melaleuca irbyana*) **Fauna:** - Powerful owl (*Ninox strenua*) - Glossy Black-cockatoo (*Calyptorhynchus lathami*)	High	Commissioning and reinstatement	(**A**) Habitat loss from vegetation clearing/removal (**B**) Fauna species injury or mortality (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	Major	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	**Significance**		**Magnitude**	**Significance[4]**
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Low	Moderate	Weeds and pests (operations)	Negligible	Low
State significant ecological constraint (Special Least concern fauna species): ▪ Echidna (*Tachyglossus aculeatus*) ▪ Platypus (*Ornithorhynchus anatinus*)	Moderate	Construction	(**A**) Habitat loss from vegetation clearing/removal (**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Moderate	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts	Low	Low	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint: ▪ Priority Back on Track flora and fauna species (that are not listed under as threatened under the provisions of the EPBC Act or NC Act)	Low	Construction	(**A**) Habitat loss from vegetation clearing/removal (**B**) Fauna species injury or mortality (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Aquatic fauna (design and construction) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Moderate	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Moderate	Low	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Negligible
State significant ecological constraint: ▪ Flora and fauna species not listed under the EPBC Act but listed as Least concern under the provisions of the NC Act and flora that is listed as Special least concern under the provisions of the NC Act	Low	Construction	(**A**) Habitat loss from vegetation clearing/removal (**B**) Fauna species injury or mortality (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**I**) Noise, dust, and light impacts (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation.	High	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Aquatic fauna (design and construction) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Moderate	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible
		Operation	(**B**) Fauna species injury or mortality (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**I**) Noise, dust, and light impacts (**K**) Aquatic habitat degradation	Moderate	Low	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ BPA habitat values for Endangered, Vulnerable and Near Threatened (EVNT) taxa (State) ▪ BPA habitat values (State)	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	Moderate	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Low	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ BPA habitat values (Regional)	Moderate	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	Moderate	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Low	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ State riparian corridors	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	High	Major	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ State riparian/terrestrial corridors	High	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste) (**K**) Aquatic habitat degradation	Moderate	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Negligible	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (BPA): ▪ Regional terrestrial corridors	Moderate	Construction	(**A**) Habitat loss from vegetation clearing/removal (**C**) Reduction in biological viability of soil to support plant growth due to soil compaction (**D**) Displacement of flora and fauna species from invasion of weed and pest species (**F**) Edge effects (**G**) Habitat fragmentation (**H**) Barrier effects (**J**) Increase in litter (waste)	High	High	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Fauna passage (design and construction) Fauna fencing (design and construction)	Moderate	Moderate (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Flora and fauna (design, pre-construction and construction proposed mitigation measures) Weeds and pests (pre-construction and construction mitigation measures) Erosion and sediment control (pre-construction and construction) Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by 'Environmental value impacted' and 'Delivery phase'	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	(**D**) Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	Weeds and pests (operation) Fauna fencing (operation)	Negligible	Low

Table notes:

1 Refer to Sections 3.5.1 and 3.5.2 for the assessment methodology for 'sensitivity' and 'magnitude' criteria.
2 Potential impacts to terrestrial and aquatic ecology values in the above table are based upon those presented in Section 5.1.2
3 The use of offsets has not been considered as a mitigation measure for the purposes of project mitigation for the assessment of potential impacts.
4 In instances where the mitigated significance returns a rating of High or above, offsets may be an option to reduce the residual ecological impacts in the long term. Offset for biodiversity values are discussed further in Section 5.4

5.3.3 Significant residual impact assessment for MNES (migratory species)

This section assesses the potential for significant residual impacts from the Project on migratory fauna using the relevant criteria outlined in the MNES Guidelines. MNES that constitute a controlling provision of the project are discussed within the MNES technical report (i.e. EPBC Act threatened species and communities. Migratory species that are also listed as an MNES threatened species are assessed as threatened species the MNES technical report. Following the MNES guidelines the Project is likely to have a significant impact on a migratory species if there is a possibility that it will:

- Substantially modify, destroy or isolate an area of important habitat for a migratory species
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species
- Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species.

An area of important habitat for a migratory species is:

- Habitat utilised by a migratory species within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.

The following sections assess the potential for significant residual impact on the migratory species identified as potentially occurring within the Project area using the criteria set out in the MNES Guideline.

There are 22 migratory species relevant to the ecology study area (i.e. that are identified in desktop searched, have predicted habitat within the ecology study area, and are not listed as threatened under the EPBC Act) including eight migratory terrestrial species and 14 migratory wetland species. Marine migratory fauna (e.g. cetaceans and pelagic marine birds) were excluded from this list due to the absence of marine environments in the ecology study area. The ecology, life history and distribution of these species are summarised in Appendix B. Relevant Commonwealth documents applicable to each species including threat abatement plans, approved conservation advice, and recovery plans are also summarised in Appendix B.

Key potential impacts to migratory fauna are considered to include the following:

- Direct clearing of species habitats
- Injury/mortality to individuals during vegetation clearing in the construction period (where nests are present).

A range of mitigation measures have been proposed to ameliorate these impacts wherever possible (refer Section 5.2.2). These include measures considered as effective in addressing the recognised threats for each species as recognised in approved conservation advice, and DAWE-adopted threat abatement plans (as identified in the following sections for each species) including but not restricted to:

- Flora and Fauna Sub-plan will incorporate species-specific monitoring strategies including detailed pre-construction site surveys and operational monitoring to ensure degradation to adjacent habitats is not occurring as a result of the Project – applicable to all species
- Biosecurity Management Plan to protect fauna habitats adjacent to the Project from deleterious impacts including weed invasion, proliferation of pest predators and invasion by introduced pathogens (such as Myrtle rust and *Phytophthora cinnamomi*) – applicable to all species
- Erosion and Sediment Control Plan and Surface Water Sub-plan to protect water quality values associated with wetlands and waterways – applicable to aquatic species/wetland birds

- Air Quality Sub-plan includes measures to minimise dust impacts on vegetation/habitats including dust monitoring and suppression methods – applicable to all species
- Fauna crossing structures and associated fencing and site-specific (crossing) vegetation rehabilitation to allow continued landscape connectivity for fauna across the alignment – applicable to terrestrial fauna
- Reinstatement and Rehabilitation Plan to detail rehabilitation of temporary construction areas not required for Project operation – applicable to all species.

Given the degraded nature of the majority of the woodlands within the disturbance footprint (due to vegetation clearance, previous tree thinning and weed invasion) indirect impacts such as edge effects (for example dust deposition) are considered to be suitably mitigated under the Projects mitigation measures and restricted to the construction period.

The assessment of significant impacts on the identified migratory species from the Project is based on:

- Current knowledge of the species, including local populations and habitat requirements (refer Appendix B and Sections 5.3.3.1, 5.3.3.2, 5.3.3.3 and 5.3.3.4)
- Predictive habitat modelling for each species based on the habitat assumptions associated with each species (refer Appendix A), along with the findings of ecological surveys (refer Section 4.4). Where ‘suitable habitat’ is referred to in the following assessments it refers to the predicted habitat area output of the habitat modelling as specific to the species addressed.
- The current understanding and layout of the Project (Section 1.6)
- Information on potential impacts of Project during construction and operation (Section 5.1)
- Proposed Project mitigation measures (Section 5.2).

A summary of the findings of the significant residual impact assessment for migratory species is provided in Table 5.7.

Table 5.7 Summary of the results of the significant impact assessment for migratory species

Migratory species	Status*		Results of assessment	Table containing assessment against MNES Guidelines
	EPBC Act	NC Act		
Aerial migrants				
Fork-tailed swift (*Apus pacificus*)	M	SLC	No significant impact likely	Table 5.8
Marine migrants				
Gull-billed tern (*Gelochelidon nilotica*)	M	SLC	No significant impact likely	Table 5.9
Pacific golden plover (*Pluvialis fulva*)	M	SLC	No significant impact likely	Table 5.9
Caspian tern (*Hydroprogne caspia*)	M	SLC	No significant impact likely	Table 5.9
Common sandpiper (*Actitis hypoleucos*)	M	SLC	No significant impact likely	Table 5.9
Sharp-tailed sandpiper (*Calidris acuminata*)	M	SLC	No significant impact likely	Table 5.9
Pectoral sandpiper (*Calidris melanotos*)	M	SLC	No significant impact likely	Table 5.9
Red-necked stint (*Calidris ruficollis*)	M	SLC	No significant impact likely	Table 5.9
Latham’s snipe (*Gallinago harwickii*)	M	SLC	No significant impact likely	Table 5.9
Black-tailed godwit (*Limosa limosa*)	M	SLC	No significant impact likely	Table 5.9
Red-necked Phalarope (*Phalaropus lobatus*)	M	SLC	No significant impact likely	Table 5.9
Common greenshank (*Tringa nebularia*)	M	SLC	No significant impact likely	Table 5.9
Marsh sandpiper (*Tringa stagnatilis*)	M	SLC	No significant impact likely	Table 5.9
Oriental dotterel (*Charadrius veredus*)	M	SLC	No significant impact likely	Table 5.9

Migratory species	Status*		Results of assessment	Table containing assessment against MNES Guidelines
	EPBC Act	NC Act		
Woodland migrants				
Rufous fantail (*Rhipidura rufifrons*)	M	SLC	No significant impact likely	Table 5.10
Oriental cuckoo (*Cuculus optatus*)	M	SLC	No significant impact likely	Table 5.10
Spectacled monarch (*Symposiachrus trivirgatus*)	M	SLC	No significant impact likely	Table 5.10
Black-faced monarch (*Monarcha melanopsis*)	M	SLC	No significant impact likely	Table 5.10
Satin flycatcher (*Myiagra cyanoleuca*)	M	SLC	No significant impact likely	Table 5.10
Wetland migrants				
Yellow wagtail (*Motacilla flava*)	M	SLC	No significant impact likely	Table 5.11
Glossy ibis (*Plegadis falcinellus*)	M	SLC	No significant impact likely	Table 5.11
Eastern osprey (*Pandion haliaetus*)	M	SLC	No significant impact likely	Table 5.11

Table note:

M = migratory SLC = Special least concern

It is unlikely that the thresholds outline in the guideline will be exceeded in relation to important habitat for each of the 22 migratory species outlined in the draft referral guideline (refer Referral guideline for 14 birds listed as migratory species under the EPBC Act). Given the extensive remnant habitat that will not be disturbed adjacent to and surrounding the Project a significant impact resulting from a loss of important habitat is unlikely. Given the extensive remnant habitat that will not be disturbed adjacent to and surrounding the Project and the loss of habitat below the threshold a significant impact is unlikely.

5.3.3.1 Aerial migrants

This section provides a summary of information related to the aerial migratory species that have potential to occur within the ecology study area and assesses this species against the MNES significant impact criteria for migratory species.

Fork-tailed swift (*Apus pacificus*)

Fork-tailed swift is an aerial, insectivorous bird that weighs 30-40 g. The species breeds in Siberia and migrates to Australia, arriving during October-September. The species feeds aerially on flying insects and possibly also roosts aerially. The species forages over all terrestrial habitats, and is most commonly observed over open habitats, such as woodlands and marshes. The species is less common over forest and rainforest (DAWE 2020c).

There are no significant threats to the species in Australia (DAWE 2020c). Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (BirdLife International 2009).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers a wide range of habitats important for this species, from inland open plains to wooded areas, where it is exclusively aerial. The threshold for an ecologically significant proportion of a population (individuals) is 1,000 individuals internationally and 100 individuals nationally. No area threshold can be determined for this species. The proportion likely to result in a significant impact if affected is 1,000 internationally and 100 nationally (DAWE 2020b).

No database records occur for this species within the Project disturbance footprint. A recent record (2018) occurs within the ecology study area to the north of the Project disturbance footprint and west of Gatton. Records for this species occur in all directions of the Project with most records occurring along the eastern coastline.

Given this is an aerial species and does not breed in Australia habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 99.46 ha of important habitat for this species within the Project disturbance footprint (refer Table 4.29).

Assessment against the significant impact criteria for Fork-tailed swift is shown in Table 5.8.

Table 5.8 Assessment against the significant impact criteria: Aerial migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	The Project will impact areas of open floodplain and woodland that are suitable habitat for the species. This area is considered to constitute important habitat for the species, however considering the vast amount of habitat available for this species and the relatively small area being cleared there will not be enough to substantially modify destroy or isolate important habitat.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Biosecurity Management Sub-plan will mitigate the impacts of invasive species on the species. If the abundance of feral predators (i.e. cats and foxes) increase due to the Project, it is unlikely to have any impact due to the aerial behaviour of the species.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	The species breeds in Siberia. When over-wintering in Australia the species feeds aerially and possible also roosts aerially. It is considered unlikely that the Project will result in a disruption of the species' lifecycle.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on aerial migrants (Fork-tailed swift) will result from the Project.

5.3.3.2 Marine migrants

This section provides a summary of information related to each of the 13 marine migratory species that have potential to occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Oriental dotterel (*Charadrius veredus*)

Oriental plover is a medium sized insectivorous plover with long legs and weighing approximately 95g. They breed in China/Mongolia from April to July and fly south to Australia. They inhabit coastal sites however are far more often recorded in inland habitats. The species is known to forage at night, around mud flats and clay pans, coastal areas or sparely vegetated plains with short grass in arid and semi-arid zones. They have been observed in artificial habitats such as playing fields, lawns and cattle camps. The species is less common in lightly wooded grasslands. The species has no important habitat used for breeding in Australia.

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss, over-tourism and strikes from aircraft in airfields are potential threats to the species (DAWE 2020c). Whilst not specific to the Oriental dotterel, predation by invasive species such as fox and cats is also a threatening process (DotE 2015). Introduction of exotic tall grass species could also reduce the habitat of this species. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint and only one record occurs within the ecology study area. The record is to the south of the disturbance footprint and west of Gatton dated 1991. A number of records for this species occur at Atkinsons and Seven Mile Lagoons located approximately 18 km north of the Project disturbance footprint. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Oriental dotterel is shown in Table 5.9.

Pacific golden plover (*Pluvialis fulva*)

The Pacific golden plover is a medium sized upright wader. The species breeds in Arctic tundra in northern hemisphere summer and migrates to the southern hemisphere in winter. It is estimated that 4 per cent (approximately 9000) of the world's population of Pacific Golden Plover occur in Australia, present between September and May. This species inhabits coastal areas, feeding on sandy or muddy shores. They roost on sandy beaches, rocky points or exposed reefs. Moreton Bay Ramsar listed areas are considered to be important habitat within Australia (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss, over-tourism and strikes from aircraft in airfields are potential threats to the species (DAWE 2020c). Whilst not specific to the Pacific golden plover, predation by invasive species such as fox and cats is also a threatening process (DotE 2015). Introduction of exotic tall grass species could also reduce the habitat of this species. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. Records occur between Gatton and Atkinsons Lagoon including recent (2018). Whilst database records exist inland for this species, most occur along the eastern coastline. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Pacific golden plover is shown in Table 5.9.

Gull-billed tern (*Gelochelidon nilotica*)

The Gull-billed tern is a large-sized tern that feeds on insects and fish. This species inhabits freshwater swamps, lakes, beaches, estuarine mudflat as well and more inland environments such as croplands and grasslands (BirdLife Australia 2020). They are found all over the world (except for Antarctica). Breeding is not fixed to any one environment, but prefer protected, dry ground on an island in a lake.

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. No records for this species occur within the Project disturbance footprint. Several records occur within the ecology study area to the south of the alignment near Gatton dated 2013 and 2004. Numerous records occurring in the surrounding landscape from Gatton to Atkinsons Lagoon and at Laidley. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

There is no important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). Important breeding habitat could be considered as areas that provide shallow water. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Gull-billed tern is shown in Table 5.9.

Caspian tern (*Hydroprogne caspia*)

Caspian tern is a large-sized piscivorous tern. This species is found throughout Eurasia, North America, Africa and Australasia (BirdLife Australia 2020). They occur all over the Australian coastline and along major inland rivers and wetlands in the western districts of Queensland. They breed socially, but outside of breeding occur in small groups or are solitary. Whilst most Caspian terns are found in coastal habitats, they also inhabit inland lakes, wetlands, waterholes, rivers and creeks. They prefer clear water in order to spot their prey.

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Important inland breeding sites for this species in Queensland include Lake Bindegolly and Lake Moondarra otherwise breeding occurs on offshore islands (Higgins and Davies 1996). Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. No records for this species occur within the Project disturbance footprint. Two records occur at the western end of the ecology study area near Helidon dated 2012 and 2013. Two records from 2012 and 2015 occur within the ecology study area at Gatton. A number of other records for this species exist in the surrounding landscape specifically near Laidley and between Gatton and Atkinsons Lagoon. Most records for this species occur along the eastern coastline. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

There is no important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Caspian tern is shown in Table 5.9.

Common sandpiper (*Actitis hypoleucos*)

Common sandpiper is a small migratory wader, typically 20 cm in length. They mostly eat molluscs, crustaceans and insects. This species breeds in Europe, Asia and Africa from April to August and then migrates south to Australia. Their habitat includes coastal wetlands, rocky shores, and mudflats as well as inland wetlands such as lakes, reservoirs, dams, claypans, and sometimes in marginal grasslands. Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. No records for this species occur within the Project disturbance footprint or the ecology study area. The nearest records occur to the north and south of Gatton (2016), Laidley (2017) and Atkinsons Lagoon (1980s). Inland records for this species are sparse and most occur along the eastern coastline. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Common sandpiper is shown in Table 5.9.

Sharp-tailed sandpiper (*Calidris acuminata*)

Sharp-tailed sandpiper is a medium-sized summer migratory wader, typically 20 cm in length. This species breeds in Siberia from June to August and then migrates south to Australia. They are most common around coastal environments but are also sparsely scattered around inland wetlands such as lakes, dams, claypans, sewage works and inundated vegetation. Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. No records for this species occur within the Project disturbance footprint. Several records occur within the ecology study area near Gatton from 2010 to 2014. A number of records occur in the surrounding landscape from Gatton to Atkinsons Lagoon and surrounding Laidley. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Sharp-tailed sandpiper is shown in Table 5.9

Pectoral sandpiper (*Calidris melanotos*)

Pectoral sandpiper is an omnivorous medium-sized summer migratory wader, typically 21 cm in length. It feeds on algae, seeds, crustaceans, arachnids and insects. This species breeds in Siberia from June to August and then migrates south to Australia. They are most common around coastal environments but are also rarely seen in inland wetlands such as lakes, dams, claypans, sewage works and inundated vegetation. Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. No records for this species occur within the Project disturbance footprint or the ecology study area. Records from the surrounding area, including recent (2018) occur in the surrounding landscape with numerous records at Gatton and Lake Clarendon. Records for this species in SEQ are sparse with most occurring along the coast near Brisbane. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Pectoral sandpiper is shown in Table 5.9.

Red-necked stint (*Calidris ruficollis*)

Red-necked stint is an omnivorous medium-sized summer migratory wader, typically 21 cm in length. It feeds on algae, seeds, crustaceans, arachnids and insects. This species breeds in Siberia, however in the non-breeding season 80 per cent of the world's population resides in Australia. They are most common around coastal environments but are also rarely seen in inland wetlands such as lakes, dams, claypans, sewage works and inundated vegetation. Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (DAWE 2020c).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint and a single record from 2014 occurs within the ecology study area near Gatton. Other nearby records occur from Gatton to Atkinsons Lagoon and at Laidley. Inland records for this species are scattered and most occur along the eastern coastal regions. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Given this is predominantly a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population or is at the limit of the species range. However, there is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). Given the species breeds outside of Australia there is no habitat associated with the Project that is considered important breeding habitat for the species. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for marine migrants is shown in Table 5.9.

Latham's snipe (*Gallinago hardwickii*)

Latham's snipe is an omnivorous medium-sized migratory wader, typically 30 cm in length. It feeds on plant material, seeds, molluscs, crustaceans, arachnids and insects. The species does not breed in Australia. This species breeds in Japan and far eastern Russia, and then migrates to Australia during the northern hemisphere winter (between August and January). They inhabit wetlands such as swamps, creek or river margins, lakes, dams, claypans, sewage works and inundated vegetation/floodplains. They prefer areas that include some form of shelter or cover (low/dense vegetation). Latham's Snipe has also been recorded near artificial habitats such as airfields, ploughed paddocks, irrigation channels, dairy farms and drainage ditches. Their roosting habitats include dense vegetation near foraging habitats. They could also potentially occur in Bluegrass Dichanthium dominant grasslands in the Brigalow Belt Bioregion (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint. A record from 2000 occurs within the ecology study area at Helidon and at Gatton from 2013. A number of records occur in the surrounding landscape particularly near Helidon, Gatton, Laidley and Atkinsons Lagoon. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Latham's snipe is shown in Table 5.9.

Black-tailed godwit (*Limosa limosa*)

Black-tailed godwit is an omnivorous large-sized migratory wader, typically 40 to 44 cm in length. It feeds on annelids, crustaceans, arachnids, fish eggs and spawn and tadpoles of frogs, and occasionally seeds (DAWE 2020c). This species breeds in Mongolia and far east Russia, and then migrates to Australia for the northern hemisphere winter. This species does not breed in Australia. In Australia they prefer coastal regions, however they can be found scattered around inland regions. They inhabit primarily sheltered bays estuaries, lagoons mudflats, saltmarsh, salt flats. River pools, swamps floodplains, bores, freshwater lakes and saline lakes, and shallow, sparsely vegetated wetlands. Black-tailed Godwit has also been recorded near artificial habitats such as sewage farms and saltworks. Their roosting habitats include claypans (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or the ecology study area. Database records exist at Gatton and Laidley however, these are either undated or old (1966). Other nearby records for this species occur at Lake Clarendon and Atkinsons Lagoon. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Black-tailed godwits shown in Table 5.9.

Red-necked phalarope (*Phalaropus lobatus*)

Red-necked phalarope is a small migratory wader, typically 18 to 19 cm in length. This species generally feeds on invertebrates such as zooplankton, but as well by spinning to disturb flying insects (DAWE 2020c). Red-necked phalarope breeds in Arctic and subarctic North America, Europe and Russia. It then migrates to waters off the eastern coast of South America, Arabian Sea/northern Indian Ocean and east to the Philippines and Australia. This species does not breed in Australia. Whilst it occurs mostly at sea in non-breeding times, they have been found scattered around inland regions. When inland they inhabit lakes and artificial habitats such as sewage farms and saltworks (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). No important habitat has been identified for this species. Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint. Several records exist within the ecology study area near Helidon dated 1988. A single record from the same year occurs at Helidon. No other database records occur near the Project or within a 50 km buffer of the Project disturbance footprint. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Red-necked phalarope is shown in Table 5.9.

Common greenshank (*Tringa nebularia*)

Common greenshank is a large migratory wader, typically 30-35 cm in length. This species generally feeds on molluscs, crustaceans, insects, and occasionally fish and frogs (DAWE 2020c). Common greenshank breeds in Palaearctic region (BirdLife 2020). It then migrates through the East Asian-Australasian Flyway to Western Australia and north around the Torres strait around November. This species does not breed in Australia. They are found in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. When inland they inhabit swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and salt flats (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion) (Department of the Environment and Heritage 2005).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint or within the ecology study area. The nearest records for the species occur between Gatton and Atkinsons Lagoon along with Laidley. Most records for this species occur to the east along the coast. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Common greenshank is shown in Table 5.9.

Marsh sandpiper (*Tringa stagnatilis*)

Marsh sandpiper is a medium-sized migratory wader, typically 22-26 cm in length. This species generally feeds on molluscs, crustaceans, insects, and occasionally fish (DAWE 2020c). Marsh sandpiper breeds in Palaearctic and subarctic North America, Europe and Russia. It then migrates through the East Asian-Australasian Flyway to Western Australia and north around the Torres strait around November. This species does not breed in Australia. They are found in permanent or ephemeral wetlands, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015). Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion) (Department of the Environment and Heritage 2005).

This species is not listed as one of the 14 migratory species outlined in the Draft Referral Guideline for migratory bird species under the EPBC Act. No records for this species occur within the Project disturbance footprint. Two records from 2010 and 2014 occur within the ecology study area near Gatton. Several records occur within the ecology study area to the north of Laidley however only one of these has a date (2001). Most nearby records occur between Gatton and Atkinsons Lagoon. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.15 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Marsh sandpiper is shown in Table 5.9.

Table 5.9 Assessment against the significant impact criteria: Marine migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	No important habitat has been identified for these species; therefore, it is not likely to modify, destroy or isolate important habitat for the species. It is not expected that thresholds outlined in the guidelines will be exceeded as a result of disturbance associated with the Project.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Biosecurity Management Sub-plan will mitigate the impacts of invasive species on the species. If the abundance of feral predators (i.e. cats and foxes) increase due to the Project, it is unlikely to have any impact due to the aerial behaviour of the species.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	These species do not breed in Australia. When over-wintering in Australia the large proportion of the respective populations occur in coastal regions and may only use inland wetlands as stop overs during a migratory journey. It is considered unlikely that the Project will result in a serious disruption of the species’ lifecycle.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a ‘significant impact’ on marine migrants will result from the Project.

5.3.3.3 Woodland migrants

This section provides a summary of information related to each of the five woodland migratory species that have potential to occur within the ecology study area and assesses these species against the MNES significant impact criteria or migratory species.

Oriental cuckoo (*Cuculus optatus*)

The Oriental cuckoo migrates to Australia during its non-breeding season which occurs from September to May (DAWE 2020c). This species migrates from north-east Asia. When this species occupies the northern hemisphere, it breeds throughout Eurasia where it parasitizes on other birds, particularly laying eggs in the nest of northern warblers. During the northern hemisphere autumn, the species migrates south to Indonesia, New Guinea and northern Australia. Whilst some individuals remain in Australia through winter most return north in autumn (Morcombe 2003). This species utilises habitat associated with the coastal regions of northern and eastern Australia including offshore islands. This species primarily utilises a variety of habitat including monsoon rainforest, wet sclerophyll forest and open woodlands (DAWE 2020c) however, will also occupy vine scrub, riverine thicket, paperbark swamps and mangroves (Morcombe 2003).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as any non-breeding habitat that this species occupies including monsoonal rainforest, vine thicket, wet sclerophyll forest or open Acacia, Casuarina or Eucalypt wooded areas. The threshold for an ecologically significant proportion of a population (individuals) is 10,000 internationally and 1,000 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 250,000 ha internationally and 25,000 ha nationally. The proportion likely to result in a significant impact if affected is 10,000 internationally and 1,000 nationally (DAWE 2020b).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). No records for this species occur within the Project disturbance footprint or within the ecology study area. Two records occur 2 km to the south-west of the Project disturbance footprint west of Helidon from 2014. Other records within a 50 km buffer of the Project disturbance footprint occur near Murphy’s Creek, Mount Sylvia, Rosewood and south of Gatton. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records for this species occur within forested areas east of the Great Dividing Range. Whilst a number of records occur inland these are sparse. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 0.43 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29) The Project is not at the limit of this species range. A review of the available literature does not reveal any impacts from invasive species on the Oriental cuckoo. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Oriental cuckoo is shown in Table 5.10.

Black-faced monarch (*Monarcha melanopsis*)

The Black-faced monarch migrates between Australia and New Guinea. During the summer breeding months this species is found along the eastern coastal region of Australia, during winter the species retreats to the north overwintering in New Guinea. Rather than making the full migration north to New Guinea a portion of the population remains in northern Australia during winter usually consisting of younger birds (DAWE 2020c). This species utilises rainforest as breeding habitat selecting trees with large leaves as nesting sites where they construct a nest at the top of the tree, in smaller saplings or in low shrubs. The species is known to breed from the Atherton region of Queensland’s wet tropics, SEQ and near Lake Entrance in south-east Victoria (DAWE 2020c). Breeding generally occurs between October and March although there is regional variation across the species’ range. Eggs hatch between 13 and 15 days with fledging occurring seven days or more later. Fledgling success appears to be poor for this species with an estimated 0.1 fledged young per nest per breeding event (BA NRS 2002).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat to be wet sclerophyll forest in sheltered gullies with dense understorey consisting of ferns and shrubs. The threshold for an ecologically significant proportion of a population (individuals) is 4,600 internationally and 460 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 2,600 ha internationally and 260 ha nationally. The proportion likely to result in a significant impact if affected is 465 internationally and 47 nationally (DAWE 2020b).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). Threats to this species include collision with windows (Taplin 1991) and lighthouses (Makin 1961). No records for this species occur within the Project disturbance footprint. A single record from 1998 occurs within the ecology study area to the south of the Lockyer Reserves. Other records within a 50 km buffer of the Project disturbance footprint occur throughout the Toowoomba Range to the west, Lockyer Reserves to the north, between Rosewood and D’Aguilar National Park to the east/north-east and Main Range National Park to the south. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records for this species occur within forested areas of eastern Australia including inland. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 0.43 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. Invasive species that have the potential to impact the Black-faced monarch includes Black rat, (*Rattus rattus*) and exotic vines associated with riparian area (e.g. Rubber vine (*Cryptostegia grandiflora*)) (DAWE 2020c).

Assessment against the significant impact criteria for Black-faced monarch is shown in Table 5.10.

Satin flycatcher (*Myiagra cyanoleuca*)

Satin flycatchers tree species including paperbarks, eucalypts and banksias for nest building constructing nests in the outer branches (BA NRS 2002). The species lays three or four eggs in a clutch with both sexes incubating the eggs for short durations over a period of 17 days (BA NRS 2002). Breeding occurs between November and January where the species occurs above 600 m above sea level in south-eastern Australia (Frith 1969). This varies slightly at lower elevations and different regions in Australia. Satin flycatchers will occupy eucalypt forests with an open understorey or with a grass as ground cover, they are not associated with rainforest (DAWE 2020c).

This species generally occupies eucalypt forest that occurs near wetlands or waterways. Compared to other flycatcher species they tent to occupy forests that are taller and wetter frequently in gullies (DAWE 2020c).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as essential habitat during breeding which includes high elevation eucalypt forest and woodland whilst common habitat includes tall wet sclerophyll forest associated with gullies or waterways and open grassy woodlands. Migratory habitat is more general whilst wintering habitat includes rainforest, mangroves and paperbark swamps. The threshold for an ecologically significant proportion of a population (individuals) is 17,000 internationally and 1,700 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 4.400 ha internationally and 440 ha nationally. The proportion likely to result in a significant impact if affected is 1,700 internationally and 170 nationally (DAWE 2020b).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). Nest parasitism from cuckoo species could be considered as a threat to the species (Brooker & Brooker 1989). The main threats to this species result from land clearing and logging of mature forest in Australia’s south-east (Blakers et al. 1984). No records for this species occur within the Project disturbance footprint or the ecology study area. The nearest record in relation to the project occurs to the south of Gatton approximately 2.5 km from the Project disturbance footprint and is dated 1999. Another record occurs to the south of Helidon approximately 3.5 km from the Project disturbance footprint dated 1999. A number of records occur for this species in all directions of the Project with most occurring within a 50 km buffer of the Project disturbance footprint in forested areas at the Toowoomba Range to the west, D’Aguilar National Park to the north-east and Main Range National Park to the south. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records for this species occur within forested areas of eastern Australia including inland. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 0.43 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. Invasive species that have the potential to impact the Satin flycatcher includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (e.g. Rubber vine (*Cryptostegia grandiflora*)) (DAWE 2020c).

Assessment against the significant impact criteria for Satin flycatcher is shown in Table 5.10.

Spectacled monarch (*Symposiachrus trivirgatus*)

Breeding for Spectacled monarch typically occurs between September and April nesting in the vertical fork of a tree sampling or shrub located near a water body or watercourse. Two eggs are typically laid with the female undertaking most of the incubation. The incubation period is typically between 15 and 18 days. Both parents feed young until a few days after fledging which occurs 17 to 20 days after the young hatch (DAWE 2020c).

The Spectacled monarch typically occupies rainforests, mangroves and wet gullies associated with dense wet eucalypt forests (Morcombe 2003). Other densely vegetated habitats are utilised by this species including mangroves, drier forest and woodlands (DAWE 2020c).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as dense vegetation consisting mostly of rainforest, moist forest or wet sclerophyll forest along with mangroves, drier forest and woodlands that provide dense vegetation. The threshold for an ecologically significant proportion of a population (individuals) is 6,500 internationally and 650 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 2,100 ha internationally and 210 ha nationally. The proportion likely to result in a significant impact if affected is 650 internationally and 65 nationally (DAWE 2020b).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). No records for this species occur within the Project disturbance footprint or within the ecology study area. The nearest record occurs approximately 4 km from the Project disturbance footprint to the north of Gatton dated 2017. A record from 2014 occurs a similar distance to the south of Helidon. Other records within a 50 km buffer of the Project disturbance footprint occur to the west at the Toowoomba Range, north at the Lockyer Reserves, north-east at D'Aguilar National Park, south-east at the Teviot Range and to the south at Main Range National Park. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records for this species occur within forested areas east of the Great Dividing Range with inland records sparse of largely absent. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 0.43 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. Invasive species that have the potential to impact the Spectacled monarch includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (e.g. Rubber vine (*Cryptostegia grandiflora*)) (DAWE 2020c).

Assessment against the significant impact criteria for Spectacled monarch is shown in Table 5.10.

Rufous fantail (*Rhipidura rufifrons*)

Rufous fantails typically breed from September to February with the majority of eggs laid between November and December. Breeding occurs slightly later at higher elevations with two to four eggs typically laid in a small nest that forms a cup-shape. Nesting material consists of a variety of plant material, moss and spider web (Higgins et. al 2006). Nests are constructed in trees, shrubs or vines between 34 cm and six metres from the ground and are typically placed 1.6 m high (Higgins et. al 2006). It is suggested that trees with big leaves are selected as to hide the nest (Huggett 2000). Both male and female will share incubation of the eggs, if the first nesting attempt is unsuccessful the pair will re-lay a second clutch (Higgins et. al 2006). Incubation takes between 5 and 17 days (Huggett 2000).

Where Rufous fantails are found in east and south-east Australia, they are associated with primarily wet sclerophyll forest, typically in gullies with a dense understorey of ferns. The species also occurs in sub-tropical to temperate regions where rainforest exists. Rufous fantails appear to have a tolerance for secondary forest. Whilst migrating they will stopover in drier sclerophyll forest and woodland ecosystems that have a shrubby, heath like understorey. In the north and north-east of their distribution they are known to occupy tropical rainforest, monsoonal rainforest and various type of vine thicket (Higgins et. al 2006).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as moist habitat with dense vegetation, across mangrove, rainforest, riparian forest and thickets, along with wet eucalypt forest with a dense understorey. A wider range of habitat becomes important for this species during migration including dry eucalypt forest/woodlands and Brigalow shrublands. The threshold for an ecologically significant proportion of a population (individuals) is 48,000 internationally and 4800 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 7,500 ha internationally and 750 ha nationally. The proportion likely to result in a significant impact if affected is 3,400 internationally and 344 nationally (DAWE 2020b).

The main threat to this species is thought to be fragmentation of habitat through the loss of core moist forest breeding habitat as a result of land clearing and urban encroachment particularly where clearing has occurred along remnant forest along migratory routes (Huggett 2000). No records for this species occur within the Project disturbance footprint. Two records occur within the ecology study area north of Helidon dated 1999 and 2000. Another record occurs within the ecology study area at Gatton however this is an old record dated 1974. Database records within a 50 km buffer of the Project disturbance footprint occur in all directions of the Project. Most of these occur at the Toowoomba Range, between Rosewood and Brisbane and at Main Range National Park. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records for this species occur within forest areas east of the Great Dividing Range with inland records sparse of largely absent. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 0.43 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. Invasive species that have the potential to impact the Rufous fantail includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (e.g. Rubber vine (*Cryptostegia grandiflora*)) (DAWE 2020c).

Assessment against the significant impact criteria for Rufous fantail is shown in Table 5.10.

Table 5.10 Assessment against the significant impact criteria: Woodland migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	No important habitat has been identified for these species; therefore, it is not likely to modify, destroy or isolate important habitat for the species. It is not expected that thresholds outlined in the guidelines will be exceeded as a result of disturbance associated with the Project.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Biosecurity Management Sub-plan will mitigate the impacts of invasive species on the species. If the abundance of feral predators (i.e. cats and foxes) increase due to the Project, it is unlikely to have any impact due to the aerial behaviour of the species.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species	Given the small proportion of predicted habitat within the Project disturbance footprint for migratory woodland species it is unlikely that much of this would consist of breeding habitat. As such the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of the population.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on woodland migrant will result from the Project.

5.3.3.4 Wetland migrants

This section provides a summary of information related to each of the three wetland migratory species that have potential to occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Glossy ibis (*Plegadis falcinellus*)

Glossy ibis is the smallest ibis in Australia and known to live up to 8 years on average. Glossy Ibis feed on aquatic invertebrates such as molluscs and crustaceans. They have been occasionally observed to feed on fish, frogs and tadpoles, dryland invertebrates, lizards, small snakes and nestling birds. They sexually mature in one or two years and typically breed from mid-spring to the end of summer and may persist breeding from September to April pending the availability of resources. They normally lay up to 3 to 6 eggs at a times, and chicks take 25-28 days to fledge. Parents will care for young several weeks after fledging. This species forms colonies for nesting, sometimes with a mix of other species of ibis and colonial birds. Nesting material consists of a platform nest of sticks, usually with a lining of aquatic plants, between the upright branches of trees or shrubs growing in water (BirdLife Australia 2020). Australian breeding habitat types include vegetated swamps in the semi-arid and arid regions (DAWE 2020c).

Globally they occur in North America, Europe, Asia, and Africa. In Australia, Glossy ibis are found from Kimberley down south to the Eyre Peninsula and east to Queensland New South Wales and Victoria. Glossy ibis' preferred habitat for foraging and breeding are fresh water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation. The species is occasionally found in wooded swamps, artificial wetlands (such as irrigated fields. No important habitat has been identified.

The main threat to this species is thought to be wetland destruction or degradation, this includes water diversion and drainage alteration. Increasing salinity, groundwater extraction human disturbance, pollution and grazing also threaten the species. Two records occur within the Project disturbance footprint at Forest Hill dated 2017. A number of records exist within the ecology study area to the west at Helidon, numerous both to the north and south of the Project disturbance footprint at Gatton and at Forest Hill. Records within a 50 km buffer of the Project disturbance footprint occur in all directions except to the south-west. An estimated 6.44 ha of HEV/HES wetlands is predicted to be impacted as a result of the Project. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Most records occur towards the east of the alignment and the eastern coastline where this species is more abundant. The Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 57.95 ha of important habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is not at the limit of this species range. Invasive species that have the potential to impact the Glossy ibis, generally invasive plants that can alter or degrade wetland ecosystems and exotic fish (tilapia) species that may outcompete with food resources (DAWE 2020c).

Assessment against the significant impact criteria for Glossy ibis is shown in Table 5.11.

Yellow wagtail (*Motacilla flava*)

Yellow wagtails are a small passerine wagtail around 15-16cm long with dark legs and uniform grey-green rump. They breed from Europe to Siberia and migrate south to Africa, SE Asia and Australia. In Australia, they are found in mostly coastal northern areas but also further south in NSW and southern Western Australia from November to April (Pizzey and Knight 2003).

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as mostly well-watered open grasslands and the fringes of wetlands. Roosts in mangroves and other dense vegetation. In Australia the species typically utilises open habitats associated with water including swamps, salt marshes, sewage ponds, extensive lawns and airfields, damp pasture, bare and ploughed ground and sometimes on drier plains inland (Morcombe 2003). The threshold for an ecologically significant proportion of a population (individuals) is 10,000 internationally and 1,000 nationally. No area threshold can be determined for this species. The proportion likely to result in a significant impact if affected is 10,000 internationally and 1,000 nationally (DAWE 2020b).

Severe fragmentation of habitat, a reduction in habitat quality can lead to a decrease in the area of suitable habitat for the Yellow wagtail. These factors have potentially lead to a general decrease in the population size (BirdLife International 2020). It is not known if invasive species have the potential to impact the Yellow wagtail (DAWE 2020c). An estimated 6.44 ha of HEV/HES wetlands is predicted to be impacted as a result of the Project. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

Database records do not indicate that this species occurs within the Project disturbance footprint, ecology study area or from within a 50 km buffer of the Project disturbance footprint. The nearest records for this species occur a little more than 50 km north-east of the Project disturbance footprint at Wynnum North from 2014. Only a few other records occur along the coast between Brisbane and Caboolture. Most database records for this species occur in northern Australia (on the coast) and are of single individuals.

A total of 65.15 ha of important habitat will be removed as a result of the Project (refer Table 4.29). A lack of database records combined with the fact that the Project is outside of the species' Australian migratory distribution means a significant impact on this species is unlikely. The Project is not likely to exceed thresholds for this species as outlined in the guidelines referring to a loss of an ecologically significant proportion of a population.

Assessment against the significant impact criteria for Yellow wagtail is shown in Table 5.11.

Eastern osprey (*Pandion haliaetus*)

The Eastern osprey (*Pandion haliaetus*) is a medium-sized raptor with a total length of 50 to 65 cm and wingspan 145 to 170 cm. Ospreys are one of the most widely distributed birds of prey, second to the Peregrine falcon. They are distributed globally occupying both temperate and tropical regions across all continents except Antarctica. Their diet mainly consists of fish, however, have been to known to feed on crustaceans, insects, reptiles, birds and mammals (DAWE 2020c). They live on average 30 years, and have clutch sizes of one to four eggs, with brooding attempts separated by periods of up to three years. They typically inhabit coastal habitat and terrestrial wetlands of tropical and temperate Australia. Less frequently they are seen travelling over heath, woodland or forest when travelling between foraging sights (DAWE 2020c). No important populations have been identified in Australia, although a management plan has been developed for New South Wales and one proposed for South Australia.

The Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act (DAWE 2020b) considers important habitat as moist habitat with dense vegetation, across mangrove, rainforest, riparian forest and thickets, along with wet eucalypt forest with a dense understorey. A wider range of habitat becomes important for this species during migration including dry eucalypt forest/woodlands and Brigalow shrublands. The threshold for an ecologically significant proportion of a population (individuals) is 48,000 internationally and 4800 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 7,500 ha internationally and 750 ha nationally. The proportion likely to result in a significant impact if affected is 3,400 (individuals) internationally and 344 nationally (DAWE 2020b).

Major threats include habitat loss or degradation, bioaccumulated pollutants, and food reduction due to competition with fisheries. Any invasive species that has the capacity to greatly reduce fish abundance is considered harmful to this species.

This species occurs within 1 km at several locations near Gatton with two records located to the north of the Project disturbance footprint dated 2013 and 2016 and one to the south dated 2007. A record to the south of Helidon dated 2013 occurs within approximately 5 km of the Project disturbance footprint. Other records for this species from within a 50 km buffer occur to the north-west at the Toowoomba Range, and from the north to the south-east with numerous scattered occurrence records. Most records outside of a 50 km buffer occur along the coast to the east.

No important habitat for this species will be removed as a result of the Project (refer Table 4.29). A lack of database records combined with the fact that the Project is outside of the species' Australian migratory distribution means a significant impact on this species is unlikely. The Project is not likely to exceed thresholds for this species as outlined in the guidelines referring to a loss of an ecologically significant proportion of a population.

Assessment against the significant impact criteria for Eastern osprey is shown in Table 5.11.

Table 5.11 Assessment against the significant impact criteria: Wetland migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	A small amount of wetland habitat has been identified for these species which is considered important for the species. This area is small and not likely to be modified, destroyed or isolated as a result of the Project. It is not expected that thresholds outlined in the guidelines will be exceeded as a result of disturbance associated with the Project.

Criterion	Assessment against the significance criteria
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Biosecurity Management Sub-plan will mitigate the impacts of invasive species on the species. If the abundance of feral predators (i.e. cats and foxes) increase due to the Project, it is unlikely to have any impact due to the aerial behaviour of the species.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	Given the small proportion of predicted habitat within the Project disturbance footprint for wetland migratory species it is unlikely that much of this would consist of breeding habitat. As such the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of the population.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on wetland migrants will result from the Project.

5.3.4 Significant residual impact assessment for MSES

The Significant Residual Impact (SRI) guideline criteria details when an action is likely to have a 'significant residual impact' to a MSES as defined in the Environmental Offsets Regulation 2014 (Offsets Regulation). Table 5.12 presents a significant residual impact assessment of the MSES identified as potentially present within the ecology study area, in accordance with the SRI Guideline. The areas of significant impacts are based on the overall Project disturbance footprint. This may be an overestimation of the final impact area following design refinements for the Project.

The extent of remnant habitat located within the Project disturbance footprint comprises four category B (remnant vegetation) REs as mapped by the Department of Resources. These comprise one REs listed as 'endangered' *Eucalyptus tereticornis* woodland on Quaternary alluvium (RE12.3.3 – 1.62 ha); an 'of concern' woodland comprising *E. crebra* woodland on sedimentary rock (RE12.9-10.7 – 1.08 ha), and 'least concern' fringing riparian woodlands consisting of *E. tereticornis/Casuarina cunninghamiana* (RE12.3.7 – 2.24 ha) and *Corymbia citriodora* subsp. *variegata* open forest on sedimentary rock (RE12.9-10.2 – 27.32 ha). There is also 66.39 ha of high value regrowth and 535.12 ha of non-remnant lands within the Project disturbance footprint (refer Table 4.20 for further information regarding REs within the Project disturbance footprint). High value regrowth is listed as Category C vegetation and is not a prescribed environmental matter under the Environmental Offsets Regulation 2014. As such, it is not treated further in the following assessment.

The State Development Assessment Provision requires assessment of the Project against the criteria set out in the *Significant Residual Impact Guideline for matters of state environmental significance and prescribed activities assessable under the Sustainable Planning Act 2009* (the SRI Guideline) (DSDIP 2014a). The SRI Guideline criteria details when an action is likely to have a 'significant residual impact' to a MSES as defined in the Environmental Offsets Regulation 2014.

Table 5.12 below presents a preliminary significant residual impact assessment of the MSES identified as present in the desktop and field review and in accordance with the SRI Guideline. The impacts to 'regulated vegetation' are based on the current VM Act vegetation mapping as will be required when considering environmental offsets. The areas of significant impacts are based on the Project disturbance footprint as currently known.

Table 5.12 Significant residual impact assessment for matters of state environmental significance

Matter of State environmental significance	Significant Residual Impact Guideline criteria	Likelihood of Significant Impact as a result of the Project
Regulated vegetation		
'Endangered' or 'of concern' regional ecosystem (RE)	An action is **Likely** to have an SRI on an 'endangered' or 'of concern' RE if the action will result in: (a) clearing of more than 5ha of 'endangered' or 'of concern' RE vegetation; (b) clearing that results in an overall area (not confined to property boundaries) of 'endangered' or 'of concern' RE vegetation of less than 5ha; **OR**	**Not anticipated.** Under current Regulated Vegetation management (RVM) mapping the Project area encompasses 1.62 ha of 'endangered' and 1.08 ha of 'of concern' remnant vegetation (Category B)

<table>
<tr><th>Matter of State environmental significance</th><th>Significant Residual Impact Guideline criteria</th><th>Likelihood of Significant Impact as a result of the Project</th></tr>
<tr><td></td><td>(c) clearing that results in the physical separation of ‘endangered’ and ‘of concern’ RE communities within and on adjoining sites.</td><td>Clearing will not result in the clearing of more than 5 ha of ‘endangered’ or ‘of concern’ vegetation.</td></tr>
<tr><td>a prescribed RE (Category B other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature (Appendix 3 of the Queensland Environmental Offsets Policy)</td><td>Remnant vegetation within the defined distance of a watercourse
An action is Likely to have an SRI on remnant vegetation within the defined distance of a watercourse if the action will result in:
a) permanent removal of vegetation within the defined distance of a stream order 2 or higher where no rehabilitation is proposed;
b) building of an online detention basin greater than 1ha in size or other similar works that result in the clearing of vegetation which fragments up and downstream remnant areas on any stream order; OR
c) permanent clearing of more than 0.5ha of an endangered or of concern RE, within the defined distance of a watercourse.</td><td>Significant impact anticipated.
The defined distance for 1st and 2nd order, 3rd and 4th order, 5th order streams and greater in the Project area is 25 m, 50 m and 100 m respectively from a defined bank.
The removal of the vegetation associated with Project construction is expected to be permanent and will not be rehabilitated. The Project will require the permanent removal of 0.77 ha of Category B vegetation within the defined distance of a watercourse.</td></tr>
<tr><td>Remnant vegetation intersection with a VM Act wetland</td><td>An action is Likely to have an SRI on remnant vegetation intersecting with a wetland if the action will result in:
(a) clearing within the defining banks of a defined wetland area exceeding the thresholds specified in Table 2, SDAP Module 8;
(b) clearing involving the permanent removal of more than 25% of the vegetation located within 50m of the defining bank of a defined wetland; OR
(c) clearing involving the permanent removal of more than 50% of the vegetation located between 50m and 100m of the defining bank of a defined wetland.</td><td>Not anticipated.
There will be no impact within the defining banks of a defined wetland area. There will not be any permanent removal of Category B regulated vegetation within 100 m of the defining bank of a defined wetland within the Project disturbance footprint (refer Section 4.3.18).</td></tr>
<tr><td>Essential Habitat (EH)</td><td>An action is Likely to have an SRI on EH if the action will result in:
clearing of EH exceeding the thresholds specified in Table 1, SDAP Module 8, and resulting in a greater than 10% permanent reduction in the extent of EH mapped on site.
<table><tr><th colspan="3">Clearing limits per regional ecosystem</th></tr><tr><td>Structure Category</td><td>Width (m)</td><td>Area (ha)</td></tr><tr><td>Dense and mid-dense</td><td>10</td><td>0.5</td></tr><tr><td>Sparse and very sparse</td><td>20</td><td>2</td></tr><tr><td>Grassland</td><td>25</td><td>5</td></tr></table></td><td>Significant impact anticipated.
There will be permanent removal of approx. 95.66 ha of Category B and Category C regulated vegetation mapped as essential habitat within the Project disturbance footprint.</td></tr>
<tr><th colspan="3">Connectivity areas</th></tr>
<tr><td>Connectivity areas</td><td>In deciding if an SRI is likely to occur on a connectivity area, an administering agency (that is the State) must consider the significance of the vegetation in the context of the local and the regional landscape. The measure of impact significance is based on how the prescribed activity will change the size and configuration of remnant vegetation areas and the level of fragmentation that will result at the local scale (5km radius) given regard to the regional scale (20km radius). Impact significance is measured by the reduction in the extent of remnant vegetation and increase in patchiness at the local scale.</td><td>Not anticipated.
The landscape Project impacts to the extent of remnant vegetation in the area have been analysed using DESs ‘landscape fragmentation and connectivity’ tool.</td></tr>
</table>

Matter of State environmental significance	Significant Residual Impact Guideline criteria	Likelihood of Significant Impact as a result of the Project
	In highly fragmented landscapes at the regional scale, an SRI on connectivity areas will be associated with smaller impacts compared to impacts within regionally intact landscapes, as the extent and configuration of existing connectivity areas in fragmented landscapes is limited.	Assessment result Outputs from landscape fragmentation and connectivity analysis indicate that impacts for core areas will equate to 0.31% (Significance Test 1), and the number of core remnant areas remaining post impact will not change from pre-impact (11) (Significance Test 2). The impacts are therefore not significant
Designated precincts in Strategic Environmental Areas		
Designated precincts in Strategic Environmental Areas	The *Regional Planning Interests Act 2014* (RPI Act), which commenced on 13 June 2014, repealed the Wild Rivers Act 2005. The river systems that were declared under the Wild Rivers legislation have been rolled into the RPI Act framework as Strategic Environmental Areas (SEAs). The RPI Act SEAs are: ▪ the Cape York Strategic Environmental Area ▪ the Channel Country Strategic Environmental Area the Frazer Island Strategic Environmental Area ▪ the Gulf Rivers Strategic Environmental Area ▪ the Hinchinbrook Island Strategic Environmental Area	**Not anticipated.** Outside of any designated Strategic Environmental Areas.
Wetlands and watercourses		
a wetland in a wetland protection area, or wetlands of high ecological significance shown on the map of Queensland wetland environmental values a wetland or watercourse in high ecological value waters	**Wetland and watercourses** An action is Likely to have an SRI on a wetland or watercourse if: (a) works are undertaken within a wetland in a WPA, a wetland of HES or the bed or banks of a HEV watercourse that will result in a permanent degradation of the landform, vegetation or water quality; (b) in an urban area, works are undertaken within 50m of a wetland in a WPA, a wetland of HES or the bed or banks of a HEV watercourse that will result in a permanent and significant change to surface or groundwater hydrology or water quality; OR (c) in a non-urban area, works are undertaken within 200m of a wetland in a WPA, a wetland of HES, or the bed or banks of a HEV watercourse that will result in a permanent and significant change to surface or groundwater hydrology or water quality	**Significant impact anticipated.** Works within the Project disturbance footprint are likely to be undertaken within HEV wetlands and watercourses. Mitigations for these impacts are outlined in Table 5.3 in the Terrestrial and Aquatic Ecology Technical Report. The works are not considered to be in an 'urban area' as defined under Schedule 24 of the Planning Regulation 2017 where mapped HES/HEV wetlands occur. Whilst these impacts will be mitigated there is potential to impact mapped HEV watercourses at the western section of the Project disturbance footprint to the north of Helidon. The works are also located approximately 80 m and 290 m from two HES wetlands at the western end of the Project disturbance footprint north-east of Calvert. The Project is within 200 m from a single HES wetland in the eastern portion of the footprint and has the potential to cause permanent and significant change to surface hydrology and water quality associated with this area.

Matter of State environmental significance	Significant Residual Impact Guideline criteria	Likelihood of Significant Impact as a result of the Project
		The Project will directly impact HEV watercourses and associated mapped wetland areas in the western portion of the footprint that may result in a permanent degradation of the landform, vegetation or water quality.
Protected wildlife habitat		
an area contains plants that are endangered wildlife or vulnerable wildlife	**Plants - Protected wildlife habitat (plants that are 'endangered' or 'vulnerable' wildlife)*** Refer to the assessment of the SRI Guideline significant impact criteria for threatened flora (refer Table 5.13). An action is Unlikely to have an SRI on a plant that is 'endangered' or 'vulnerable' wildlife if the action will result in: (a) clearing of plants that are threatened wildlife and not located within a natural setting (i.e. does not meet the definition of 'in the wild' under the *Nature Conservation Act 1992*) where the proposal includes translocation; (b) clearing of up to 10% of the total number of plants that are threatened wildlife occurring on a site where the proposal results in 90% of all plants that are threatened wildlife being retained and protected as a reserve or similar; (c) clearing of regenerating plants that are threatened wildlife which have previously been cleared within the last 5 years and that are historically maintained through slashing or grazing; OR (d) the proposed relocation of an area of plants that are threatened wildlife less than 1000m2 not occurring in a relatively natural ecological situation (e.g. bushland), to a permanent retention area via an approved management plan.	**Significant impact anticipated.** Protected plant trigger maps indicate that endangered or vulnerable flora exists within the Project disturbance footprint west of Calvert and south-west of Grandchester. Database records indicate one 'vulnerable' species and one 'endangered' species may occur within the Project disturbance footprint. *Eucalyptus taurina* (vulnerable) has been predicted to occur within the ecology study area but not within the Project disturbance footprint. No records exist for this species within the ecology study area or the Project disturbance footprint is species will not be assessed further. *Melaleuca irbyana* (endangered) has been predicted to occur within the ecology study area and the Project disturbance footprint. Records exist for this species within the ecology study area north-east of Calvert. A single individual was recorded on the edge of the Project disturbance footprint near Grandchester during project surveys. Potential habitat for the Bailey's cypress (vulnerable) is located within the Project disturbance area. There are a number of other plant species which are listed as MNES which have the potential to inhabit the Project disturbance footprint, including Lloyds olive (*Notelaea iloydii*) which was identified (2 individuals) from the Project disturbance footprint. These species have been assessed under the MNES significant impact guidelines and as such are not assessed here (refer Appendix J – MNES technical report). Pre-clearing surveys will be required to identify if any threatened plant species occur within the Project disturbance footprint. In the event threatened species are found to occur it is assumed translocation will not take place and that all plants within the Project disturbance footprint will be removed.

Matter of State environmental significance	Significant Residual Impact Guideline criteria	Likelihood of Significant Impact as a result of the Project
		Significant impact expected for the following: Bailey's cypress and Swamp tea-tree (refer Table 5.13).
a habitat for an animal that is: ▪ endangered wildlife, or ▪ vulnerable wildlife, or ▪ a special least concern animal *(an echidna or a platypus)*	**Animals - Protected wildlife habitat (habitat for an animal that is 'endangered' or 'vulnerable' wildlife or a special least concern animal)*** Refer to the assessment of the SRI Guideline significant impact criteria for threatened fauna (refer Table 5.14) and special least concern fauna (refer Table 5.15).	**Significant impact anticipated.** Significant impacts are not expected for the following: Platypus and Echidna as suitable habitat for these species occurs within the Project disturbance footprint. **Significant impact expected for the following:** Glossy-black cockatoo and Powerful owl There are a number of other species which are listed as MNES which have the potential to inhabit the project disturbance footprint, including the Koala (*Phascolarctos cinereus*) and Grey falcon (*Falco hypoleucos*) which were observed during targeted fauna surveys. These species have been assessed under the MNES significant impact guidelines and as such are not assessed here (refer EIS Appendix J: Matters of National Environmental Significance Technical Report).
Fish habitat area		
an area declared under the Fisheries Act (Qld) to be a fish habitat area	An action is Likely to have an SRI on a declared FHA or highly protected zones of marine parks if the action: (a) is not for a listed purpose or a structure type; AND (b) will result in a residual Project disturbance footprint within the declared FHA and/or highly protected marine park zone of 40m^2 or greater in area.	**Not anticipated.** No declared fish habitat areas have been mapped within the water quality study area. The nearest gazetted fish habitat area is located approximately 120 km downstream of the water quality study area (refer Surface Water Quality Technical Report).
Waterway providing for fish passage		
any part of a waterway providing for passage of fish only if the construction, installation or modification of waterway barrier works will limit the passage of fish along the waterway	An action is **Likely** to have an SRI on a <u>waterway providing for fish passage</u> if the action will result in: a) a permanent modification to the volume, depth, timing, duration or flow frequency of the waterway; b) permanent modification or fragmentation of fish habitat including but not limited to in stream vegetation, snags and woody debris, substrate, bank or riffle formation necessary for breeding and/or survival of native fish species; **c)** the mortality or injury of fish species; **Or** d) works that permanently reduce the level of fish passage provided in a tidal waterway or a waterway identified as a major high- risk waterway for waterway barrier works, to a, e) level that would increase stress on fish populations.	**Significant impact not anticipated.** There are 26 individual waterways which cross the Project alignment. Of these nine are mapped as 'low', seven are mapped as 'moderate', two are mapped as 'high' and eight are mapped as 'major'. Of these waterways, several are intersected multiple times (refer Surface Water Quality Technical Report). The Project has potential to permanently modify fish habitat, although it is anticipated final design will maintain flows along creek lines via installation of culverts/bridges at crossings. Permanent fragmentation of fish habitat will not occur. The final Project design will ensure that the localised impacts due to waterway crossings will lead to permanent modifications to habitat necessary for native fish breeding or survival.

Matter of State environmental significance	Significant Residual Impact Guideline criteria	Likelihood of Significant Impact as a result of the Project
		Mitigation measures will be in place to minimise/eliminate mortality/injury to fish species from instream works required for the Project. Notwithstanding the above, an action is UNLIKELY to have a SRI on a waterway providing for fish passage if: (a) measures have been put in place to provide equal or better fish passage for the waterway during construction and operation activities; AND (b) the waterway is restored to its existing condition immediately on completion of the works; OR (c) for works that permanently alter existing fish passage, equal or better passage will be provided immediately on completion of the works.

5.3.4.1 Matters of state environmental significance conservation significant species assessments

Section 4.4.3 identifies areas of potential habit for threatened and special least concern species with potential to occur within the Project area. This section provides a significant impact assessment for conservation significant species as listed under the provisions of the NC Act which have potential to be impact by the Project activities. For species listed under the EPBC Act, refer Section 5.3.3 (non-threatened migratory species) or EIS Appendix J: Matters of National Environmental Significant Technical Report (EPBC Act controlling provisions of the Project).

The Project area provides potential habitat for Swamp tea-tree (endangered under the NC Act) and Bailey's Cypress Pine (near-threatened under the NC Act). The Project area also provides potential habitat for the Powerful owl (vulnerable under the NC Act) and Glossy-black cockatoo (vulnerable under the NC Act), as well as the Platypus (SLC under the NC Act) and Short-beaked echidna (SLC under the NC Act). Information regarding the ecology, distribution and known threats to these species is provided in Appendix B.

The SRI Guideline criteria for assessing significant impacts to State listed species are similar in some respects to the criteria set out for threatened species in the MNES guidelines. A significant impact assessment for Swamp tea-tree and Bailey's Cypress Pine is provided in Table 5.13. Significant impact assessment for Threatened fauna is provided in Table 5.14, and Table 5.15 provides a significant impact assessment for Special least concern species.

Table 5.13 Matters of state environmental significance significant residual impact criteria – Threatened Flora

Criteria	Assessment against significance criteria Bailey's cypress (*Callitris baileyi*)	Assessment against significance criteria Swamp tea-tree (*Melaleuca irbyana*)
Lead to a long term decrease in the size of a local population of the species	*Callitris baileyi* has been recorded within the Ecology study area (in 1987) within 500 m from the rail corridor. Although this is a reliable specimen backed record the location data indicates this record is from further north of the Ecology study area in the area of The Bluff (west of Rosewood). More recent records (2009 and 2019) occur to the north and south of the Ecology study area in the Little Liverpool Range. A recent record (2019) occurs 500 m north of the ecology study area to the north of Helidon. A total of 28.40 ha of general habitat for the species is estimated to be within the Project disturbance area. Many specimen backed records occur in the surrounding area (largely east of Laidley) which will not be disturbed by the Project. The Project will follow an area that has encountered previous disturbance (existing road). Whilst records exist within the ecology study area there are none from within the Project disturbance area. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' distribution it likely that the Project will only have a minor impact on a local distribution. The Project is not expected to lead to a long term decrease in the size of a local population.	A single specimen of *Melaleuca irbyana* has been recorded within the Ecology study area during Project surveys. A total of 124.35 ha of general habitat and 4.43 ha of essential habitat considered suitable for the species is estimated to be within the Project disturbance area. This species is known to occur widely to the east and south-east of the Project. Vegetation communities (REs) in which the species is known to occur (RE 12.3.18, 12.3.19 and 12.9-10.27) are mapped as occurring in the Ecology study area only near Calvert. None of these areas occur within 90 m of the Project disturbance footprint. The Project will follow an area that has encountered previous disturbance (existing road). Whilst records exist within the ecology study area there are none from within the Project disturbance area. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' distribution it likely that the Project will only have a minor impact on a local distribution. The Project is not expected to lead to a long-term decrease in the size of a local population.
Reduce the area of occurrence of the species	The Project area is estimated to contain 28.40 ha of general habitat considered suitable for the species. There is potential for this species to occur within the Project area and it is likely that the Project will reduce the area of occupancy of the species but only to a minor extent.	The Project area is estimated to contain 124.35 ha of general habitat and 4.43 ha of essential habitat considered suitable for the species. In addition, a single specimen was identified and there is potential for additional specimens of this species to occur within the Project disturbance footprint. The Project will reduce the area of occupancy of the species.
Fragment an existing population	The Project area comprises of 28.40 ha of general habitat for the species representing only a minor proportion of the range of occurrence. Specimen backed records indicate that the areas to the north of the Project could be considered suitable habitat for the species along with areas to the south. The landscape in which the Project occurs is already highly fragmented. The Project predominantly impacts heavily disturbed (unsuitable) lands and is co-located with existing rail infrastructure for much of its length. Regardless of the linear nature of the Project it is unlikely to fragment existing populations and there will be large areas of suitable lands left undisturbed by the Project. The Project is considered unlikely to fragment an existing population.	The Project area comprises 124.35 ha of general habitat and 4.43 ha of essential habitat considered suitable for the species. In addition, a single specimen was identified and there is potential for additional specimens of this species to occur within the Project disturbance footprint. The landscape in which the Project occurs is already highly fragmented. The Project predominantly impacts heavily disturbed (unsuitable) lands and is co-located with existing rail infrastructure for much of its length. Regardless of the linear nature of the Project, it is unlikely to fragment existing populations and there will be large areas left undisturbed by the Project. The Project is considered unlikely to fragment an existing population.

Criteria	Assessment against significance criteria Bailey's cypress (*Callitris baileyi*)	Assessment against significance criteria Swamp tea-tree (*Melaleuca irbyana*)
Result in genetically distinct populations forming as a result of habitat isolation	*Callitris baileyi* has been recorded within the Ecology study area previously (1987) within 500 m from the rail corridor, although location data indicates this may be erroneous. More recent records (2009 and 2019) occur north and south of the ecology study area. A total of 28.40 ha of general habitat for the species is estimated to be within the Project disturbance area. Many specimen backed records occur in the surrounding area which will not be disturbed by the Project. The landscape in which the Project occurs is already highly fragmented. The Project predominantly impacts heavily disturbed (unsuitable) lands and is co-located with existing rail infrastructure for much of its length. Whilst records exist within the ecology study area there are none from within the Project disturbance area. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' distribution it likely that the Project will only have a minor impact on a local distribution. The project is not likely result in genetically distinct populations forming as a result of habitat isolation	*Melaleuca irbyana* has been recorded within the Ecology study area. A total of 124.35 ha of general habitat and 4.43 ha of essential habitat considered suitable for the species is estimated to be within the Project disturbance area. This species is known to occur widely to the east of the Project disturbance footprint. The landscape in which the Project occurs is already highly fragmented. The Project predominantly impacts heavily disturbed (unsuitable) lands and is co-located with existing rail infrastructure for much of its length. Whilst records exist within the ecology study area there are none from within the Project disturbance area. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' distribution it likely that the Project will only have a minor impact on a local distribution. Given the species is well represented to the east of the Project disturbance footprint, this project is not likely result in genetically distinct populations forming as a result of habitat isolation.
Result in invasive species that are harmful to a vulnerable species becoming established in the species habitat	Future works for the Project will require a Project Biosecurity Management Plan covering both construction and operation activities. Measures will be taken as outlined in the Plan incorporating mitigation measure to control the introduction and spread of weed pest species across the Project area. The local landscape is already subject to extensive weed infestation with *Lantana camara* commonly observed within the Project area in November 2019 survey. The Plan will be in place for the life of the Project and will minimise the potential for weed invasion. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.	
Introduce disease that may cause the population to decline	The Project Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.	
Interfere with the recovery of the species	No State recovery plan exists for *Callitris baileyi*. Any loss of suitable habitat for this species would limit its chance to extend its range and would result in further restriction of its occurrence. The estimate removal of 28.40 ha of general habitat may interfere with the recovery of this species locally.	No State recovery plan exists for *Melaleuca irbyana*. Any loss of suitable habitat for this species would limit its chance to extend its range and would result in further restriction of its occurrence. The estimated removal of 124.35 ha of general habitat and 4.43 ha of essential habitat may interfere with the recovery of this species locally.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations could be considered as small populations at risk of local extinction. There is a high likelihood that this species is going to be encountered during vegetation clearing for the Project given there are specimen backed records from within the Project alignment. Even though there is a high likelihood that this species will be impacted by clearing activities the number of individuals in the local area would not be considered as a population at risk of local extinction based on the number of specimen back records.	Ecologically significant locations could be considered as small populations at risk of local extinction. There is a high likelihood that this species is going to be encountered during vegetation clearing for the Project given there are specimen backed records from within the Project alignment. Even though there is a high likelihood that this species will be impacted by clearing activities the number of individuals in the local area would not be considered as a population at risk of local extinction based on the number of specimen back records.

Criteria	Assessment against significance criteria Bailey's cypress (*Callitris baileyi*)	Assessment against significance criteria Swamp tea-tree (*Melaleuca irbyana*)
Assessment of potential for significant residual impacts	The Project will result in the clearance of 28.40 ha of general habitat suitable for *Callitris baileyi* which has the potential to reduce the area of occurrence for the species locally. Historical records for this species indicate that although its range is restricted it is quite common where suitable habitat occurs. **Project has potential to cause a 'significant residual impact' on this species**	The Project will result in the clearance of 124.35 ha of general habitat and 4.43 ha of essential habitat for *Melaleuca irbyana* which has the potential to reduce the area of occurrence for the species locally. Historical records for this species indicate that although its range is restricted it is quite common where suitable habitat occurs. **Project has potential to cause a 'significant residual impact' on this species**

Table 5.14 **Matters of state environmental significance significant residual impact criteria – Threatened Fauna (Glossy-black cockatoo and Powerful owl)**

Criteria	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Powerful owl)
Lead to a long term decrease in the size of a local population of the species	The species was not recorded during Project surveys. There is a single database record from 1989 within the ecology study area at the western section of the alignment near Helidon. A single record occurs to the south of the ecology study area south of Gatton, dated 2002. Numerous records (including recent) occur in the areas of Toowoomba Range, Helidon Hills and Main Range National Park. Several records exist to the east between Rosewood and Brisbane with scattered records to the north throughout D'Aguilar National Park. The nearest of these occur within approximately 15 km of the Project disturbance footprint (AoLA 2020). There is a predicted 45.11 ha of general habitat for the species within the Project disturbance footprint. This is a conservative estimate based on predictive mapping and may be a substantial overestimate of the actual habitat available for the species. Given the extant database records the species is likely to occur along the Toowoomba Range and in the Helidon Hills. They feed almost exclusively on the seeds of species of she-oaks. In the Project area they will feed on *Allocasuarina litoralis* and *Casuarina cunninghamiana*. Feeding areas are often restricted, showing a strong fidelity to particular trees. This species can travel 10 km from roosting or nesting sites to feed trees and require large hollow trees for nesting (Glossy Black Conservancy 2010). There is substantial remnant and regrowth vegetation surrounding the Project in the Lockyer Reserves, Toowoomba Range and Main Range where there is a number of species records across the wider area. As such there will be substantial suitable habitat for the species in the surrounds that will not be disturbed by the Project. Threatening processes for Glossy black-cockatoo include loss of hollow bearing trees and inappropriate fire regimes impacting habitat areas. The Project has adopted species specific habitat measures regarding the retention/avoidance of large tree hollows suitable for breeding purposes (refer Table 5.2). It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also provide access to otherwise inaccessible areas during a bushfire event. It is uncertain how many, or if any individuals may use habitat within the Project disturbance footprint. The need for large hollow bearing trees and *Allocasuarina/Casuarina* food trees indicated that a reduction of these resources has the potential to reduce suitable habitat for the species. Nevertheless, given the relatively small area that will be impacted within the Project disturbance area compared to the extensive similar habitat remaining in the surrounding area, it is considered unlikely the Project will have a major impact that would lead to a long term decrease in the size of a local population.	Numerous records exist for Powerful owl throughout Toowoomba Range and Lockyer Reserves to the west of north-west of the Project disturbance footprint dated between 1997 and 2019. The closest of these records exists approximately 5 km from the alignment to the north of Gatton. To the east several records exist between Marburg and Rosewood dated 1986 to 1987 with a number of records between the Teviot Range and D'Aguilar National Park. To the south records occur within and around Main Range National Park (AoLA 2020). There is a predicted 28.63 ha of general habitat for the species within the Project disturbance footprint. Given the extant database records the species is likely to occur in surrounding reserves and national parks near Toowoomba, north of Gatton, north and south of Ipswich and near Main Range to the south. This species depends on medium to large arboreal prey items including Brush-tailed and Ring-tailed possums and Greater gliders foraging within treed areas (Kavanagh 1997). This species requires large tracts of old forest for nesting habitat with a pair occupying and defending an all-purpose territory year-round (Kavanagh 1997). There is substantial remnant and regrowth vegetation surrounding the Project around Toowoomba and north of Helidon and Gatton where there is a number of species records across the wider area. As such there will be substantial suitable habitat for the species in the surrounds that will not be disturbed by the Project. Threatening processes for Powerful owl include habitat fragmentation, inappropriate fire regimes and predation of chicks by feral predators (OEH 2017c). The landscape in which the project is located is already heavily fragmented. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also provide access to otherwise inaccessible areas during a bushfire event. The Project Biosecurity Management Plan will control pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. It is uncertain how many, or if any individuals may use habitat within the Project disturbance footprint. The need for large hollow bearing trees within a bushland setting indicates that a reduction of mature trees has the potential to reduce suitable habitat for the species. it is considered possible that the Project may have a significant impact that could lead to a long term decrease in the size of a local population.

Criteria	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Powerful owl)
Reduce the area of occurrence of the species	The Project area is estimated to contain 45.11 ha of general habitat considered suitable for the species although this is likely to be a substantial overestimate. There are extensive areas adjacent to the south, west and north-west of the Project disturbance footprint in the Main Range and Toowoomba Range areas that would comprise suitable habitat for the species. It is likely that the species occurs in these areas given the specimen backed records. There is potential for the Project to reduce the area of occupancy of the species but only to a very minor extent given the availability of habitat in the local area.	The Project area is estimated to contain 28.63 ha of general habitat considered suitable for the species. There is substantial remnant and regrowth vegetation surrounding the Project around Toowoomba, north of Helidon and Gatton and in the Little Liverpool Range. There are several species records across the wider area, mainly to the east and west of the Project. There is potential for the Project to reduce the area of occupancy of the species.
Fragment an existing population	The Project area is estimated to contain 45.11 ha of general habitat considered suitable for the species although this is likely to be a substantial overestimate. There are extensive areas adjacent to the south, west and north-west of the disturbance footprint in the Main Range and Toowoomba Range areas that would comprise suitable habitat for the species. The linear nature of the Project could fragment existing populations; however, this is an avian species and highly mobile. The Project is considered unlikely to fragment an existing population.	The Project disturbance footprint is estimated to contain 28.63ha of general habitat considered suitable for the species. There are large areas of similar habitat adjacent to the Project that would be considered suitable habitat for the species. The linear nature of the Project could fragment existing populations; however, this is an avian species and highly mobile. The Project is considered unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The Project area is predicted to contain 45.11 ha of general habitat considered suitable for the species although this is likely to be a substantial overestimate. There are extensive areas adjacent to the east and west of the disturbance footprint in the Inglewood area that would comprise suitable habitat for the species. Although the Project is linear this is an avian species and highly mobile. The Project will not result in habitat isolation occurring on a local population of the species.	The Project disturbance footprint is estimated to contain 28.63 ha of general habitat considered suitable for the species. Although the Project is linear this is an avian species and is highly mobile. The Project is not likely to result in habitat isolation occurring on a local population of the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the species habitat	Future works for the Project will require a Project Biosecurity Management Plan covering both construction and operation activities. Measures will be taken as outlined in the Plan incorporating mitigation measure to control the introduction and spread of weed pest species across the Project area. The local landscape is already subject to extensive weed infestation with *Lantana camara* commonly observed within the Project area in November 2019 survey. The Plan will be in place for the life of the Project and will minimise the potential for weed invasion. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.	
Introduce disease that may cause the population to decline	The Project Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.	

Criteria	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Powerful owl)
Interfere with the recovery of the species	There is no State recovery plan for Glossy Black-cockatoo. The Project disturbance footprint comprises a maximum of 45.11 ha of general habitat suitable for roost/foraging for the species, which is likely to be an overestimate. There are no known nest sites within the ecology study area. There is abundant similar habitat in the surrounding area. The Project is considered unlikely to interfere with the recovery of the species.	A NSW State recovery plan for large forest owls, which includes Powerful owl is available, however there is no recovery plan in QLD. The Project disturbance footprint is estimated to contain 28.63 ha of general habitat considered suitable for the species. The species distribution extends from northern Queensland to southern New South Wales extending west into South Australia (AoLA 2020). There is abundant similar habitat in the surrounding area for this species. The Project will not interfere with the recovery of the species.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations include large tree hollows in which this species relies on for breeding and preferred *Allocasuarina/Casuarina* food trees. Given that this species has an affinity for particular food trees the loss of any trees could be considered a disruption to an ecologically significant location. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher, including pre-clearing habitat to identify evidence of Glossy-black cockatoo feeding evidence and potential habitat features (such as large tree hollows). Nevertheless, the Project has potential to disrupt an ecologically significant location.	Ecologically significant locations include large vertical tree hollows in which this species relies on for breeding (Kavanagh 1997). The removal of any large hollow bearing trees could be considered a disruption to an ecologically significant location. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher, including pre-clearing habitat to identify potential habitat features (such as large tree hollows). The Project has potential to disrupt an ecologically significant location.
Assessment of potential for significant residual impacts	The Project will result in the clearance of 45.11 ha of general habitat suitable for Glossy-black cockatoo which has potential to reduce the area of occurrence of the species. The Project also has potential to disrupt an ecologically significant location (large tree hollows and food trees). **Project has potential to cause a 'significant residual impact' on this species**	The Project is estimated to result in the clearance of 28.63ha of general habitat suitable for Powerful owl which has potential to reduce the area of occurrence of the species. The Project also has potential to disrupt an ecologically significant location (large tree hollows and foraging areas). **Project has potential to cause a 'significant residual impact' on this species**

Table 5.15 Matters of state environmental significance Guideline criteria – Special Least Concern species (Short-beaked echidna and Platypus)

Criteria	Assessment against significance criteria (Short-beaked echidna)	Assessment against significance criteria (Platypus)
Lead to a long term decrease in the size of a local population of the species	Echidna has been recorded from within the Project disturbance footprint to the north-east of Helidon where the alignment intersects Seventeen Mile Road (2015). The next closest database record occurs within 2 km south of the Project disturbance footprint at Helidon (2002). Numerous records occur within the surrounding landscape throughout the alignment. The Project comprises 75.71 ha of general habitat for the species. This is a wide-ranging species which occurs all over Australia in most habitats. Echidnas have ranges observed between 21 and 93 ha and are able to live anywhere that provides a good supply of ants and termites (AoLA 2020). There is extensive suitable habitat surrounding the Project, particularly in bushland remnants around the Lockyer Reserves and Toowoomba Range, which will remain undisturbed. The species is threatened by habitat loss, road mortality and predation by feral predators (mainly dogs) (NPWS 1999). Pre-clearance surveys will be carried out where suitable habitat for this species is identified within the final temporary construction disturbance footprint. Should the species be found individuals will remain undisturbed and allowed to leave the construction area of their own volition or be relocated from the area of disturbance by qualified fauna spotter-catchers. The Project Biosecurity Management Plan will control pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The Project will largely impact lands already subject to extensive disturbance from agriculture and grazing. Whilst record exists within the Project disturbance footprint the area of predicted habitat that will be removed is relatively minor compared to the species' distribution. The impact on a local individual's home range would be minor and is not likely to lead to a long term decrease in the size of a local population.	There are two records of Platypus between Gatton and Laidley, one within the ecology study area and one within the Project disturbance footprint where the alignment meets Sandy Creek. Neither of these occurrences have dates available creating uncertainty in their reliability. The same is true for a record approximately 2 km south of the Project disturbance footprint at Laidley. The nearest record with a date occurs approximately 2 km south of the Project disturbance footprint at Helidon, however this is an old record (1876). The most recent records (2014 and 2015) within proximity to the Project disturbance footprint occurs within approximately 5 km of the alignment south-east of Helidon where Lockyer Creek intersects Flagstone Creek Road. Several records occur upstream of the Project on Lockyer Creek, the closest (1996) approximately 3 km north-west of the Project disturbance footprint and three other records (1975-2011) approximately 15 km away. Threats to the species include loss of habitat through land clearing and installation of dams, predation by feral predators, entanglement in fishing gear and litter, aquatic habitat degradation (OEH 2018b). The Project is very unlikely to lead to loss of habitat and will not lead to permanent instream (dam or causeway) structures. Aquatic habitat disturbance/degradation will be temporary (during construction) and mitigated against, particularly through erosion and sediment control measures (refer Table 5.2). The Project Biosecurity Management Plan will control pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The disturbance footprint comprises 47.77 ha of general habitat for the species. This is a conservative estimate based on predictive mapping and is very likely a substantial overestimate of the actual habitat available for the species. The project will cross the Lockyer Creek, Sandy Creek and Western Creek, including minor waterways the Project will cross 25 waterways in total. Construction disturbance at crossings will be temporary and localised. The project will not create flow disturbance or create new impoundments when construction is finished. The Project will not lead to a long term decrease in the size of a local population.
Reduce the area of occurrence of the species	The Project area is estimated to contain 75.71 ha of general habitat considered suitable for the species. This is a wide-ranging species which occurs all over Australia and in most habitats. The Project is not considered likely to reduce the occurrence of the species and it is likely that the species occurs in the area given the specimen backed records. There is potential for the Project to reduce the area of occupancy of the species but only to a very minor extent.	The disturbance footprint comprises 47.77 ha of general habitat for the species. This is a conservative estimate based on predictive mapping and is very likely a substantial overestimate of the actual habitat available for the species. The species is likely only present in the Lockyer Creek catchment. Impacts to waterways will be temporary and restricted to construction of crossing structures. The Project is not expected to reduce the area of occupancy of the species.

Criteria	Assessment against significance criteria (Short-beaked echidna)	Assessment against significance criteria (Platypus)
Fragment an existing population	The Project area comprises 75.71 ha of general habitat for the species. There are extensive areas surrounding the Project comprising suitable habitat for the species. This species is wide ranging and is able to live in a variety of habitats as long as food is available. Given the linear nature of the Project and the fact this is a terrestrial species there is potential to fragment a local population either side of the alignment. Nevertheless, the final design of the Project will incorporate fauna-friendly crossing structures allowing passage across the alignment. The Project is considered unlikely to fragment an existing population.	The species is likely only present in the Lockyer Creek catchment. The project will cross the Lockyer Creek, Sandy Creek and Western Creek, including minor waterways the Project will cross 25 waterways in total. Construction disturbance at crossings will be temporary and localised. The project will not create flow disturbance or create new impoundments when construction is finished. The Project will not fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The Project disturbance footprint comprises of 75.71 ha of general habitat for the species. There are extensive areas to the north and west of the Project that comprise suitable habitat for the species. This species is wide ranging and is able to live in a variety of habitats as long as food is available. Given the linear nature of the Project and the fact this is a terrestrial species there is potential to fragment local population either side of the alignment. Nevertheless, the final design of the Project will incorporate fauna-friendly crossing structures allowing passage across the alignment. The Project is considered unlikely to cause fragmentation such that genetic isolation of populations will occur.	The species is likely to be only present in the Lockyer Creek catchment. The project will cross the Lockyer Creek and Sandy Creek. Including minor waterways and waterways in the Bremer River catchment (Western Creek) the Project will cross 25 waterways in total. Construction disturbance at crossings will be temporary and localised. The project will not create flow disturbance or create new impoundments when construction is finished. The Project will not cause fragmentation such that genetic isolation of populations will occur.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations include ground timber such as hollow logs in which the species may utilise for feeding, refuge and reproduction. This species has potential to be encountered during vegetation clearing for the Project. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher during clearing, including pre-clearing surveys to investigate potential habitat features. Individuals will be translocated to suitable habitat away from the works area. The Project is unlikely to disrupt an ecologically significant location to the extent a significant impact is likely to occur on the species.	Ecologically significant locations for this species include streambank burrows which the species uses for breeding and resting. Mitigation measures during construction disturbance will include pre-clearing surveys to investigate potential Platypus presence and burrows within and in the vicinity of crossing areas. Individuals will be translocated or encouraged to move away from the works area. Platypus is known to have home ranges well over 2.5 km and will use multiple burrows. The Project is considered unlikely to disrupt an ecologically significant location to the extent a significant impact is likely to occur on the species.
Assessment of potential for significant residual impacts	**Project is unlikely to cause a 'significant residual impact' on this species**	**Project is unlikely to cause a 'significant residual impact' on this species**

5.4 Biodiversity offsets

Residual impacts are those impacts that remain after the successful implementation of the avoidance hierarchy and mitigation measures (refer Section 5.2). The significance of residual impacts reflects the effectiveness of the proposed mitigation measures but allows for the identification of areas where further management measures may be required.

Although sensitive environmental receptors will be avoided where practicable and potential impacts will be minimised and mitigated to the greatest extent practical (refer Section 5.2), in some instances the magnitude and significance ratings will remain unchanged following the implementation of the mitigation measures.

There is the potential for some Project activities to have a cumulative, irreversible and/or permanent impact upon some terrestrial and aquatic l Sensitive environmental receptors, even after the implementation of all mitigation measures, including rehabilitation. Significant impact assessment for MNES (non-threatened migratory species) in accordance with the MNES significant impact guidelines is presented in Section 5.3.3.

A '*significant impact'* is defined as '*an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts*' (DotE 2013).

Significant impact assessment for non-threatened migratory species potentially impacted by the Project indicated that significant impacts are unlikely to occur for these species. As such the provisions of offsets for non-threatened migratory species as listed under the EPBC Act is not required under the EPBC Act Offsets Policy.

For MSES, impacts to prescribed matters that are considered to constitute significant residual impacts will need to be offset in accordance with the Offsets Act. The Environmental Offsets Regulation 2014 (Qld) and associated Queensland Environmental Offsets Policy 2017 (henceforth referred to as the Offsets policy), provides guidance related to the offsets related to MSES. The purpose of the Offsets policy is to provide a decision-support tool to enable administrating agencies the ability to assess offsets proposals to ensure that they meet the requirements of the Offsets Act.

Assessment of MSES prescribed matters has been undertaken in accordance with the MSES significant impact criteria (refer Section 5.3.4). Analysis indicates that residual impacts for the following Sensitive environmental receptors occur:

- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature)
- Essential Habitat (EH)

Protected wildlife habitat for the following species:

- Bailey's cypress (*Callitris baileyi*)
- Swamp tea-tree (*Melaleuca irbyana*)
- Glossy-black cockatoo (*Calyptorhynchus lathami*)
- Powerful owl (*Ninox strenua*)

A summary of the volume of anticipated significant residual impacts is provided in Table 5.16.

In order to mitigate the residual impacts to the sensitive environmental receptors identified above, environmental offsets will be required. ARTC's Environmental Offset Delivery Strategy – Qld (Strategy) is contained as Appendix J within this report. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans.

Table 5.16 Quantification of anticipated significant residual impacts

Sensitive environmental receptor	Identified Significant residual Impact following assessment against the SRI guidelines (refer Sections 5.3.3 and 5.3.4)
Regulated vegetation	
a prescribed RE (Category B other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature	0.77 ha
Essential Habitat (EH)	95.66 ha
Wetlands	
wetland or watercourse in high ecological value (HEV) waters	6.44 ha
Protected wildlife habitat	
Flora	
Bailey's cypress (*Callitris baileyi*)	28.40 ha
Swamp tea-tree (*Melaleuca irbyana*)	128.78 ha
Fauna	
Glossy-black cockatoo (*Calyptorhynchus lathami*)	45.11 ha
Powerful owl (*Ninox strenua*)	28.63 ha

An Environmental Offset Delivery Plan will be developed and implemented by ARTC prior to construction. The Environmental Offset Delivery Plan will quantify the significant residual impacts of the Project and detail offsets to address these significant residual impacts.

The Environmental Offset Delivery Plan will:

- Quantify the significant residual impact of the Project on MSES and MNES
- Detail offsets to address significant residual impacts for MSES (except where those matters are also significant residual impacts on MNES)
- Detail offsets to address significant residual impacts for MNES
- Include:
  - Details of milestones to establish the offset
  - Evidence that significant residual impacts can be offset
  - The offset delivery mechanisms, comprising one or more of: land-based offsets, direct benefit management plans, offset transfers or offset payments
  - Identification of land required to provide the offset
  - A legally binding mechanism that ensures protection and management of land-based offset areas.

6 Commitments

The approach outlined in this report is adequate to address sensitive environmental receptors relevant to the Project. The report describes aspects of the environment relevant to these matters and addresses the relevant sections of the Project EIS ToR.

As the Project moves into the detailed design and construction phases, more focused and comprehensive ecological surveys in accordance with the Commonwealth's and Queensland's survey guidelines will be undertaken under the Project's Flora and Fauna Sub-plan. Ecological survey plans (e.g. targeted fauna and flora surveys, vegetation mapping verification) have been developed, with on-ground surveys to commence in Q2/Q3 2021. The surveys will aim to confirm and map out terrestrial and aquatic habitat, vegetation communities and extant threatened populations, along with known threats within and adjacent to the Project disturbance footprint.

The surveys will aim to address any changes to the Project design and footprint, along with informing the design and construction, including specific measures to avoid, mitigate, minimise impacts on a sensitive environmental receptors, along with ongoing monitoring activities.

The surveys will also have the added benefit in addressing some of the recommendations in conservation advices, recovery plans and threat abatement plans including:

- Surveys may identify extent and quality of habitat
- Identify new populations and knowledge of the species ecology
- Surveys may be designed to monitor known populations for certain species
- The Project is also a mechanism to engage the public about a species.

As part of these surveys, ARTC will look to collaborate and supplement existing studies being undertaken by local councils, environmental groups and government agencies.

During detailed design ARTC will also finalise the location and design of fauna movement structures across Project alignment, targeting key locations. ARTC will work with the relevant stakeholders including DTMR, local councils, DES and where applicable local environmental groups to finalise the location and design of any crossing structures. This will be especially important in areas of future development or complementary to any ecological corridor strategies within the ecology study area.

Environmental offsets will be provided where Project works are found to have a significant residual impact on flora and fauna that are matters of national or State environmental significance following the results of the targeted surveys for MNES species outlined above.

A Preliminary Environmental Offset Delivery Plan (PEODP) will be prepared in consultation with DES/DAWE prior to construction. The PEODP will detail the following (at a minimum):

- Quantifies the significant residual impact of the Project on matters of State environmental significance
- Quantifies the significant residual impact of the Project on matters of national environmental significance
- Quantifies habitat values of lands associated with matters of national environmental significance requiring offsets as per the relevant assessment guidelines and details the required quantum of offsets as per the DAWE offset calculator
- Details proposed offsets to address significant residual impacts for matters of State environmental significance (except where those matters are also significant residual impacts on matters of national environmental significance)
- Details proposed offsets to address significant residual impacts for matters of national environmental significance
- The PEODP will also include:
  - Details of milestones to establish the offset
  - Evidence that significant residual impacts can be offset

- The offset delivery mechanism(s) comprising one or more of: land-based offsets; direct benefit management plans; offset transfers and/or offset payments
- Identification of land required to provide the offset
- A legally binding mechanism that ensures protection and management of land-based offset areas.

7 Cumulative impact assessment

Cumulative impacts were assessed using the methodology identified in Section 3.6, incorporating the projects identified in Table 3.10 and depicted in Figure 3.4. Cumulative impacts were assessed using the methodology identified in Section 3.5, incorporating the projects identified in Table 3.10 and depicted in Figure 3.4.This assessment has been based on sensitive environmental receptors occurring within the disturbance footprint (refer Table 7.1).

The cumulative impacts of multiple projects occurring in the vicinity of the Project disturbance footprint will likely include the continued loss of biodiversity in the SEQ bioregion. The major potential impacts identified as a result of the Project are common to all projects throughout the region and are therefore cumulative in nature. Six projects have been identified within the Cumulative impact study area (refer Figure 3.4), which are either currently underway or are going through the EIS process, all of which will likely result in some extent of:

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

Cumulative impacts range from short-term to long-term. The total impact area of significant environmental receptors contained within the footprint of the projects occurring within the cumulative impact study area, based on bioregional and State extents, is provided in Table 7.1.

The results of the significance assessment of these cumulative impacts are presented in Table 7.2.

Table 7.1 Cumulative impacts as calculated for within the Cumulative impact study area

Sensitive environmental receptor @	A. Extent within cumulative impact study area (50km extent) (ha) (i.e. 1,256,897.35 ha)	B. Extent within cumulative impact Project disturbance footprint* (defined projects Figure 3.4) (i.e. 13,596.00 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to significant environmental receptors within Cumulative impact study area#	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance (refer Table 3.5 for magnitude criteria) considering D and E.
Commonwealth receptors (EPBC Act listed migratory species)						
Common sandpiper (*Actitis hypoleucos*)	117,370.20	1,332.74	1,413.32	1.20	5.70	Low
Fork-tailed swift (*Apus pacificus*)	1,254,287.58	10,986.29	11,620.87	0.93	5.46	Low
Sharp-tailed sandpiper (*Calidris acuminata*)	121,522.20	1,344.03	1,436.02	1.18	6.41	Low
Pectoral sandpiper (*Calidris melanotos*)	117,516.26	1,332.74	1,413.32	1.20	5.70	Low
Red-necked stint (*Calidris ruficollis*)	117,731.91	1,332.74	1,413.32	1.20	5.70	Low
Oriental Dotterel (*Charadrius veredus*)	118,392.34	1,367.67	1,466.07	1.24	6.71	Low
Oriental cuckoo (*Cuculus optatus*)	47,172.47	67.65	68.16	0.14	0.76	Low
Latham's snipe (*Gallinago hardwickii*)	139,791.00	1,665.53	1,799.41	1.29	7.44	Low
Gull-billed tern (*Gelochelidon nilotica*)	43,628.59	289.26	304.70	0.70	5.06	Low
Caspian tern (*Hydroprogne caspia*)	43,535.89	293.62	314.13	0.72	6.53	Low
Black-tailed godwit (*Limosa limosa*)	118,399.55	1,332.74	1,413.32	1.19	5.70	Low
Black-faced monarch (*Monarcha melanopsis*)	111,945.80	125.61	131.68	0.12	4.61	Low
Spectacled monarch (*Symposiachrus trivirgatus*)	73,348.82	67.65	68.16	0.09	0.76	Low
Yellow wagtail (*Motacilla flava*)	117,370.20	1,332.74	1,413.32	1.20	5.70	Low
Satin flycatcher (*Myiagra cyanoleuca*)	51,603.33	67.65	68.16	0.13	0.76	Low
Eastern osprey (*Pandion haliaetus*)	43,295.91	289.26	304.70	0.70	5.06	Low
Red-necked phalarope (*Phalarops lobatus*)	117,370.20	1,332.74	1,413.32	1.20	5.70	Low
Glossy ibis (*Plegadis falcinellus*)	150,840.86	1,654.96	1,839.64	1.22	10.04	Low
Pacific golden plover (*Pluvialis fulva*)	117,370.20	1,332.74	1,413.32	1.20	5.70	Low
Rufous fantail (*Rhipidura rufifrons*)	63,774.15	81.42	81.94	0.13	0.63	Low

Sensitive environmental receptor @	A. Extent within cumulative impact study area (50km extent) (ha) (i.e. 1,256,897.35 ha)	B. Extent within cumulative impact Project disturbance footprint* (defined projects Figure 3.4) (i.e. 13,596.00 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to significant environmental receptors within Cumulative impact study area#	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance (refer Table 3.5 for magnitude criteria) considering D and E.
Common greenshank (*Tringa nebularia*)	118,309.16	1,332.74	1,413.32	1.19	5.70	Low
Marsh sandpiper (*Tringa stagnatilis*)	121,124.66	1,344.03	1,436.24	1.19	6.42	Low
State significant ecological constraints						
Regulated vegetation (VM Act)						
Endangered remnant vegetation (REs)	25442.55	57.27	58.89	0.23	2.75	Low
Of concern remnant vegetation (REs)	104163.37	194.41	196.77	0.19	1.20	Low
Least concern remnant vegetation (REs)	78848.87	270.88	300.45	0.38	9.84	Low
High value regrowth vegetation (HVR)	78263.40	854.84	922.04	1.18	7.29	Low
Regulated vegetation (Category B) intersecting watercourses and wetlands	18,934.45	66.37	67.14	0.35	1.15	Low
Regulated vegetation (Category C) intersecting watercourses and wetlands	4,132.32	84.16	85.69	2.07	1.78	Low
MSES wildlife habitat	510018.78	1154.75	1174.59	0.23	1.69	Low
Essential habitat	302360.68	1293.94	1389.60	0.46	6.88	Low
Nature Conservation (Koala) Conservation Plan 2017 mapping						
Koala Priority Areas	189410.50	268.66	462.15	0.24	41.87	Low
Koala Habitat Areas	242603.43	1289.48	1385.10	0.57	6.90	Low
Koala Habitat Restoration Area - Koala Priority Area	43,123.54	115.8	235.30	0.55	50.79	Low
Koala Habitat Restoration Area	146,479.11	592.62	753.69	0.51	21.37	Low
Wetlands						
State significant wetlands - HEV wetlands	2,344.79	0.05	6.48	0.28	99.28	Low
Threatened flora habitat * (NC Act):						
Bailey's cypress pine (*Callitris baileyi*)	193,406.43	0.00	28.40	0.01	100.00	Low

Sensitive environmental receptor @	A. Extent within cumulative impact study area (50km extent) (ha) (i.e. 1,256,897.35 ha)	B. Extent within cumulative impact Project disturbance footprint* (defined projects Figure 3.4) (i.e. 13,596.00 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to significant environmental receptors within Cumulative impact study area#	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance (refer Table 3.5 for magnitude criteria) considering D and E.
Swamp tea-tree (*Melaleuca irbyana*)	453782.37	1584.21	1712.99	0.38	7.52	Low
Threatened fauna habitat * (NC Act):						
Birds						
Glossy black-cockatoo (*Calyptorhynchus lathami lathami*)	112,453.89	0.00	45.11	0.04	100.00	Low
Powerful owl (*Ninox strenua*)	62,071.30	0.00	28.63	0.05	100.00	Low
Least concern flora and fauna, special least concern fauna * (NC Act) and Priority Back on Track flora and fauna species						
Platypus (*Ornithorhynchus anatinus*)	93,010.69	0.00	47.77	0.05	100.00	Low
Short-beaked echidna (*Tachyglossus aculeatus*)	452,100.31	0.00	75.71	0.02	100.00	Low
Least concern flora and fauna	1,254,288.00	11,393.00	12027.29	0.96	5.27	Low
Priority Back on Track species (not listed under the EPBC Act or NC Act)	1,254,288.00	11,393.00	12027.29	0.96	5.27	Low
Biodiversity Planning Assessment (BPA)						
Local or Other Habitat Values	7660.53	89.22	99.87	1.30	10.66	Low
Regional Habitat Values	43047.85	48.55	57.65	0.13	15.78	Low
State Habitat Values	194703.43	276.94	286.56	0.15	3.35	Low
State Habitat for EVNT taxa	65637.55	156.62	159.52	0.24	1.82	Low
Regional Terrestrial Corridor	255264.39	87.86	228.67	0.09	61.58	Low
State Riparian Corridor	42630.07	903.69	926.21	2.17	2.43	Low

Table notes:

* Denotes the combined footprint of the cumulative impact projects
# Denotes the area of interest for the cumulative impact assessment, identified in Figure 3.3 as a nominal 50 km buffer from the Project.
@ Sensitive environmental receptors that are not contained within the Project area been omitted from analysis (refer Section 5.3.1).

Table 7.2 **Significance assessment of cumulative impacts within the Cumulative impact area**

Sensitive environmental receptor(s)	Potential impacts[#]	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
Commonwealth receptors (EPBC Act listed migratory species)							
Commonwealth significant Sensitive environmental receptor (migratory species listed under the EPBC Act): ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Fork-tailed swift (*Apus pacificus*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Pectoral sandpiper (*Calidris melanotos*) ▪ Red-necked stint (*Calidris ruficollis*) ▪ Oriental dotterel (*Charadrius veredus*) ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Gull-billed tern (*Gelochelidon nilotica*) ▪ Caspian tern (*Hydroprogne caspia*) ▪ Black-tailed godwit (*Limosa limosa*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Yellow wagtail (*Motacilla flava*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Eastern osprey (*Pandion haliaetus*) ▪ Red-necked phalarope (*Phalaropus lobatus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Pacific golden plover (*Pluvialis fulva*) ▪ Rufous fantail (*Rhipidura rufifrons*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) ▪ Common greenshank (*Tringa nebularia*) ▪ Marsh sandpiper (*Tringa stagnatilis*)	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects	2	2	1	3	8	Medium
	Habitat fragmentation	1	1	1	3	6	Low
	Barrier effects	1	1	1	3	6	Low
	Reduction in connectivity of biodiversity corridors	1	1	1	3	6	Low
	Fauna species injury or mortality	1	2	1	3	7	Medium
	Dust and light and contaminant disturbance	1	1	1	3	6	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State significant ecological constraints							
State Significant Ecological Constraint (VM Act): ▪ Endangered remnant vegetation (REs)	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
State Significant Ecological Constraint (VM Act): ▪ Of concern remnant vegetation (REs)	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State Significant Ecological Constraint (VM Act): ▪ Least concern remnant vegetation (REs)	Habitat loss from vegetation clearing/removal	2	3	1	1	7	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	Fauna species injury or mortality	1	1	1	1	4	Low
	Dust and light and contaminant disturbance	1	1	1	1	4	Low
	Increase in litter (waste)	1	1	1	1	4	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low
State Significant Ecological Constraint (VM Act): ▪ High value regrowth vegetation (HVR)	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	8	Medium
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State Significant Ecological Constraint (VM Act): - Regulated vegetation (Category B) intersecting watercourses and wetlands	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low
State Significant Ecological Constraint (VM Act): - Regulated vegetation (Category C) intersecting watercourses and wetlands	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	8	Medium
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State significant ecological constraint: ■ MSES wildlife habitat ■ Essential habitat	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
State significant ecological constraint (*Nature Conservation (Koala) Conservation Plan 2017*): ■ Koala Priority Areas ■ Koala Habitat Areas ■ Koala Habitat Restoration Area - Koala Priority Area ■ Koala Habitat Restoration Area	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low

Sensitive environmental receptor(s)	Potential impacts[#]	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State significant ecological constraint: ▪ State Significant High ecological value (HEV) Wetlands	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
State Significant Ecological Constraint (species listed as threatened under the NC Act): **Flora:** ▪ Bailey's cypress pine (*Callitris baileyi*) ▪ Swamp tea-tree (*Melaleuca irbyana*) **Fauna:** ▪ Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) ▪ Powerful owl (*Ninox strenua*)	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Medium

Sensitive environmental receptor(s)	Potential impacts[#]	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State significant ecological constraint: ▪ Special Least concern fauna species: – Platypus (*Ornithorhynchus anatinus*) – Echidna (*Tachyglossus aculeatus*)	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low
State significant ecological constraint: ▪ Priority Back on Track flora and fauna species (that are not listed under as threatened under the provisions of the EPBC Act or NC Act)	Habitat loss from vegetation clearing/removal	2	3	1	1	7	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	Fauna species injury or mortality	1	1	1	1	4	Low
	Dust and light and contaminant disturbance	1	1	1	1	4	Low
	Increase in litter (waste)	1	1	1	1	4	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State significant ecological constraint: ▪ Flora and fauna species not listed under the EPBC Act but listed as Least concern under the provisions of the NC Act and flora that is listed as Special least concern under the provisions of the NC Act	Habitat loss from vegetation clearing/removal	3	3	1	1	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	Fauna species injury or mortality	1	1	1	1	4	Low
	Dust and light and contaminant disturbance	1	1	1	1	4	Low
	Increase in litter (waste)	1	1	1	1	4	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low
State Significant Ecological Constraint (BPA): ▪ Local or other habitat values	Habitat loss from vegetation clearing/removal	1	3	1	1	6	Low
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	Fauna species injury or mortality	1	1	1	1	4	Low
	Dust and light and contaminant disturbance	1	1	1	1	4	Low
	Increase in litter (waste)	1	1	1	1	4	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State Significant Ecological Constraint (BPA): ▪ State habitat values for EVNT taxa	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
State Significant Ecological Constraint (BPA): ▪ State habitat values	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State Significant Ecological Constraint (BPA): ▪ Regional habitat values	Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	Fauna species injury or mortality	1	1	1	2	5	Low
	Dust and light and contaminant disturbance	1	1	1	2	5	Low
	Increase in litter (waste)	1	1	1	2	5	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	Displacement of species from invasion of weed and pest species	1	1	1	2	6	Low
State Significant Ecological Constraint (BPA): ▪ Local habitat values	Habitat loss from vegetation clearing/removal	2	3	1	1	7	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	Fauna species injury or mortality	1	1	1	1	4	Low
	Dust and light and contaminant disturbance	1	1	1	1	4	Low
	Increase in litter (waste)	1	1	1	1	4	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low

Sensitive environmental receptor(s)	Potential impacts#	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
State Significant Ecological Constraint (BPA): ■ State significant corridor	Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	Edge effects Habitat fragmentation Barrier effects Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	Fauna species injury or mortality	1	1	1	3	6	Low
	Dust and light and contaminant disturbance	1	1	1	3	6	Low
	Increase in litter (waste)	1	1	1	3	6	Low
	Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low

Table notes:

Table 3.11 defines the consequences of the impact significance ratings, as follows:

- Low (sum of relevance factors = 1 to 5): Negative impacts need to be managed by standard environmental management practices. Special approval conditions unlikely to be necessary. Monitoring to be part of general project monitoring program
- Medium (sum of relevance factors = 6 to 9): Mitigation measure likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required
- High (sum of relevance factors = 10 to 12): Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary

8 Conclusion

This report has been prepared in accordance with Sections 11.96 – 11.108 of the ToR for an environmental impact statement: Inland Rail Helidon to Calvert Project issued on 5 October 2017 by the Coordinator-General. This document has been prepared to accompany EIS Appendix J: Matters of National Environmental Significance Technical Report, which specifically addresses the EPBC Act controlling provisions of the Project (i.e. Threatened species and communities listed under the EPBC Act). Therefore, in order to avoid repetition, the EPBC Act controlling provisions of the Project have been excluded from this document. This technical report has been prepared for the purpose of supporting the EIS for the Project.

The ecology study area provides suitable habitat for eight NC Act listed conservation significant species (i.e. three plants and five animals) (non-MNES) as well as potential habitat for 22 non-threatened, migratory species as listed under the EPBC Act. In addition, several Endangered, Of concern and Least concern REs are also present within the ecology study area that are protected under the VM Act. The ecology study area contains a suite of Sensitive environmental receptors, including protected areas, HVR vegetation, conservation significant flora and fauna species regionally significant species as well as bioregional corridors (local, regional and State significant).

Fifty (50) sensitive environmental receptors were identified within the ecology study area for the purposes of this assessment. These varied from broad scale sensitive environmental receptors such as protected areas and bioregional corridors, down to finer species-scale Sensitive environmental receptors, including conservation significant and migratory species. These Sensitive environmental receptors were grouped into high, moderate and low sensitivity categories based on factors including conservation status, exposure to threatening processes, resilience and representation in the broader landscape.

The construction, operation and decommissioning of the Project has the potential to impact on ecology sensitive environmental receptors including but not necessarily limited to:

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

The nature of each unmitigated potential impact was considered in relation to the identified sensitive environmental receptors to derive an initial assessment of impact significance for the Project.

This was determined by assigning sensitivity and magnitude ratings which were then allocated a significance rating through the significance assessment matrix. The potential impacts upon the Sensitive environmental receptors were then assigned a major, high, moderate, low or negligible rating.

The proposed avoidance and mitigation measures for the Project were identified in order to reduce the significance of the potential impacts upon the sensitive environmental receptors. The mitigation strategies associated with the Project are presented in Section 5.2. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate), which included a range of mitigation measures and management plans, the impacts to the identified Sensitive environmental receptors were generally reduced.

Aside from avoidance and impact minimisation, the application of additional mitigation measures was not likely to significantly reduce impacts associated with the direct loss of vegetation/habitat through clearing/removal, resulting in a residual impact to each of the sensitive environmental receptors. Following initial impact assessment and the application of mitigation measures, each Sensitive environmental receptor (where applicable) as analysed to determine if the Project would result in Significant residual impact in accordance with the relevant Commonwealth or State significant impact guideline.

In accordance with the outcomes of the MNES significant impact guideline (refer Section 5.3.3), there are **no significant impacts expected** for the following non-threatened EPBC Act listed migratory species:

- Common sandpiper (*Actitis hypoleucos*)
- Fork-tailed swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Pectoral sandpiper (*Calidris melanotos*)
- Red-necked stint (*Calidris ruficollis*)
- Oriental dotterel (*Charadrius veredus*)
- Oriental cuckoo (*Cuculus optatus*)
- Latham's snipe (*Gallinago hardwickii*)
- Gull-billed tern (*Gelochelidon nilotica*)
- Caspian tern (*Hydroprogne caspia*)
- Black-tailed godwit (*Limosa limosa*)
- Black-faced monarch (*Monarcha melanopsis*)
- Yellow wagtail (*Motacilla flava*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Eastern osprey (*Pandion haliaetus*)
- Red-necked phalarope (*Phalaropus lobatus*)
- Glossy ibis (*Plegadis falcinellus*)
- Pacific golden plover (*Pluvialis fu*lva)
- Rufous fantail (*Rhipidura rufifrons*)
- Spectacled monarch (*Symposiachrus trivirgatus*)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*).

Assessment of MSES prescribed has been undertaken in accordance with the MSES significant impact criteria (refer Section 5.3.4). Analysis indicates that the Project is likely to result in significant residual impacts to following sensitive environmental receptors, with all remaining sensitive environmental receptors unlikely to be subject to a significant residual impacts in accordance with the MSES guidelines:

- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature): 0.77 ha
- Essential Habitat (EH): 95.66 ha
- High ecological value (HEV) waters – 6.44 ha
- Protected wildlife habitat for the following species:
  - Bailey's cypress (*Callitris baileyi*): 28.40 ha
  - Swamp tea-tree (Melaleuca irbyana): 128.78 ha
  - Glossy-black cockatoo (*Calyptorhynchus lathami*): 45.11 ha
  - Powerful owl (*Ninox strenua*): 28.63 ha

Potential predicted cumulative impacts within 50 km of the Project were assessed incorporating the footprints of six other projects. Impacts include habitat loss from vegetation clearing/removal, fauna species injury or mortality, reduction in biological viability of soil to support growth due to soil compaction, displacement of flora and fauna species due to invasion of weeds and pest species, reduction in connectivity of biodiversity corridors, edge effects, habitat fragmentation, barrier effects, noise, dust, and light impacts and increase in litter (waste) and aquatic habitat degradation.

However, the significance of the predicted cumulative impact as a result of the Project added to the seven other similar projects that occur within 50 km of the Project boundary are likely to be higher on the following environmental sensitive environmental receptors:

- EPBC Act listed, non-threatened migratory species:
  - Latham's snipe (*Gallinago hardwickii*) – Project impact makes a 7.44 per cent contribution to the clearing of approximately 1,799.41 ha (sum of cumulative impact) which constitutes 1.29 per cent of the available habitat within the cumulative impact study area
  - Pectoral sandpiper (*Calidris melanotos*), Red-necked stint (*Calidris ruficollis*), Black-tailed godwit (*Limosa limosa*), Yellow wagtail (*Motacilla flava*), Red-necked phalarope (*Phalarops lobatus*), Pacific golden plover (*Pluvialis fulva*), Common greenshank (*Tringa nebularia*) and Marsh sandpiper (*Tringa stagnatilis*) – Project impact makes a 5.70 per cent contribution to the clearing of approximately 1,413.32 ha (sum of cumulative impact) which constitutes 1.19 per cent of the available habitat within the cumulative impact study area.
- NC Act listed fauna species habitat
  - Essential habitat - Project impact makes a 6.88 per cent contribution to the clearing of approximately 1,389.60 ha (sum of cumulative impact) which constitutes 0.46 per cent of the available habitat within the cumulative impact study area
  - Category C Regulated vegetation (High Value Regrowth) - Project impact makes a 7.29 per cent contribution to the clearing of approximately 922.04 ha (sum of cumulative impact) which constitutes 1.18 per cent of the available habitat within the cumulative impact study area.

The sensitive environmental receptors identified through the EIS will be subject to further investigations and surveys during the detailed design phase to more accurately determine the magnitude of the significant residual impacts upon the identified MNES and MSES. The specific mitigation measures will then be applied to ensure that the significance ratings of any potential impacts are classified as low as is reasonably practicable. In order to mitigate the residual impacts to the sensitive environmental receptors identified above, environmental offsets will be required.

ARTC's Environmental Offset Delivery Strategy – Qld (Strategy) is contained in Appendix J of this report. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans. A Detailed Environmental Offset Delivery Plan and Offset Area Management Plans will be developed and implemented by ARTC prior to construction commencement.

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APPENDIX

I

Terrestrial and Aquatic Ecology Technical Report

Appendix A Predictive Habitat Modelling Methodology

HELIDON TO CALVERT ENVIRONMENTAL IMPACT STATEMENT

IR_1381

Inland Rail Helidon to Calvert EIS

Appendix A – Predictive habitat modelling methodology

Australian Rail Track Corporation

Reference: 3300

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1 Introduction

1.1 Background

For the purposes of the Inland Rail Program (Helidon to Calvert) (the Project) predictive habitat models for flora and fauna have been prepared. These models have been designed to map the potential areas that are likely to be analogous to habitat associated with *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth (Cth)) (EPBC Act) listed migratory species, and *Nature Conservation Act 1992* (Qld) (NC Act) listed threatened and near-threatened species. This mapping has the following objective:

- To provide predictive habitat modelling for EPBC Act listed migratory fauna species and NC Act listed threatened and near-threatened flora and fauna species to:
  - Identify areas of potential habitat
  - Facilitate the calculation of potential disturbance areas associated with the Project and to subsequently inform significant adverse residual impacts for matters of national environmental significance (MNES) and matters of State environmental significance (MSES).

This document outlines the methodology used for the development of the predictive habitat models and provides the species/community specific assumptions and mapping requirements required to reproduce the predictive habitat models for each individual species or community. The models have been used to prepare maps indicating the potential extent of each threatened / migratory species associated with the Project as identified in the Project Environmental Impact Statement (EIS) Terms of Reference (ToR), in addition to those species identified from the desktop review phase of the Project EIS.

1.2 Context

For context with respect to the methodology's compliance with EPBC Act Survey Guidelines for threatened species, the more conservative approach of this methodology surpasses the guidelines expectations. The *"How to use these guidelines"* statement includes:

"*… Alternatives to a dedicated survey may also be appropriate. For example, a desktop analysis of historic data may indicate that a significant impact is not likely. Similarly, a regional habitat analysis may be used to determine the importance of a site to the listed birds. Proponents should also consider the proposals impact in the context of the species' national, regional, district and site importance to establish the most effective survey technique(s)…"*

This methodology includes analysis of historic and current data gained from a range of sources (as listed in Table 1.1 (Section 1.3) with direct and current survey efforts including dedicated ground truthing surveys of the database mapping and follow-up ecological assessments within the project area as part of the projects geotechnical drilling survey program.

1.3 Review of existing databases and literature

Each predictive fauna habitat model has been developed to deliver a process that is robust, transparent and repeatable. The first stage in developing each of the models involved determining the extent of species occurrence and the availability of information pertaining to available species habitat.

A total of four ecological assessment reports were identified to present the MNES and NC Act values, including species protected under the EPBC Act and the NC Act within the Project ecology study area. In addition to these reports, six government databases were accessed to identify MNES and NC Act listed species and communities that have potential to occur within the Project ecology study area. These data sources are listed in Table 1.1 and Table 1.2.

Table 1.1 Database and document review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (2018 and 2020)	13/03/2020	Project footprint with 50 km buffer applied	Ongoing inspection of records of flora and fauna, including threatened species listed under the EPBC Act.
Flying Fox Monitoring Program: https://data.qld.gov.au/dataset/flying-fox-monitoring-program (DES 2020a)	24/03/2020	Project footprint within 15 km buffer applied	Show the general location of flying-fox roosts in Queensland recorded by the DES and includes camp survey data for continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Flying-fox roost monitoring and locations: https://www.ehp.qld.gov.au/wildlife/livingwith/flyingfoxes/roost-locations.html#flying_fox_roost_locations (DES 2020b)	06/02/2020	MNES study area	show the general location of flying-fox roosts in Queensland recorded by the department and include continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Birds Australia (2019)	29/03/2019	MNES study area	Records of avian fauna, including threatened species listed under the EPBC Act.
EPBC Act Protected Matters Search Tool (Australian Government 2020)	17/03/2020	MNES study area	Provides a "predictive" account of MNES identified within a specific area. Includes MNES such as world heritage properties, national heritage places or wetlands of international importance and threatened species.
Regulated Vegetation Management Map (Queensland Government 2019a)	17/03/2020	MNES study area	Mapping of REs and High Value Regrowth that provide habitat for TECs and threatened species under the EPBC Act.
Wetland Info database (DES 2019a)	17/03/2020	Impact assessment area	Provides interactive maps, species records, case studies and legislation associated with Queensland wetlands.
Wildlife Habitat Map, version (Queensland Government 2019b)	17/03/2020	MNES study area	Modelled habitat for threatened species listed under the EPBC Act.
Wildlife Online database (DES 2019a) incorporating WildNet and Herbrecs datasets	17/03/2020	MNES study area	Records of flora and vertebrate fauna including threatened species listed under the EPBC Act.
Queensland Springs Database (QLD Government 2019b)	17/03/2020	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression GDEs.
Matters of national environmental significance (QLD Government 2019c)	17/03/2020	MNES study area	Location of MNES, including: ▪ Threatened species as listed under the EPBC Act ▪ Migratory species listed under the EPBC Act ▪ TECs listed under the EPBC Act ▪ Critical habitats ▪ World Heritage Properties ▪ National Heritage Places ▪ Wetlands of International Importance (i.e. Ramsar) ▪ Great Barrier Reef Marine Park ▪ Commonwealth Marine Area ▪ Nuclear Areas.

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia	02/05/2019	Ecology study area	Records of flora and vertebrate fauna, including conservation significant species listed under the EPBC Act and/or NC Act
EPBC Act Protected Matters Search Tool (Australian Government)	02/05/2019	Ecology study area	MNES listed under the EPBC Act, such as world heritage properties, national heritage places or wetlands of international importance
Essential Habitat Map, version 4.18 (Queensland Government Dataset)	02/05/2019	Ecology study area	Essential Habitat and Essential Regrowth Habitat under the *Vegetation Management Act 1999* (Qld) (VM Act) for a conservation significant species listed under the EPBC Act and/or the NC Act
Regulated Vegetation Management Map (Queensland Government Dataset)	11/07/2019	Ecology study area	Mapping of Regional Ecosystems (REs) and High Value Regrowth that provide habitat for TECs and conservation significant species under the EPBC Act and/or NC Act
Wildlife Online database (Queensland Government)	02/05/2019	Ecology study area	Records of flora and vertebrate fauna, including conservation significant species listed under the EPBC Act and/or NC Act
Queensland Springs Database (Queensland Government Dataset)	02/05/2019	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression groundwater dependent ecosystems (GDE).

Table 1.2 Assessments and reports providing ecological information for areas associated with the Project

Document title	Reference	Summary of significant findings related to MNES
Southern Freight Rail Corridor Study (March 2010) (C2K Project study area adjacent to east of Project)	AECOM (2010)	Confirmation of the presence of the Swamp Tea-tree (*Melaleuca irbyana*) Forest of SEQ threatened ecological community (TEC) located immediately east of MNES study area Observations of Koala (*Phascolarctos cinereus*) located immediately east of MNES study area – anecdotally known to occur throughout the study area from community consultation feedback.
Australian Rail Track Corporation/Transport - Land/southwest of Ipswich/Queensland/Inland Rail Helidon to Calvert Project (EPBC referral 2017/7883)	ARTC (2017a)	Observations of Koala (*Phascolarctos cinereus*) presence (scats) – eight distinct locations along the alignment
Initial Advice Statement: Inland Rail, Helidon to Calvert – 15 February 2017.	ARTC (2017b)	Provides initial details on how the project is likely to impact upon MNES. This includes identification of the potential presence of 15 threatened species.
Inland Rail – Gowrie to Kagaru Geotechnical investigations. MNES assessment report – 23 July 2018 Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan – 31 October 2018	EMM (2018a, 2018b, 2018c, 2018d)	Confirmation of the presence of Lloyd's olive (*Notelaea lloydii*) near Laidley Observations of Koala (*Phascolarctos cinereus*) presence throughout alignment (scats and scratches)
Inland Rail – Helidon to Calvert Geotechnical investigations. MNES assessment report – 29 May 2019	Eco logical (2019a, 2019b)	No threatened species observed

In addition to the assessment of pre-existing datasets and reports identified above, the Project EIS field team has deployed a total survey effort of approximately 330 person hours (i.e. 33 field days) between September 2017 and September 2018 assessing environmental attributes associated with the Project ecology study area. Data associated with this field analysis aided in the validation and iteration of the predictive habitat mapping.

2 Species included within the predictive habitat mapping model

A total of three conservation significant flora species and five conservation significant fauna species listed under the provisions of the NC Act were identified as occurring or potentially occurring within the Project ecology study area (refer Table 2.1 and Table 2.2). All of these species have potential to occur within the ecology study area.

In addition, 25 migratory species as listed under the EPBC Act have been identified from desktop based assessments as potentially occurring within the ecology study area (refer Table 2.3). All of these species have undergone habitat modelling.

Table 2.1 Conservation significant flora species identified from database searches

Family	Species name	Common name	NC Act Status*	Data source			Likelihood of occurrence
				Wildnet	PMST	Atlas	
Cupressaceae	*Callitris baileyi*	Bailey's cypress	NT	✓	-	✓	Possible
Myrtaceae	*Melaleuca irbyana*	Swamp tea-tree	V	✓	-	✓	Possible
Myrtaceae	*Eucalyptus taurina*	Helidon ironbark	E	-	-	-	Possible

Table notes:
- = Species not listed or no common name EX = Extinct E = Endangered V = Vulnerable NT = Near threatened LC = Least concern
✓ = species present within database record within the Project ecology study area
PMST = Protected Matters Search Tool

Table 2.2 Conservation significant fauna species identified from database searches

Family	Species name	Common name	NC Act status*	Data source			Likelihood of occurrence
				Wildnet	PMST	Atlas	
Cacatuidae	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo	V	✓	-	✓	Likely
Elapidae	*Hemiaspis damelii*	Grey snake	E	-	-	✓	Possible
Ornithorhynchidae	*Ornithorhynchus anatinus*	Platypus	SLC	✓	-	✓	Possible
Strigadae	*Ninox strenua*	Powerful owl	V	✓	-	-	Possible
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	SLC	✓	-	✓	Likely

Table notes:
- = Species not listed or no common name E = Endangered V = Vulnerable SLC = Special least concern
✓ = species present within database record within the Project ecology study area
PMST = Protected Matters Search Tool

Table 2.3 Migratory fauna species identified from database searches

Family	Species name	Common name	EPBC Act status*	Data source			Likelihood of occurrence
				WildNet	PMST	Atlas	
Migratory terrestrial species							
Apodidae	*Apus pacificus*	Fork-tailed swift	M	-	-	✓	Likely
Apodidae	*Hirundapus caudacutus*	White-throated needletail	V, M	-	✓	✓	Likely
Charadriidae	*Charadrius veredus*	Oriental dotterel	M	✓	-	-	Possible
Cuculidae	*Cuculus optatus*	Oriental cuckoo	M	-	✓	-	Likely

Family	Species name	Common name	EPBC Act status*	Data source			Likelihood of occurrence
				WildNet	PMST	Atlas	
Dicruridae	*Monarcha melanopsis*	Black-faced monarch	M	-	✓	✓	Likely
Dicruridae	*Myiagra cyanoleuca*	Satin flycatcher	M	-	✓	-	Possible
Dicruridae	*Motacilla flava*	Yellow wagtail	M	-	✓	-	Possible
Dicruridae	*Symposiachrus trivirgatus*	Spectacled monarch	M	✓	✓	-	Likely
Muscicapidae	*Rhipidura rufifrons*	Rufous fantail	M	-	✓	✓	Likely
Migratory wetlands species							
Accipitridae	*Pandion haliaetus*	Eastern osprey	M	-	✓	-	Possible
Charadriidae	*Pluvialis fulva*	Pacific golden plover	M	✓	-	-	Possible
Laridae	*Gelochelidon nilotica*	Gull-billed tern	M	✓	-	-	Possible
Laridae	*Hydroprogne caspia*	Caspian tern	M	✓	-	-	Possible
Scoloacidae	*Calidris ferruginea*	Curlew sandpiper	CE, M	-	✓	-	Possible
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	M	-	✓	-	Likely
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	M	✓	✓	-	Likely
Scolopacidae	*Calidris melanotos*	Pectoral sandpiper	M	-	✓	-	Possible
Scolopacidae	*Calidris ruficollis*	Red-necked stint	M	✓	-	-	Possible
Scolopacidae	*Gallinago hardwickii*	Latham's snipe		✓	✓	✓	Likely
Scolopacidae	*Limosa limosa*	Black-tailed godwit	M	✓	-	-	Possible
Scolopacidae	*Numenius madagascariensis*	Eastern curlew	CE, M	-	✓	-	Possible
Scolopacidae	*Phalaropus lobatus*	Red-necked Phalarope	M	-	-	✓	Possible
Scolopacidae	*Tringa nebularia*	Common greenshank	M	-	✓	-	Possible
Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper	M	✓	✓	-	Possible
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	M	✓	-	✓	Possible

Table notes:

- = Species not listed or no common name M = Migratory

✓ = species present within database record within the Project ecology study area PMST = Protected Matters Search Tool

3 Predictive habitat modelling input datasets

Predictive habitat modelling was undertaken to identify and map areas that are considered to have the potential to provide habitat for the conservation significant species and communities listed in Table 2.1, Table 2.2 and Table 2.3 which have potential to occur within the Project ecology study area. This modelling provides greater certainty in predicting the likelihood of a conservation significant species occurring within the Project ecology study area.

In addition to specimen and community specific RE associations that are identified within Table 5.1, Table 5.2 and Table 5.3, additional GIS layers and field derived information have been utilised to identify areas of habitat within the Project ecology study area where applicable to a species. These layers include:

- RE datasets (Version 11) and pre-clearing regional ecosystem layers
- High resolution aerial photography with site derived datasets (i.e. utilisation of condition data, species records and general observational data pertaining to species habitat)
- Historic records of conservation significant species (derived from government databases and previous ecological investigations)
- Field derived datasets related to habitat suitability and the presence of micro-habitat features
- Topographic and geological information
- Government derived cadastral datasets
- Drainage feature datasets (Waterway barrier works mapping).

4 Predictive habitat modelling categories

4.1 Matters of National environmental significance migratory species

4.1.1 General context

Each predictive habitat model allowed partitioning of migratory fauna species using current scientific knowledge and pre-existing data derived from historic surveys and State based mapping identified above. The specific habitat assumptions for each species that were subject to predictive mapping are provided in Table 5.1.

The species-specific assumptions allowed the following areas to be identified for each threatened species:

- Unlikely habitat
- Potential habitat
- Important habitat.

The use of these habitat categories aligns with the Commonwealth Department of Agriculture, Water and Environment's (DAWE's) habitat definitions for species protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

An overview of each of these categories is provided in the sections below.

4.1.2 Unlikely habitat

Unlikely habitat consists of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species. However, it is acknowledged that these areas may provide temporary habitat for species during exceptional circumstances. It is considered that occurrences of the subject species within these areas is an anomaly as these areas are not likely to support the species in the long term.

4.1.3 Potential habitat

Potential habitat consists of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information to assess the area as Important habitat. Potential habitat also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records. Potential habitat may include areas of suboptimal habitat for species. As Potential habitat for many species may include most of the mature vegetation communities of the specific bioregion, the potential habitat category restricts the habitat to a more limited and realistic set of environmental parameters which are supported by literature and field-based observation. Species specific assumptions that define the Potential habitat category are identified in Table 5.1.

4.1.4 Important habitat

In line with DAWE's guidelines, Important habitat has been identified for migratory species under the Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act. Important habitat for migratory birds is defined in Table 2 of the Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act (Commonwealth of Australia 2015).

Species specific assumptions that define the Important habitat category for the above mentioned species is provided in Table 5.1.

4.2 Non-matters of national environmental significance flora and fauna species

4.2.1 General context

Each predictive habitat model allowed partitioning of habitat for flora and fauna species using current scientific knowledge and pre-existing data derived from historic surveys and State based mapping identified above. The specific habitat assumptions for each species that were subject to predictive mapping are provided in Table 5.2 and Table 5.3.

The species-specific assumptions allowed the following areas to be identified for each threatened species:

- Unlikely habitat
- General habitat
- Essential habitat
- Core habitat.

The use of these habitat definitions has been accepted by the Commonwealth Department of Environment and Energy (DotEE) for similar linear infrastructure project EISs (e.g. Santos Gas Field Development EIS) and negotiations with the regulators at the inception of the Project EIS has indicated that they are amenable to the use of this modelling for the Project EIS.

An overview of each of these categories for NC Act listed species is provided in the sections below. A schematic of the interaction between the habitat categories for NC Act listed species is presented in Figure 5.1

4.2.2 Unlikely habitat

Unlikely habitat consisted of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species. However, it is acknowledged that these areas may provide temporary habitat for species during exceptional circumstances. It is considered that occurrences of the subject species within these areas is an anomaly.

4.2.3 General habitat

General habitat consisted of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information to assess the area as essential or core habitat (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). General habitat also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records. General habitat may include areas of suboptimal habitat for species. Species specific assumptions that define the general habitat category are identified in Table 5.2 and Table 5.3.

4.2.4 Essential habitat

Essential habitat consists of areas containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter) or areas that have been confirmed as containing suitable habitat as identified by a specimen backed record or indirect evidence of the species (i.e. scat, trace, track, fur/feather, distinctive vocalisation or other site based evidence). Essential habitat has been defined from known records (regardless of currency), generally with a 1 km buffer or site-based observation of the species during site investigations. In addition, if the 1 km buffer from the known record intersects an area identified as general habitat the general habitat rating was elevated to essential habitat. Species specific assumptions associated with the mapping of essential habitat, and instances that deviate from the above criteria are detailed in Table 5.2 and Table 5.3.

4.2.5 Core habitat

Core habitat consists of essential habitat in which the species is known, and the habitat is recognised under relevant recovery plans or other relevant plans/policies/regulations. Where essential habitat intersects with areas identified as important within the relevant bioregion specific Biodiversity Planning Assessment (BPA), these areas have been elevated to the core habitat category. Species specific assumptions associated with the mapping of core habitat areas are detailed in Table 5.2 and Table 5.3.

5 Predictive habitat models and general assumptions associated with their development

5.1 Flora and fauna habitat models

The predictive flora habitat model for each flora and fauna species was designed to provide a dynamic, robust and predictive GIS layer that could incorporate data from scientific literature, verified government datasets, specimen backed datasets (i.e. data derived from a known/confirmed location of an observed specimen) and field identified records into a single layer that could be used to identify areas that are known, or considered to have the potential to support specific EPBC Act listed migratory species and NC Act threatened and near-threatened species. Development of these layers had the ultimate objective to:

- Predict areas that have the potential to support EPBC Act listed migratory fauna species
- Predict areas that have the potential to support NC Act listed threatened and near-threatened flora and fauna species
- Facilitate the quantification of impacts to inform later stages of the EIS process
- Facilitate the assessment of assessment of impact significance in accordance with relevant MNES and MSES significant impact criteria, policies and guidelines

The habitat modelling was created using ESRI ArcGIS, specifically the ESRI ArcGIS Model Builder which facilitated the development of scripts that allowed for the species-specific development of queries that utilised a range of GIS input datasets (e.g. vegetation communities containing site derived and filed verified information).

The models also incorporated the use of selecting relevant components and performing functions such as buffers and intersects that reflected the preferred habitat of a particular species. As a result of this process output habitat layers were generated for each species according to their individual requirements. The species-specific requirements that were used to generate the species-specific queries used to map potential habitat are identified in Table 5.1, Table 5.2 and Table 5.3 . Once produced model outputs were reviewed internally by suitably qualified and experience ecologists to assess that they accurately reflected/identified habitat suitable for supporting the relevant species. If anomalies were identified, GIS iterations were undertaken to produce outputs of greater accuracy. However, it is noted that whilst species that were identified to have potential to occur within the broader region underwent habitat modelling, the results of the modelling did not necessarily identify habitat within the Project MNES study area for all of the species modelled. Where this occurred, these species (i.e. without identified habitat within the ecology study area) did not undergo impact assessment as part of the Project EIS.

As the predictive flora and fauna habitat model mapping has been designed to identify areas of potential habitat for NC Act and/or EPBC Act listed species, several assumptions to the model have been made and derived from scientific literature and expert advice. These assumptions are outlined below.

- Heterogeneous RE polygons – Mapping has been designed to identify maximum areas of disturbance based on a precautionary approach. In the case of heterogeneous polygons, if the RE code is contained within the heterogeneous polygon, then the entire polygon is selected. This is of particular importance to species such as those that rely on limited areas of habitat, which would otherwise be missed by the model. Areas of predicted habitat may be removed from mapping if field survey indicates that habitat is not available.
- Buffers – Buffers have been used when integrating a specimen backed record into the predicted mapping. Generally, a 1 km buffer from the species data point is used (in line with the methodology adopted by the [VM Act] when identifying essential habitat derived from a specimen backed record). Deviations from this methodology (where they occur), are identified in Table 5.1, Table 5.2 and Table 5.3.

- Essential habitat / Important habitat – The predictive flora and fauna habitat mapping outlined in this document primarily proposes general habitat / potential habitat as the preferred habitat requirements for many of the species mapped. This is as a result of their habitat not being fully understood or cannot be easily extrapolated from available datasets. In most cases, site derived species records were used to extrapolate preferred habitat by correlating with the underlying GIS layer. In these instances, mapped habitat will overlap with the predicted general habitat/potential habitat, which has not been elevated to the essential habitat / Important habitat level in accordance with that adopted under the VM Act. For these species, where a species point record and associated 1 km buffer intersect with areas of predicted general habitat, the area of overlap has been elevated to the essential habitat category. In instances where essential habitat is located within an area of protection, this is elevated to core habitat or Important habitat. The relationship between general habitat, species records, essential habitat, protected areas and core habitat, is outlined in Figure 5.1.
- Use of existing specimen backed records to identify habitat associations – In instances where there was insufficient literature to confidently identify areas of potential habitat, specimen backed records were used to identify the associated vegetation association (e.g. RE type). These point-selected datasets were then assessed to determine that they were consistent with the species habitat requirements. When identified as valid, the point selected data points were incorporated into the predictive mapping "recipe" for the particular species (refer Table 5.1, Table 5.2 and Table 5.3). Point selected datasets that were not identified as being able to support the species were rejected from use in further analysis.
- Minimum areas of habitat – Mapping has been designed to identify maximum areas of disturbance and therefore no minimum area of habitat has been identified. The methodology was developed to predict areas of potential habitat. However, the resolution of the mapping is constrained by the data inputs (e.g. RE mapping) and therefore areas that may potentially be identified as habitat will always be contiguous to areas of similar habitat that reflect the minimum resolution for the input dataset (e.g. minimum RE polygon size, etc.).
- Levels of habitat mapping – General habitat/ potential habitat has primarily been indicated on the predictive mapping. However, where known population occur and were confirmed, or where habitat has been identified in a recovery plan or referral document and where it overlaps with areas of predicted general habitat / potential habitat, these areas have been elevated to essential habitat / impotent habitat in accordance with that used in relation of government mapping associated with the VM Act.

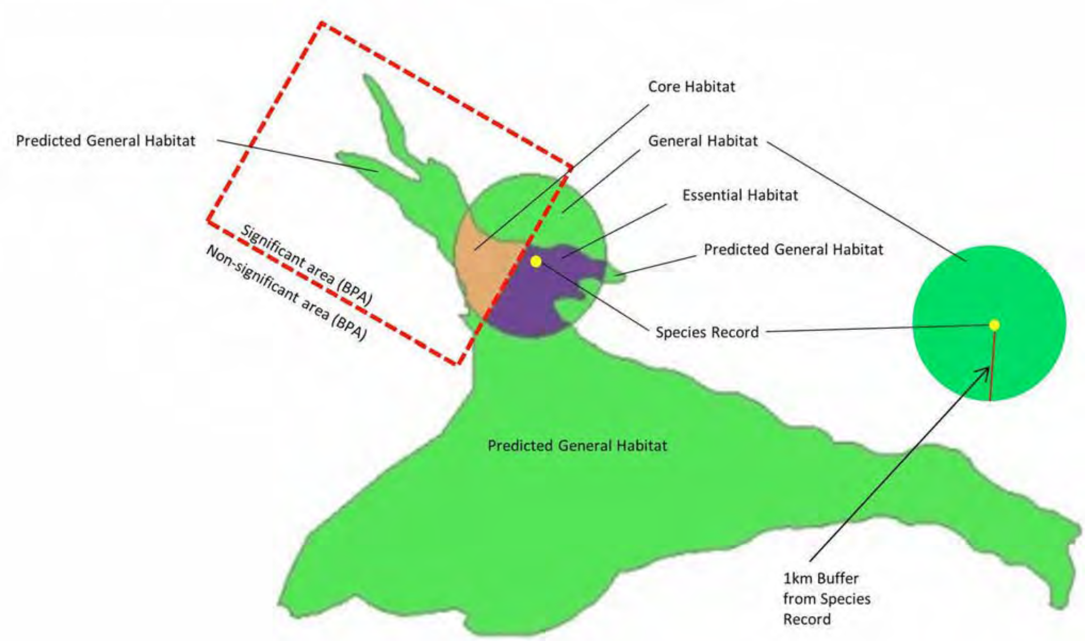

Figure 5.1 Schematic indicating the relationship between specimen backed records, predicted general habitat, essential habitat and core habitat category designations

Table 5.1 EPBC Act listed migratory species habitat assumptions used to map areas of occurrence within ecology study area

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions	
			NC Act	EPBC Act		Potential habitat	Important habitat
Birds	*Apus pacificus*	Migratory aerial species	SLC	M	Aerial insectivores, ubiquitous, rarely lands and breeds in northern hemisphere	All areas	All areas of "potential habitat" that intersect with the following is "Important habitat" ▪ Category B regulated vegetation Category C regulated vegetation
Birds	▪ Oriental cuckoo (*Cuculus optatus*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Rufous fantail (*Rhipidura rufifrons*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*)	Forest/ woodland migrants	SLC	M	This fauna group are typically found in complex habitats, including rainforests, vine thickets and wet sclerophyll forest gullies. However, during migration these species will utilise drier habitats such as riparian forests and woodlands, and larger open forest to woodland remnants with a dense understorey (Pizzey and Knight 2007).	The following is considered to be general habitat: Remnant RE within 100 m of a waterway (stream order 3 or above) BVG (5M): 1 Remnant greater than 200 ha of the following REs: 11.8.5, 11.2.5, 11.5.2, 11.5.9, 11.7.1, 11.8.13, 11.8.15, 11.12.21, 12.3.3, 12.3.19, 12.9-10.11, 12.9-10.27, 12.11.3, 12.2.14, 12.3.11 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	All areas of potential habitat associated with the following REs constitutes Important habitat: 11.8.5, 11.2.5, 11.5.2, 11.5.9, 11.7.1, 11.8.13, 11.8.15, 11.12.21, 12.3.3, 12.3.19, 12.9-10.11, 12.9-10.27, 12.11.3, 12.2.14, 12.3.11

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions	
			NC Act	EPBC Act		Potential habitat	Important habitat
Birds	▪ Yellow wagtail (*Motacilla flava*) ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Pectoral sandpiper (Calidris melanotos) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Glossy ibis (*Plegadis falcinellus*)	Wetland/ wader migrants	SLC	M	These are wetland species that associated with waterbodies, flooded paddocks and areas of inundation.	The following is considered to constitute general habitat: Lacustrine REs, lacustrine water bodies, palustrine REs, palustrine water bodies, riverine REs, riverine water bodies, estuarine REs, estuarine water bodies, marine REs and marine water bodies *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Non-breeding habitat only: mostly well-watered open grasslands and the fringes of wetlands. Roosts in mangroves and other dense vegetation. Therefore a 100m buffer around the following is considered important habitat: Lacustrine REs, lacustrine water bodies, palustrine REs, palustrine water bodies, riverine REs, riverine water bodies, estuarine REs, estuarine water bodies, marine REs and marine water bodies
Birds	▪ Osprey (*Pandion haliaetus*) - incorporating the synonym *Pandion cristata* ▪ Caspian tern (*Hydroprogne caspia*) ▪ Gull-billed tern (*Gelochelidon nilotica*)	Waterway/ Marine migrant	SLC	M	These species are found in coastal areas including beaches and estuaries. Nest trees are usually 1km from the sea (NSW OEH).	The following is considered to constitute General habitat: Lacustrine REs, Lacustrine Water bodies, Palustrine REs, Palustrine Water bodies, Riverine REs, Riverine Water bodies, Estuarine REs, Estuarine Water bodies, Marine REs and Marine Water bodies *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Bays, estuaries, along tidal stretches of large coastal rivers, mangrove swamps, coral and rock reefs, terrestrial wetlands and coastal lands of tropical and temperate Australia and off shore islands. They feed primarily in the sea or nearby estuarine waters and nest in trees (often dead or with dead tops), rocky coastlines and on artificial structures such as telecommunication towers. Ospreys are generally found on or near the coast but also range inland along large rivers, mainly in northern Australia. As such all areas of potential habitat that intersect with a wetland are Important habitat

Table notes:

M = Migratory SLC = Special least concern

Table 5.2 Listed conservation significant flora species habitat assumptions used to map areas of occurrence within Project ecology study area

Family	Scientific name	Common name	Status	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
			NC Act		General habitat	Essential habitat	Core habitat
Myrtaceae	*Melaleuca irbyana*	Swamp tea-tree	E	*Melaleuca irbyana* grows in flat areas that are periodically waterlogged, in eucalypt forest, mixed forest and *Melaleuca* woodland with a sparse and grassy understorey. It grows on poorly draining, heavy clay soils. (Byrnes 1984; Barlow 1987).	The following REs (Category B and C regulated vegetation) are considered to be general habitat: 12.9-10.11 and 12.9-10.11a, 12.9-10.27, 12.5.2x1, 12.3.18 (formally 12.3.3.c), 12.3.19, 12.3.19, 12.9-10.27 and 12.5.2x1 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Core habitat has not been mapped for this species
Myrtaceae	*Eucalyptus taurina*	Helidon ironbark	V	A medium-sized to tall ironbark tree known only from two areas in Queensland just west of Brisbane from the Helidon–Crows Nest–Gatton area and an area just south-west of Rathdowney near the Queensland–New South Wales border. *Eucalyptus taurina* grows at altitudes of 420 to 450 m asl. The species grows on ridges in shallow sandy soil derived from granite or sandstone. The main associated tree species are *Corymbia gummifera, C. trachyphloia, C. henryi, Eucalyptus baileyana, E. dura, E. helidonica*, and *Angophora woodsiana*.	The following Regional Ecosystems are considered to be General habitat when they are located at altitudes of 420 to 450 m asl: 12.5.1, 12.5.1c, 12.9-10.5, 12.9-10.5a, 12.9-10.14, 12.9-10.17, 12.9-10.20, 12.11.25, 12.11.26, 12.11.28. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute General habitat*	Any specimen backed records (buffered to a 1km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Core habitat has not been mapped for this species

Family	Scientific name	Common name	Status	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
			NC Act		General habitat	Essential habitat	Core habitat
Cupressaceae	*Callitris baileyi*	Bailey's Callitris	NT	*Callitris baileyi* grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum. (DEC 2005; Stanley and Ross 1983).	The following REs are considered to be general habitat: 12.5.13, 12.5.13b, 12.8.16, 12.8.21, 12.9-10.2, 12.9-10.7, 12.9-10.8, 12.9-10.11, 12.9-10.15, 12.9-10.17, 12.9-10.18, 12.9-10.27, 12.11.5, 12.11.5a, 12.11.5e, 12.11.6, 12.11.14, 12.11.19, 12.12.3, 12.12.5, 12.12.7, 12.12.12 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Core habitat has not been mapped for this species

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special least concern

Table 5.3 Listed conservation significant fauna species habitat assumptions used to map areas of occurrence within the Project ecology study area

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions		
			NC Act	EPBC Act		General habitat	Essential habitat	Core habitat
Birds	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo	V	-	Glossy black-cockatoo is found in open forest to woodland with *Allocasuarina littoralis, A. torulosa, A. luehmanni, Casuarina cristata*, and *C. equisetifolia (DSITI)*. This is the species sole foraging source. Large tree hollows are required for nesting.	The following RE is considered general habitat: 11.3.14, 11.3.18, 11.3.26, 11.3.32, 11.5.1, 11.5.2, 11.5.3, 11.5.4, 11.5.5, 11.5.8, 11.5.14, 11.5.18, 11.5.21, 11.7.7, 11.8.1, 11.9.13, 11.10.9, 11.10.11, 11.11.3, 11.12.13, 11.12.15, 11.3.1, 11.3.17, 11.3.28, 11.4.1, 11.4.3, 11.4.7, 11.4.9, 11.4.10, 11.5.16, 11.7.1, 11.8.3, 11.8.5, 11.8.13, 11.9.14, 11.9.5, 11.9.10, 11.11.14, 11.2.2, 12.2.14, 12.2.19b, 12.8.23, 12.9-10.6, 12.12.26, 12.2.13, 12.5.4, 12.5.9, 12.8.14, 12.8.20, 12.9-10.4, 12.9-10.9, 12.11.9, 12.11.5, 12.11.21, 12.12.7, 12.12.9, 12.12.23, 11.10.4, 11.12.5. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, State forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are core *habitat*.

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions		
			NC Act	EPBC Act		General habitat	Essential habitat	Core habitat
Birds	*Ninox strenua*	Powerful owl	V	-	The Powerful owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine (*Syncarpia glomulifera*), Black she-oak (*Allocasuarina littoralis*), Blackwood (*Acacia melanoxylon*), Rough-barked apple (*Angophora floribunda*), Cherry Ballart (*Exocarpus cupressiformis*) and a number of eucalypt species. High quality habitat generally has a high density of arboreal mammals, which are the main prey, particularly greater gliders and ringtail possums. Therefore, trees with many hollows provide higher quality habitat as they are likely to provide habitat for prey species.	The following REs are considered to be general habitat: 11.3.4, 11.3.14, 11.3.23, 11.3.25, 11.3.39, 11.8.2, 11.8.8, 11.10.2, 11.10.2a, 11.12.13b, 12.2.4, 12.2.5, 12.2.14, 12.3.2, 12.3.2a, 12.3.15, 12.5.11, 12.8.1, 12.8.8, 12.9-10.1, 12.9-10.5, 12.9-10.14, 12.9-10.14a, 12.11.1, 2.11.2, 12.11.9x1, 12.12.1, 12.12.4, 12.12.6, 12.12.6x1, 12.12.14 and 12.12.22 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Any area identified as *essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H Rating' (high or medium), 'J Rating' (Regional or State) or 'A Rating' (very high, high or medium), of any areas mapped as a national park, State forest or nature refuge area or mapped as a VDEC are *core habitat*.

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions		
			NC Act	EPBC Act		General habitat	Essential habitat	Core habitat
Mammals	*Ornithorhynchus anatinus*	Platypus	SLC	-	Platypus make their home in and near freshwater creeks, slow-moving rivers, lakes joined by rivers, and built water storages such as farm dams	The following is considered to constitute general habitat: All areas mapped as watercourses with a stream order rating of 3 and above, and lacustrine water bodies with a buffer of 100 m *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat* *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Any area identified as *essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H Rating' (high or medium), 'J Rating' (Regional or State) or 'A Rating' (very high, high or medium), of any areas mapped as a national park, State forest or nature refuge area or mapped as a VDEC are *core habitat*.
Reptiles	*Hemiaspis damelii*	Grey snake	E	-	The Grey snake is found in woodland on heavier cracking clay soils	The following REs are considered general habitat: 11.3.1, 11.3.2, 11.3.4, 11.3.5, 11.3.25, 11.4.4, 11.4.7, 11.4.9, 11.9.1, 11.9.5, 12.8.16, 12.8.17 Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute General habitat	Any specimen backed records (buffered to a 1km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, State forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions		
			NC Act	EPBC Act		General habitat	Essential habitat	Core habitat
Mammals	*Tachyglossus aculeatus*	Short-beaked echidna	SLC	-	The Short-beaked echidna is found in forests, woodlands, heath, grasslands and desert	The following is considered to be general habitat: All RE habitat (with an additional 50 m into no-remnant areas) **excluding** land zones 2 and RE 11.3.11, 11.3.40, 11.8.13, 11.10.8, 11.11.5, 11.4.1, 11.5.15, 11.7.1, 11.8.3, 11.9.4, 11.9.5, 11.10.8, 11.11.18, 11.11.21, 11.12.4, 11.12.7, 12.3.1, 12.3.16, 12.3.17, 12.3.21, 12.8.15, 12.11.1, 12.12.1, 12.5.13, 12.8.21, 12.8.22, 12.8.23, 12.9-10.15, 12.11.4, 12.11.13, 12.12.17, 12.12.18 and 12.12.26 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Any area identified as *essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H Rating' (high or medium), 'J Rating' (Regional or State) or 'A Rating' (very high, high or medium), of any areas mapped as a national park, State forest or nature refuge area or mapped as a VDEC are *core habitat*.

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special least concern

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APPENDIX I

Terrestrial and Aquatic Ecology Technical Report

Appendix B Species and Community Profiles

HELIDON TO CALVERT ENVIRONMENTAL IMPACT STATEMENT

IR_1381

Inland Rail: Phase 2 - Helidon to Calvert

Appendix B - Species and Community Profiles

Australian Rail Track Corporation

Reference: 3300

Contents

Figures

1 Flora species

1.1 Bailey's cypress pine (*Callitris baileyi*)

1.1.1 Status

EPBC Act – Not listed

NC Act – Not listed

BC Act – Endangered

1.1.2 Biology and ecology

1.1.2.1 Characteristic

Bailey's cypress pine (*Callitris baileyi*) is a tree growing to 18 m tall, with spreading or erect branches and rough greyish bark. The foliage is green, rather than bluish as with many other cypress pines (refer Photograph 1.1). The adult leaves are 2 to 5 mm long and arranged in threes, parallel with the stem. A sharp keel runs down the back of each leaf. Male and female cones occur on the same tree. Male cones are 2 to 3 mm long and are on the ends of the branchlets. Female cones are solitary on slender fruiting branchlets and are waxy, greyish-blue during development. The oblong cones measure 10 to 13 mm in diameter and the alternate scales on the cones are shorter and narrower. The central stalk of the cone is short, narrow at the base and slightly angled (Stanley and Ross 1983; OEH 2018; Harden and Thompson 2008).

Photograph 1.1 Bailey's cypress pine (*Callitris baileyi*)

Source: Miles (2017)

1.1.2.2 Known distribution

Bailey's cypress pine is found sporadically in South-east Queensland and far north NSW. It is found from around Kumbia and Yarraman to west of Brisbane down across the NSW border near Tabulum (OEH 2018) (refer Figure 1.1).

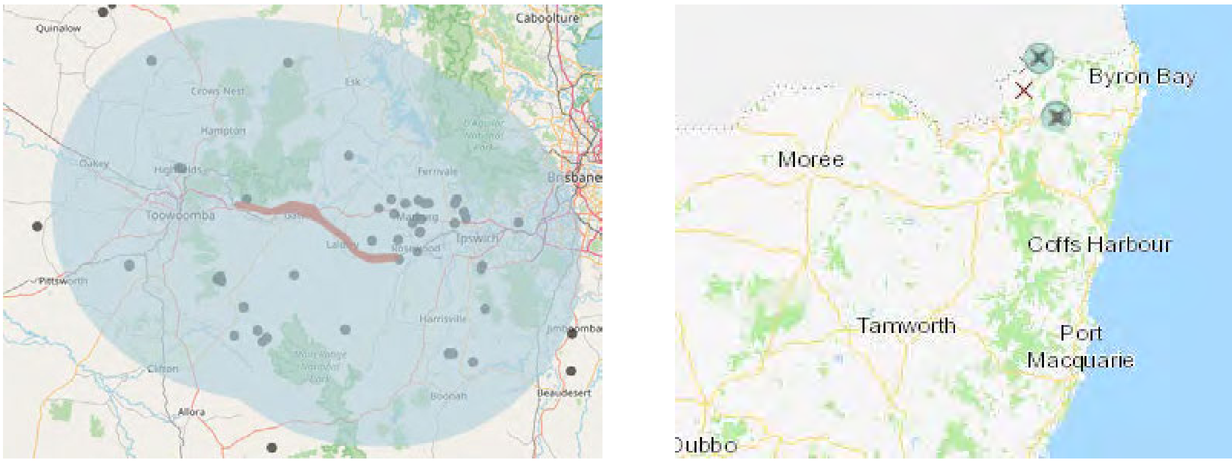

Figure 1.1 **Distribution range of the Bailey's cypress pine**

Source: ALA (2018); OEH (2019)

1.1.3 Distribution in relation to the Project

Bailey's cypress has been identified as potentially occurring within 2 km of the of ecology study area. Database records (i.e. AoLA) indicate the nearest record occurs 4 km north of Grandchester, dated 2008. A number of records exist between Hattonvale and Blacksoil. Other records exist south of the ecology study area along the main range.

1.1.3.1 Biology and reproduction

Male and female cones occur on the same tree and are recorded all year round, however not much else is known about reproduction in Bailey's cypress pine (Stanley and Ross 1983).

1.1.4 Habitat

Bailey's cypress pine grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum (OEH 2018; Stanley and Ross 1983).

1.1.5 Threatening processes

The following have been identified as potentially threatening processes to Bailey's cypress pine:

- Fire
- Risk of local extinction because population is small
- Trampling by livestock and people
- Clearing of habitat for agriculture
- Road and track maintenance works
- Grazing and disturbance by feral browsing animals (OEH 2018).

1.1.6 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from **https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=316&ReportProfileID=10131**. In effect under the BC Act 2016.

1.1.7 Summary of threat abatement/recovery plan

The conservation strategy for Bailey's cypress pine identifies two priority management sites in NSW including:

- Trough Creek in Tenterfield LGA
- Sandilands in Kyogle LGA.

Threats specific to Bailey's cypress pine identified in the strategy include:

- Current or potential future land management practices do not support conservation
- Trampling by stock
- Physical damage by campers and trail bikers
- Risk of local extinction because population is small.

Management actions outlined in the strategy include:

- Liaise with and encourage landholders to enter into agreements to maintain and enhance the species through voluntary management agreements
- In locations identified as being appropriate implement stock fencing to facilitate sustainable grazing in areas where this species occurs, particularly around cliff lines that drop to a creek
- Install locked gates providing landholder access to keep out recreational users of an area
- Survey suitable habitat and identify this species from aerial photography and historical records
- Conduct a census of the population during summer months mapping the extent of occurrence at the site and to determine if recruitment is occurring.

1.1.8 References

Atlas of Living Australia (2018). *Callitris baileyi*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890422#overview [Accessed 31 August 2018].

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Miles M. (2017). *Callitris baileyi* (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890422# [Accessed 31 August 2018].

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Stanley, T.D. and Ross, E.M. (1983). *Flora of southeastern Queensland (volume 3)*. Queensland Department of Primary Industries, Brisbane.

1.2 Helidon ironbark (*Eucalyptus taurina)*

1.2.1 Status

EPBC Act – Not listed

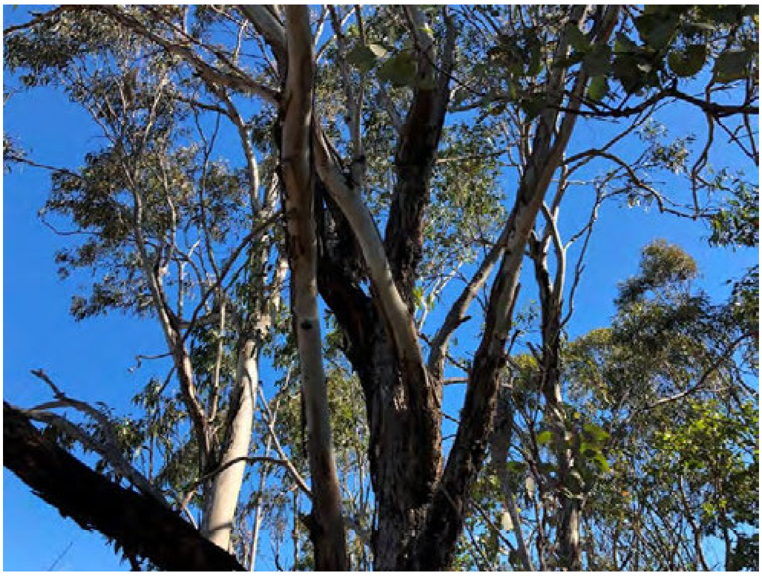
NC Act – Vulnerable

BC Act – Not listed

1.2.2 Biology and ecology

1.2.2.1 Characteristic

Shiny-leaved ironbark is a tree that grows up to 22 m tall with rough, furrowed bark to the small branches, dark grey to black, larger branches 8 cm diameter or smaller are smooth (refer Photograph 1.2). Juvenile leaves are 9-13.5 cm x 1-2.5 cm, alternate, lanceolate and strongly discolorous and not glossy. Adult leaves are 9.5-15 cm x 1.5-2.5 cm, alternate, lanceolate to narrowly lanceolate, concolourous and dull grey-green with petioles 14-18 mm long. The inflorescences are axillary in the upper leaf axils or apparently compound and terminal; formed as umbellasters, made up of 7 flowers or less if some have aborted. The peduncles are angular, 4 to 7 mm long. The pedicels are absent or up to 2 mm long. The buds are fusiform when young, becoming elliptical at maturity, 7 to 8 mm long and 3 to 3.5 mm wide. The operculum is obtuse growing to 4 by 3.5 mm. The stamens are white, inflexed and the stigma is the pinhead type. The fruits are sessile or shortly pedicellate, 5 to 6.5 mm long and 5 to 6 mm wide and obconical. The fruit disc is obscure and there are 3 to 5 exserted valves. The seeds are dark brown, dorsally reticulate, not angular, not lacunose and the hilum is ventral (Bean and Brooker, 1994).



Photograph 1.2 Helidon ironbark (*Eucalyptus taurina*) specimen.

Source: Bennett (2019)

1.2.2.2 Known distribution

Eucalyptus taurina occurs in three disjunct areas of south-eastern Queensland; north and north-east of Helidon, south of Mundubbera and east of Crows Nest. The species is found within Allies Creek State Forest, Crow's Nest Falls National Park, White Mountain State Forest, Lockyer National Park and Lockyer State Forest (Bean and Brooker 1994).

Figure 1.2 **Distribution range of Helidon ironbark**

Source: ALA (2019)

1.2.2.3 Distribution in relation to the Project

Eucalyptus taurina has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate the nearest record exists within approximately 1 km of the ecology study area at the southern end of the Lockyer Resource Reserve north of the western end of the alignment dated 1997. A number of other records exist within the Lockyer Resource Reserve between 1990 to 2005 and the Lockyer National Park (1990 to 1998). Other records exist within a 50 km buffer of the Disturbance footprint at Crows Nest to the north-west of the alignment and to the south-west near the Long Grass Nature Reserve.

Figure 1.3 **Distribution range of Helidon ironbark**

Source: ALA (2020)

1.2.2.4 Biology and reproduction

Very little is known about the biology and ecology of *E. taurina*. Flowers have been collected in October (Bean and Brooker, 1994).

1.2.2.5 Habitat

Eucalyptus taurina grows at altitudes of 420 to 450 m ASL. The species grows on ridges in shallow sandy soil derived from granite or sandstone. The main associated tree species are *Corymbia gummifera*, *C. trachyphloia*, *C. henryi*, *Eucalyptus baileyana*, *E. dura*, *E. helidonica*, and *Angophora woodsiana* (Bean and Brooker 1994).

1.2.3 Threatening processes

The following have been identified as potentially threatening processes to Helidon ironbark:

- Timber harvesting
- Disturbance of habitat during timber harvesting operations
- Loss of habitat due to vegetation clearing.

1.2.4 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as relevant for this species.

1.2.5 References

Atlas of Living Australia (2019). *Eucalyptus taurina*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2914218 [Accessed: 12 July 2019].

Bean, A.R. and Brooker, M.I.H. (1994). Four new species of ironbark (Eucalyptus L.Herit., Myrtaceae) from southern Queensland. Austrobaileya 4 (2): 189-191.

Bennett, M. (2019). Helidon ironbark (*Eucalyptus taurina*) [image] [online] Available from: https://images.ala.org.au/image/details?imageId=1cf91ad4-8c7b-496c-a41e-0823d7836703. [Accessed: 17 September 2019].

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The Herbarium Catalogue, Royal Botanic Gardens, Kew. Published on the Internet http://www.kew.org/herbcat [Accessed: on 12 July 2019].

1.3 Swamp tea-tree (*Melaleuca irbyana*)

1.3.1 Status

EPBC Act – Not listed

NC Act – Endangered

BC Act – Not listed

1.3.2 Biology and ecology

1.3.2.1 Characteristic

The Swamp tea-tree (*Melaleuca irbyana*) is a small tree growing to 8 m in height (refer Photograph 1.3). The bark is papery and white to pale brown. The leaves on the indeterminate shoots are narrowly ovate in shape, 4 to 5 mm long, 1 to 1.5 mm wide and narrow gradually to a pointed tip. The leaves on the determinate shoots are more angular-ovate in shape, 2 to 3 mm long, 1 to 1.5 mm wide, are inserted in shallow hollows on the stem and have prominent dark glands in 4 to 6 rows. The flowers are in 6 to 12 bundles of three, each 10 to 25 mm long and with 8 to 12 white or cream coloured stamens per bundle. The fruits are 3 to 3.5 mm long and 3.5 to 4 mm wide (Barlow 1987; Byrnes 1984).

Photograph 1.3 **Swamp tea-tree (*Melaleuca irbyana*)**

Source: Bennett (2017)

1.3.2.2 Known distribution

It only occurs in South-east Queensland and north eastern NSW. In Queensland it can be found in the local government areas of Beaudesert, Boonah, Logan, Ipswich, Laidley and Esk and in NSW the Casino district (ALA 2018) (refer Figure 1.4).

Figure 1.4 **Distribution range of Swamp tea-tree**

Source: ALA (2018)

1.3.2.3 Distribution in relation to the Project

Melaleuca irbyana has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area towards the eastern end of the alignment south of Bowman Park Koala Nature Refuge dated 1974. A more recent record exists from within the ecology study area west of Lanefield from 1995. Another record from 2017 exists within the ecology study area at Gatton. Other records within a 50 km buffer of the Disturbance footprint exist to the north, north-east, east and south-east of the alignment from north-east of Gatton to Harrisville and east to Brisbane.

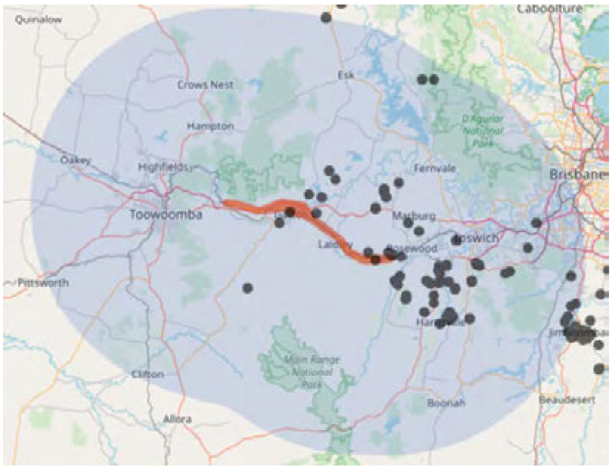

Figure 1.5 **Distribution range of Swamp tea-tree in relation to the Project**

Source: ALA (2020)

1.3.2.4 Biology and reproduction

It flowers mainly from September to January and research shows that the low survival rates and slower growth rates of seedlings in natural environments of Swamp tea-tree may contribute to explaining its original restricted distribution (Barlow 1987; Soonthornvipat 2018).

1.3.3 Habitat

It grows in flat areas that are periodically waterlogged, in eucalypt forest, mixed forest and Melaleuca woodland with a sparse and grassy understorey. It grows on poorly draining, heavy clay soils (Barlow 1987; Byrnes 1984).

1.3.4 Threatening processes

The following have been identified as potentially threatening processes to Swamp tea-tree.

- Clearing or modification of habitat
- Feral animals
- Weed invasion (Soonthornvipat 2018).

1.3.5 Threat abatement/recovery plans

No Recovery Plan has been identified as being relevant for this community.

The following Threat Abatement Plan has been identified as being relevant for this community:

- Department of Sustainability, Environment, Water, Population and Communities (2011). Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads. In effect under the EPBC Act from 06-Jul-2011
- Department of the Environment and Energy (2018). Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*. Canberra: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018. In effect under the EPBC Act from 22-Feb-2019.

1.3.6 Summary of threat abatement/recovery plans

The threats outlined in the threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads include:

- Predation by cane toads
- Larval competition with frog tadpoles or mosquitoes
- Parasite transfer
- Competition for terrestrial food
- Competition for shelter sites.

Threat abatement actions for cane toads (*Rhinella marina*) include:

- $11 million in funding from the Australian Government provided for the development of a broad-scale control method
- $9 million in funding from the Australian Government for research and management activities
- Identification of native species, ecological communities and off-shore islands that are known to have a high to moderate risk
- Identify the impacts that toads have on listed native species and ecological communities
- Where the impact is expected to be high on native species and ecological communities establish support research techniques in aiding the recovery of priority native species and ecological communities
- Develop a prioritisation tool to aid in the direction of resources for the protection of native species and ecological communities.

The consequences of potential infection outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Inability of infected plants to develop new shoots, flowers, fruit and seed
- Complete loss of some flora populations
- Dramatic alteration to the structure and composition of native plant communities
- A severe reduction in primary productivity and functionality
- Irreversible habitat loss and degradation of dependent flora and fauna
- Loss of shelter and nesting sites and food sources resulting in major declines of fauna.

Objectives and actions outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Identifying and prioritising the protection of biodiversity assets that are, or may be, impacted by Phytophthora including listed threatened species, ecological communities and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act occur
- Reduce the spread and mitigate the impacts of Phytophthora to protect priority biodiversity assets and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act
- Inform the community through education on the impacts that Phytophthora has on biodiversity and actions to mitigate these impacts
- Encourage research on Phytophthora species and option to manage infestations and protect biodiversity assets.

1.3.7 References

Atlas of Living Australia (2018). *Melaleuca irbyana*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900861 [Accessed: 7 September 2018].

Barlow, B.A. (1987). Contributions of a revision of *Melaleuca* (Myrtaceae). *Brunonia* 9(2): 173.

Bennett M. (2017). *Melaleuca irbyana*. (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900861 [Accessed: 7 September 2018].

Byrnes, N.B. (1984). A revision of *Melaleuca* L. (Myrtaceae) in northern and eastern Australia, 1. *Austrobaileya* 2(1): 72.

Soonthornvipat, T. (2018). 'Comparative ecophysiological analyses of melaleuca irbyana and melaleuca bracteata – a narrowly versus widely distributed congeneric species'. Thesis, QUT, Brisbane.

2 Fauna species – Conservation significant species – Reptiles

2.1 Grey snake (*Hemiaspis damelii*)

2.1.1 Status

EPBC Act – Not listed

NC Act – Endangered

BC Act – Endangered

2.1.2 Biology and ecology

2.1.2.1 Characteristic

The Grey snake (*Hemiaspis damelii*) is typically uniform olive grey to grey above and their belly surfaces are white to cream, usually flecked with dark grey. The top of the head and the first few scale rows are black in juveniles. This dark patch reduces to a narrow bar in adults, or sometimes may disappear completely. They have large eyes and generally grow to a total length of about 0.7 m (DES 2017).

Image not available under CC licence.

2.1.2.2 Known distribution

Its distribution extends from central inland New South Wales, north to several isolated populations near Rockhampton in Queensland. Within Queensland, records are known from near Goondiwindi and the adjacent Darling-Riverine Plain, from the Darling Downs and from the Lockyer Valley (refer Figure 2.1). The core area for the Grey snake in the Brigalow Belt is south of the Great Dividing Range between Dalby and Glenmorgan (DES 2017).

Figure 2.1 **Distribution range of the Grey snake**

Source: ALA (2018)

2.1.2.3 Distribution in relation to the Project

Hemiaspis damelii has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicated this species is known from within the disturbance footprint to the east of Gatton however, this record does not have a date. Two records (one dated 1982) occur within approximately 5 km south of the disturbance footprint to the south of Gatton. Other records from within a 50 km buffer of the disturbance footprint exist to the west, north and east of the alignment.

Figure 2.2 **Distribution range of the Grey snake in relation to the Project**

Source: ALA (2020)

2.1.2.4 Biology and reproduction

Grey snakes are active during the night when they feed on frogs and lizards (DES 2017). They bear 4 to 16 live young, usually between January and March. Young are born fully formed and individuals take about 12 months to mature (DES 2017).

2.1.3 Habitat

The Grey snake favours woodlands, usually on heavier, cracking clay soils, particularly in association with water bodies or in areas with small gullies and ditches. It shelters under rocks, logs and other debris as well as in soil cracks (DES 2017).

2.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Grey snake:

- Pasture improvement and cultivation disrupts soil structure in cracking clay soils, potentially reducing the availability of shelter for the Grey snake
- Impacts from feral animals such as cats, foxes, cane toads and pigs
- Hydrological changes to waterways has the potential to impact on those species that rely on these types of habitats for survival (DES 2017).

2.1.5 Threat abatement/recovery plan

No threat abatement/recovery plan has been identified for this species.

2.1.6 References

Atlas of Living Australia (2018). *Hemiaspis damelii*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:78a40c2c-23d8-45de-86e5-ad6f5441f276 [Accessed: 10 October 2018].

Department of Environment and Science (2017). Grey snake. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/grey_snake.html [Accessed: 10 October 2018]

3 Fauna species – Special least concern species – mammals

3.1 Platypus (*Ornithorhynchus anatinus*)

3.1.1 Status

EPBC Act – Not listed

NC Act – Special Least Concern

BC Act – Not listed

3.1.2 Biology and ecology

3.1.2.1 Characteristic

The male Platypus (*Ornithorhynchus anatinus*) is about 50 cm long and weighs about 1.5 kg while the female is typically 40 cm long, weighing 1 kg. However, size may vary with the smallest specimens found in the north and largest in the south. The Platypus has a leathery snout resembling a duck bill and broad flat tail. The snout is chocolate in colour and pliable (refer Photograph 3.1). Its streamlined body has uniform brown upperparts and pinkish brown underparts. It has short limbs and webbed feet with claws. Adult males are equipped with a 12 mm long spur on each hind ankle which can inject venom (DES 2018; Menkhorst and Knight 2011).

Photograph 3.1 Platypus (*Ornithorhynchus anatinus*)

Source: Wormleaton (2018)

3.1.2.2 Known distribution

The Platypus is found in bodies of freshwater in eastern Australia, from the Annan River in northern Queensland to the far south of Victoria and Tasmania (refer Figure 3.1). In Queensland, platypus live east of the Great Dividing Range, and in some western-flowing streams. In north Queensland, the range of the Platypus is closer to the coast (DES 2016; OEH 2018).

Figure 3.1 **Distribution range of the Platypus**

Source: ALA (2020)

3.1.2.3 Distribution in relation to the Project

Ornithorhynchus anatinus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA and WildNet) indicated this species has been identified as occurring within the Disturbance footprint at Forest Hill although no valid date exists for this record. Another record exists within the Ecology study area to the east of Gatton and does not have a valid record date. The nearest record with a date from 2014 exist to the south of the western end of the Disturbance footprint at Helidon. A number of other records exist from within a 50 km buffer of the alignment to the north at the Toowoomba Range, to the north-east between Ipswich and Esk and to the south near Main Range National Park.

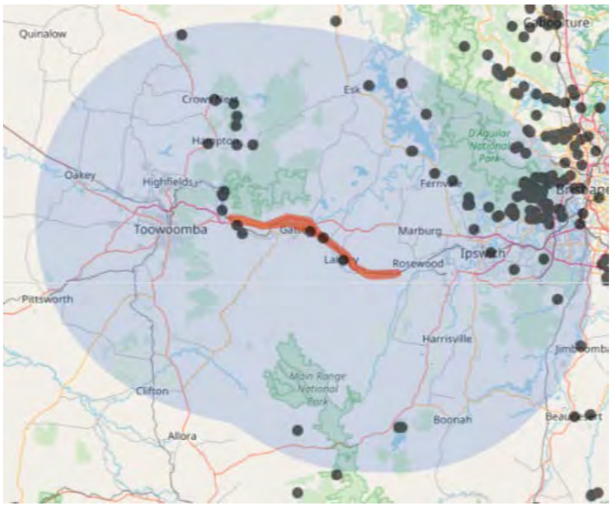

Figure 3.2 **Distribution range of the Platypus in relation to the Project**

Source: ALA (2020)

3.1.2.4 Biology and reproduction

The diet of the Platypus consists mainly of the benthic invertebrates, particularly insect larvae. They also known to feed on shrimps, water bugs, swimming beetles, tadpoles, worms, freshwater pea mussels and snails. Occasionally they will also catch cicadas and moths. Platypus are mainly crepuscular and rely on receptors in their sensitive bill to find and catch food (Australian Museum 2015; DES 2016).

In Queensland, Platypus mate in August, and about a month later in the south. After mating, the females build nesting burrows that can be up to 30 m long. After securing themselves within the burrow they lay two eggs which they incubate for about two weeks before they hatch. They are fed by their mother for a further 4 to 5 months before they leave the burrow and reach maturity at one year old (DES 2016; Menkhorst and Knight 2011).

3.1.3 Habitat

Found in freshwater streams, ranging from alpine creeks to tropical lowland rivers, lakes, shallow reservoirs and dams. They prefer areas with steep, vegetated banks for their burrows which are also concealed by vegetation (Menkhorst and Knight 2011).

3.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Platypus:

- The biggest threat to the Platypus is the loss of habitat, especially land clearing and dams that disrupt the natural water flow
- Predation by introduced species such as foxes, cats and dogs and the entanglement in litter, such as fishing line and yabby traps are also threats to the Platypus
- Pollution, algal growths, siltation and destruction of creek banks are a threat to Platypus burrows (DES 2016; OEH 2018).

3.1.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

3.1.6 References

Atlas of Living Australia (2020) *Ornithorhynchus anatinus.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ac61fd14-4950-4566-b384-304bd99ca75f [Accessed: 21 August 2020].

Australian Museum (2015). Platypus, *Ornithorhynchus anatinus*. Available from: https://australianmuseum.net.au/platypus [Accessed: 21 August 2018].

Couch, A. (2010). Platypus (Ornithorhynchus anatinus). [image] [online] Available from: https://www.flickr.com/photos/couchy/4287853248/in/photolist-q2A9XV-giiA63-bM58Kk-c5j3qG-eV4uH6-azL9T3-HweiUj-a9Zdwo-3aH6X5-3aJ2Ly-7wUnoh-bBjxyN-3aCVUp-cCeP1f-3aHiXs-3aCsQ2-boQNZk-axeLXj-dwrmTN-3aGMvS-nxBaiD-2ehiJHP-25LXtQF-xcvW5v-ayF4xA. [Accessed: 18 September 2019].

Department of the Environment and Science (2016). Platypus. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/platypus.html. [Accessed: 21 August 2018].

Menkhorst P. and Knight F. (2011). *A Field Guide to the Mammals of Australia, 3rd Edition*. Oxford University Press.

Office of Environment and Heritage, NSW (2018). Platypus. Available from: https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/platypus [Accessed: 21 August 2018].

Wormleaton, S. (2018). Swimming platypus *(Ornithorhynchus anatinus).* (Image) [Online] Available from: https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/platypus [Accessed: 21 August 2018].

3.2 Short-beaked echidna (*Tachyglossus aculeatus*)

3.2.1 Status

EPBC Act – Not listed

NC Act – Special Least Concern

BC Act – Not listed

3.2.2 Biology and ecology

3.2.2.1 Characteristic

The Short-beaked echidna (*Tachyglossus aculeatus*) is recognised by the extensive coverage of spines. It has a length of up to 450 mm and weighs up to 7 kg (females will usually weigh less). It also has hair present between the spines and they range in colour from light brown in the northern, hotter parts of Australia to darker in the south. The snout is 7 to 8 cm long and is rigid (refer Photograph 3.2). It has short, stout limbs and on the front feet they have five flattened claws which for digging. The back feet point backwards and help to push the soil away when the animal is burrowing (NPWS 1999; Queensland Museum 1995).

Photograph 3.2 Short-beaked echidna (*Tachyglossus aculeatus*)

Source: Kavanagh (2015)

3.2.2.2 Known distribution

The Short-beaked echidna is found across all States and Territories but appears to be most abundant in central and eastern Australia (ALA 2018) (refer Figure 3.3).

Figure 3.3 **Distribution range of the Short-beaked echidna**

Source: ALA (2018)

3.2.2.3 Distribution in relation to the Project

Tachyglossus aculeatus has been identified as potentially occurring within the Ecology study area. Database records (i.e. AoLA and WildNet) indicated this species exists within the Disturbance footprint dated 2015 where the alignment intersects Seventeen Mile Road near Helidon. This species exists from numerous database records within a 50 km buffer of the Disturbance footprint in all directions of the alignment.

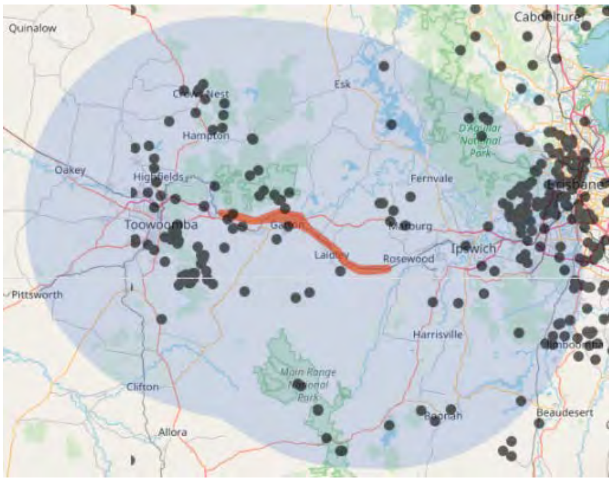

Figure 3.4 **Distribution range of the Short-beaked echidna**

Source: ALA (2020)

3.2.2.4 Biology and reproduction

Termites and ants are its preferred food however it also eats earthworms, beetles and moth larvae.

Short-beaked echidnas breed from the end of June to early September. A particular characteristic displayed by echidnas during the breeding season is the formation of 'trains'. A female lays a single egg, which is incubated in the pouch and takes about ten days to hatch. The young echidna is suckled by its mother from mammary glands in the pouch and is carried in the pouch for about three months. During this time the female will sometimes leave the young animal in a burrow, made by the female for its protection. The young echidna will leave the burrow at around 12 months of age. They have been known to live 10 to 16 years in the wild (Rismiller 1993; Rismiller and Seymour 1991; Strahan 1995).

3.2.3 Habitat

The distribution of the Short-beaked echidna ranges from undisturbed to disturbed habitats, and includes forests, woodlands, shrublands and grasslands, rocky outcrops and agricultural lands. Echidnas are usually found among rocks, in hollow logs, under vegetation or piles of debris, under tree roots or sometimes in wombat or rabbit burrows (Hyett and Shaw 1980).

3.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Short-beaked echidna:

- Habitat loss – urban development
- Roadkill on roads
- Invasive predators, mostly domestic dogs (NPWS 1999).

3.2.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

3.2.6 References

Atlas of Living Australia (2018) *Tachyglossus aculeatus.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0d4c9c0c-51d3-44e0-a365-fe0f8b791c66#overview [Accessed: 21 August 2018].

Edmonds A. (2015). *Tachyglossus aculeatus.* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0d4c9c0c-51d3-44e0-a365-fe0f8b791c66#gallery [Accessed: 30 August 2018].

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National Parks and Wildlife Service (1999). Echidnas, Helping Them in the Wild. Hurstville, New South Wales: National Parks and Wildlife Service.

Queensland Museum (1995). *Wildlife of Greater Brisbane*. Brisbane: Queensland Museum Publications.

Rismiller, P. D. (1993). 'Overcoming a prickly problem', *Australian Natural History Magazine*, vol. 24, no. 6, pp. 22–29.

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4 Fauna species – Conservation significant species – Birds

4.1 Glossy black-cockatoo (*Calyptorhynchus lathami lathami*)

4.1.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

BC Act – Vulnerable

4.1.2 Biology and ecology

4.1.2.1 Characteristic

The Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) is a small black cockatoo that is approximately 46 to 51 cm in length with a wingspan of 90 cm, a tail 21 to 23 cm and an inconspicuous crest and broad bulbous bill. Adult males have solid bright red panels in the ventral surface of their tail feathers, while females have light orange-red panels with black barring (refer Photograph 4.1). Females also have irregular patches of yellow on the head and neck. Immature individuals also have irregular patches of yellow on the head and wing coverts. Tail barring in males is lost in successive moults as the panels become bright red (Pizzey and Knight 2007; Schodde et al. 1993).

The Glossy black-cockatoo is distinguished from the Red-tailed (*C. banksii*) and Yellow-tailed (*C. funereus*) black-cockatoo by its' smaller size, dull brown tinge to the head and breast, inconspicuous crest, and red rather than yellow panels in the tail (Glossy Black Conservancy 2010).

Photograph 4.1 **Glossy black-cockatoos (*Calyptorhynchus lathami lathami*)**

Source: Fisher (2008)

4.1.2.2 Known distribution

The Glossy black-cockatoo has a widespread distribution, ranging from Gympie to the South-east Queensland border, inland to Augathella and Tambo (refer Figure 4.1). The distribution continues south into NSW spreading inland to the Central Western Plains of NSW and also into eastern Victoria (Schodde et al.1993).

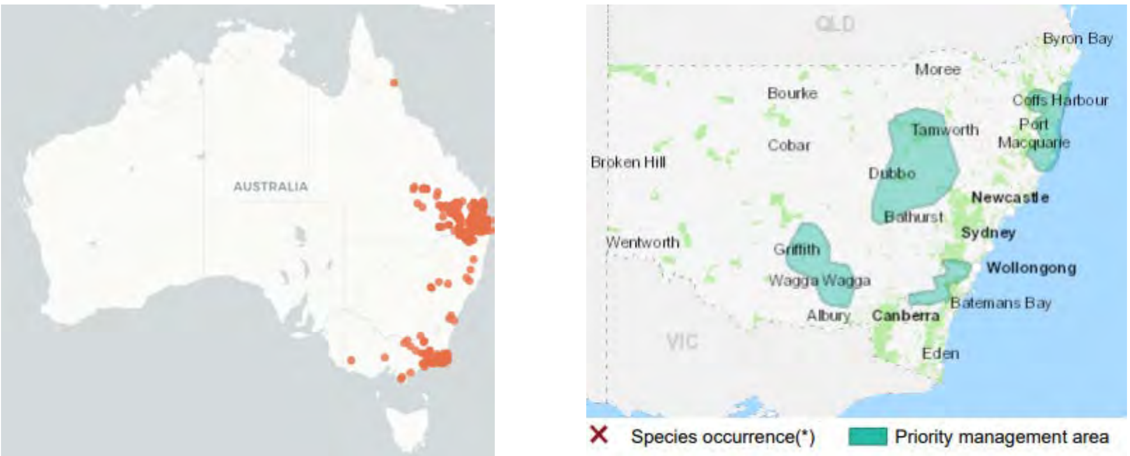

Figure 4.1 **Distribution range of Glossy black-cockatoo**

Source: ALA (2018); OEH (2017)

4.1.2.3 Distribution in relation to the Project

Calyptorhynchus lathami has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species exists within the Ecology study area from a record dated 1989 at the western end of the Disturbance footprint. Another record exists from within approximately 5 km of the Disturbance footprint to the south of Gatton. Other records within a 50 km buffer of the Disturbance footprint occur to the south at Main Range National Park, to the west along Toowoomba Range, to the north at the Lockyer Reserves and to the east and north-east between Ipswich and D'Aguilar National Park.

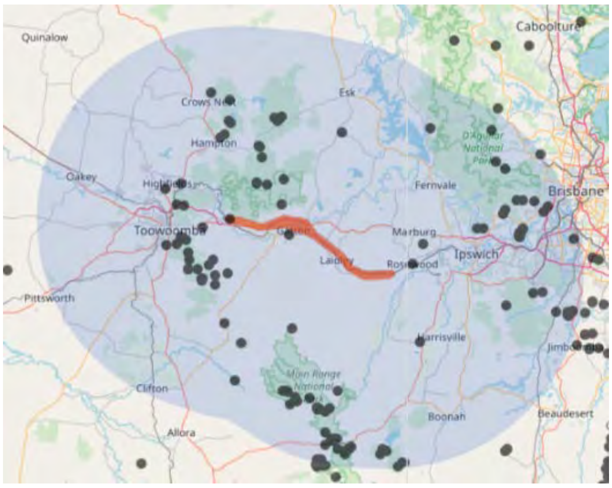

Figure 4.2 **Distribution range of Glossy black-cockatoo in relation to the Project**

Source: ALA (2020)

4.1.2.4 Biology and reproduction

The Glossy black-cockatoo feed almost exclusively on the seeds of species of *Allocasuarina* and *Casuarina* species throughout their range. In addition, within an area, feeding is often restricted to one or two individuals of a single species. This species also shows a strong fidelity to particular feed trees, returning to selected trees over consecutive years (Cameron 2005; Cameron and Cunningham 2006; Clout 1989).

Below are species that Glossy black-cockatoos' are known to feed on:

- *Allocasuarina torulosa*
- *Casuarina equisetifolia*
- *A. littoralis*
- *A. verticillata*
- *C. cristata*
- *C. pauper*
- *A. gymnanthera*
- *A. diminuta* (OEH 2017).

Glossy black-cockatoos are dependent on large hollow-bearing eucalypts for nesting. Hollows used for nests are typically located 10 to 20 m above the ground, in vertical or near vertical branches, stems, and spouts, or in trunk cavities. The same nest will be utilised in successive seasons, and they are known to often nest in close proximity to other nesting pairs. The peak breeding season occurs from March to August in South-east Queensland and north-eastern NSW and clutch size is typically comprised of a single egg (Cameron 2006; Garnett et al. 1999; Glossy Black Conservancy 2010; Pizzey and Knight 2007).

4.1.3 Habitat

The Glossy black-cockatoo prefers woodland areas dominated by she-oak (*Allocasuarina* spp.), or open sclerophyll forests/woodlands with a stratum of *Allocasuarina* spp. beneath a canopy of *Eucalyptus* spp., *Corymbia* spp. or *Angophora* spp. Glossy black-cockatoos have also been recorded in mixed *Allocasaurina*, *Casuarina*, *Callitris* and *Acacia harpophylla* woodland assemblages. In South-east Queensland, west of the Great Dividing Range, they have been observed feeding in remnant Belah (*Casuarina cristata*) and Bulloak (*Allocasuarina luehmannii*) forests (Glossy Black Conservancy 2010).

4.1.4 Threatening processes

The following have been identified as potentially threatening processes to Glossy black-cockatoo:

- Reduction of suitable habitat through clearing for development
- Decline of hollow bearing trees over time due to land management activities
- Excessively frequent fire which eliminates sheoaks, depleting habitat and feed trees
- Limited information on the location of nesting aggregations and the distribution of high quality breeding habitat
- Disturbance from coal seam gas and open cut coal mining causing loss of foraging and breeding habitat as well as disturbing reproductive attempts
- Illegal bird smuggling and egg-collecting (OEH 2017).

4.1.5 Threat abatement/recovery plans

The following threat abatement/recovery plans have been identified as being relevant for this species.

- Office of Environment and Heritage (2017). Save Our Species: Help save the Glossy Black-Cockatoo. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1178&ReportProfileID=10140. In force under the *Biodiversity Conservation Act 2016*

4.1.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Loss of existing and future hollow-bearing trees
- Excessively frequent fires eliminating sheoaks from an area and preventing their development to maturity
- Reduced access to water in close proximity to foraging and nesting habitat
- Loss of habitat through clearing for development
- Global climate change impacting the spatial and temporal distribution of the species.

Management actions outline in the Saving our Species plan includes:

- Raise awareness around the importance of large old trees, which provide roosting habitat
- Protect large and small hollow bearing trees to facilitate regenerations of habitat trees
- Encourage the retention of sheoaks in the understorey and reduce impact caused by fire, slashing/underscrubbing and over-grazing
- Maintain accessibility to surface water or provide artificial sources of water ensuring vegetation cover is maintained between roosting/foraging sites and water sources
- Raise awareness among landholders on the importance of suitable habitat for the species
- Install nest boxes to provide artificial nesting sites for the species
- Enhance and restore corridors between woodland and forest habitat.

4.1.7 References

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Cameron, M. (2006). Nesting habitat of the glossy black-cockatoo in central New South Wales. *Biological Conservation* 127, 402-410.

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Glossy Black Conservancy (2010). *Glossy black-cockatoo Conservation Guidelines for Southeastern Queensland and far North-Eastern New South Wales*. Glossy Black Conservancy.

Office of Environment and Heritage, NSW (2017). Glossy Black-Cockatoo. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10140 [Accessed: 3 September 2018].

Office of Environment and Heritage (2017). Save Our Species: Help save the Glossy Black-Cockatoo. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1178&ReportProfileID=10140 [Accessed: 16 August 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Schodde, R., Mason, I.J. and Wood, J.T. (1993). Geographical differentiation in the glossy black-cockatoo *Calyptorhynchus lathami* (Temminck) and its history. *Emu* 93, 156-166.

4.2 Powerful owl (*Ninox strenua*)

4.2.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

BC Act – Vulnerable

4.2.2 Biology and ecology

4.2.2.1 Characteristics

The Powerful owl (*Ninox strenua*) is the largest species of owl in Australia measuring 60 to 66 cm in total body length with a wingspan of 120 to 140 cm. The owl has large yellow eyes, no facial-disc with the upper body dark greyish-brown in colour with a mottled barred white lower body. The underside of the owl is whitist with dark grey-brown chevron markings (refer Photograph 4.2). Juvenile Powerful owls have a white crown and underpart contrasting its small, dark streaks and dark eye patches. Female Powerful owls have a smaller body size compared to the male, as well as a narrower head (OEH 2017a; Pizzey and Knight 2007).

Photograph 4.2 Powerful owl (*Ninox strenua*)

Source: Lochlin (2017)

4.2.2.2 Known distribution

The Powerful owl is endemic to both eastern and south-eastern Australia and inhabits the coastal side of the Great Dividing Range from Mackay to southwestern Victoria (refer Figure 4.3). In NSW the species exists in low densities through the eastern range and along the Murray River despite once being widely distributed throughout the eastern forests to the tablelands. In Queensland, the owl's possible known distribution extends from Bowen to the NSW border through South-east Queensland. Records have also suggested the species has been known to occupy suburban areas of Brisbane, Sydney and Melbourne (Birdlife International 2016; OEH 2017a; Pizzey and Knight 2007).

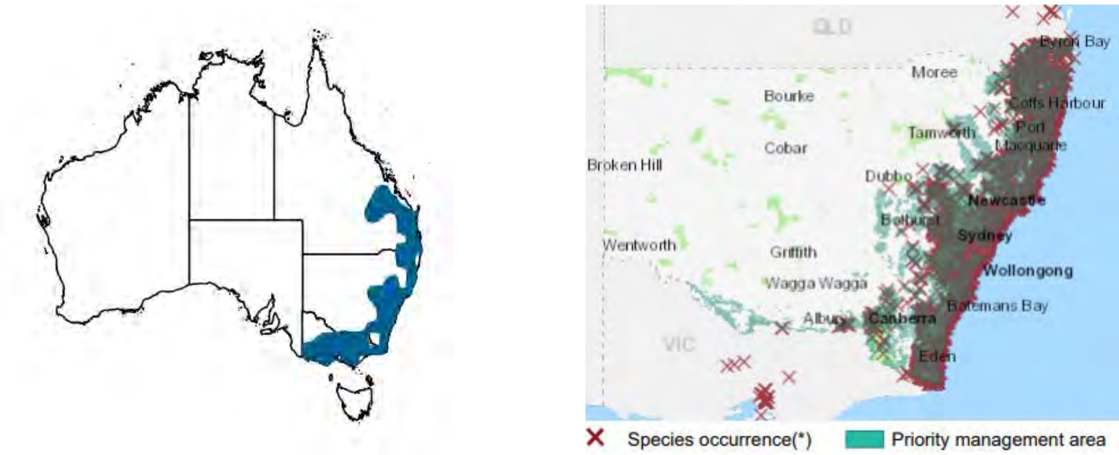

Figure 4.3 **Distribution range of the Powerful owl**

Source: ALA (2020); OEH (2017)

4.2.2.3 Distribution in relation to the Project

Ninox strenua has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within approximately 3 km of the Ecology study area from 2017 with a record to the north of Gatton. A number of records exist for this species from the Toowoomba Range to the Lockyer Reserves west and north-west of the alignment, from the Teviot Range to the D'Aguilar National Park to the east and at Main Range National Park to the south.

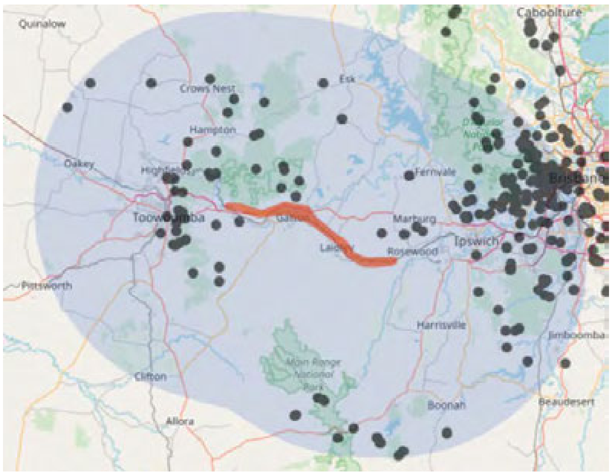

Figure 4.4 **Distribution range of the Powerful owl in relation to the Project**

Source: ALA (2020)

4.2.2.4 Biology and reproduction

The Powerful owl's main prey is dependent on habitat. However, medium-sized arboreal marsupials such as the Greater glider, Common ringtail possum and the Sugar glider constitutes much of its diet. Smaller bird species are an alternative prey to mammals for the owl species making up 10 to 50% of their diet (OEH 2017a).

The Powerful owl forms long-lasting monogamous bonds which are maintained over the species lifetime, with new breeding bonds being formed only after the death of a mate. Breeding typically occurs from late autumn to mid-winter with pairs in north-eastern NSW breeding earlier in late summer to mid-autumn. Nests are made in large tree hollows at least 0.5 m deep usually in large eucalyptus trees which are at least 150 years old. Clutch size is typically two dull white coloured eggs with an incubation period lasting approximately 38 days. As the female and young remain in the nest, the male will roost nearby between 10 to 200 m away guarding them whilst concealed in trees (OEH 2017a; Pizzey and Knight 2007).

4.2.3 Habitat

The Powerful owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The species requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. It roosts by day in dense vegetation comprising species such as Turpentine (*Syncarpia glomulifera*), Black she-oak (*Allocasuarina littoralis*), Blackwood wattle (*Acacia melanoxylon*), Rough-barked apple (*Angophora floribunda*), Scrub cherry (*Exocarpus cupressiformis*) and a number of Eucalypt species. Hollows and shrub layers are important habitat components for the Powerful owl who demonstrate high fidelity to a large territory with the size dependent on habitat quality and prey density (OEH 2017a).

4.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Powerful owl:

- Fragmentation of suitable habitats resulting from land clearing for rural and agricultural uses
- Inappropriate forest harvesting practices
- High frequency burning
- Predation of chicks by foxes, dogs and cats (OEH 2017a).

4.2.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as being relevant for this species.

- Office of Environment and Heritage (2017b). Saving our Species: Help save the Powerful Owl. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=712&ReportProfileID=10562. In force under the *Biodiversity Conservation Act 2016.*

4.2.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Previous loss and fragmentation of woodland habitat for residential and agricultural development
- Habitat loss reducing the availability of prey species, particularly the Greater glider
- Prey availability reduced as a result of high frequency hazard reduction burns.

Actions for this species outlined in the plan include:

- Compile available information, knowledge and assessment protocols to create a consensus of best practice guidelines
- Provide a single point resource for land managers to reference keeping it updated regularly
- Increase public interest through a novel educational framework
- Negotiate agreements with landholders to enter into stewardship agreements that promote retention of large old trees, riparian habitat, owl roost sites and other high value habitat

- Improve habitat quality and connectivity focusing on the restoration of arboreal habitat specific to mammalian prey
- Create wide corridors, particularly in areas such as riparian areas which are more productive for prey species due to abundant resources and soil fertility
- Install artificial hollows in high priority owl populations for both the owls and their prey. If effectiveness is demonstrated expand this as an education tool for the public highlighting the impact of the loss of hollow bearing trees
- Encourage the development of citizen science programs to increase community engagement in urban areas to create broader conservation awareness for powerful owls
- Identify known nests to ensure that no habitat degradation occurs within 100 m and facilitate the location of new nest sites.

4.2.7 References

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Office of Environment and Heritage (2017a). Powerful Owl - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10562 [Accessed: 2 September 2018].

Office of Environment and Heritage (2017b). Saving our Species: Help save the Powerful Owl. New South Wales Government. Available: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=712&ReportProfileID=10562 [Accessed: 16 August 2019].

Pizzey, G. and Knight, F. (2007). The Field Guide to the Birds of Australia. Harper Collins publishing. Sydney.

5 Fauna species – Migratory species – Birds

5.1 Black-faced monarch (*Monarcha melanopsis*)

5.1.1 Status

EPBC Act – Marine and Migratory (Bonn)

5.1.2 Biology and ecology

5.1.2.1 Characteristic

The Black-faced monarch (*Monarcha melanopsis*) is approximately 16.5 to 19 cm long weighing in at about 21 to 29 g. It has a pale bill with a black forehead and throat surrounding the bill. It has a grey upper breast that contrasts with the rich rufous underparts below and dark grey tail (refer Photograph 5.1). The immature form exhibits a darker bill lacking the black forehead and throat. The voice is a fussy, wheezy chattering with a main harsh call similar to 'Why-you, which-you' along with drawn out 'wheech you' and slurred 'r, r, rerr' or 'shsh-shsh-shirr' sounds (Pizzey and Knight 2007).

Photograph 5.1 Black-faced monarch (*Monarcha melanopsis*)

Source: Dew (2017)

5.1.2.2 Known distribution

The Black-faced monarch is widespread in eastern Australia (refer Figure 5.1) (Blakers et al. 1984). In Queensland, it is widespread from the islands of the Torres Strait and on Cape York Peninsula, south along the coasts and the eastern slopes of the Great Divide, to the NSW border (Beruldsen 1990; Blakers et al. 1984).

The Black-faced monarch is also recorded in Papua New Guinea and New Zealand (Coates 1990).

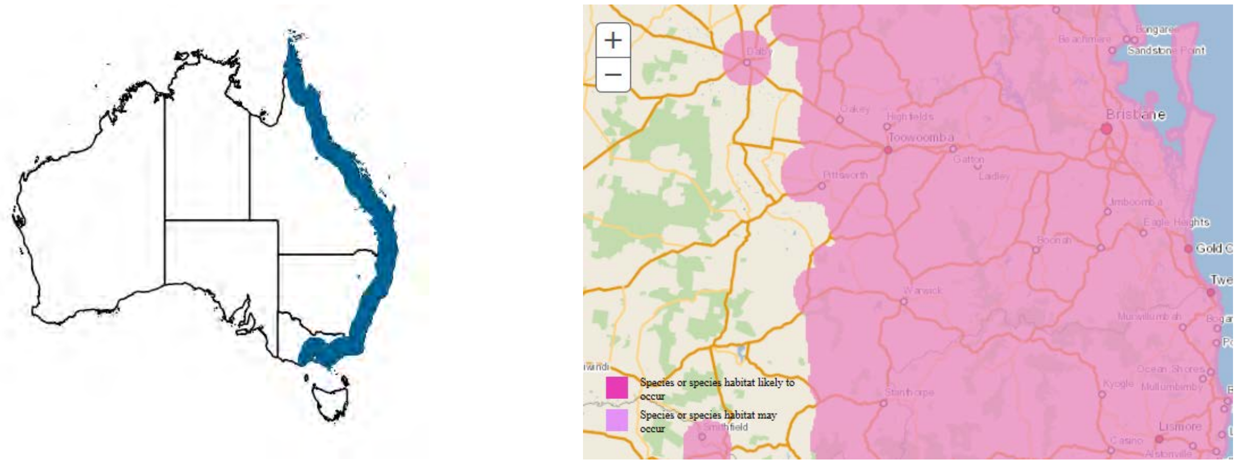

Figure 5.1 **Distribution range of the Black-faced monarch**

Source: ALA (2020), DotEE (2018)

5.1.2.3 Distribution in relation to the Project

Monarcha melanopsis has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species exists within the ecology study area at Gatton from 1973. Another record exists within the ecology study area towards the western section of the disturbance footprint from 1998. Other records exist for this species in all directions of the disturbance footprint within a 50 km buffer throughout Toowoomba Range to the west, north to Esk, north-east to D'Aguilar National Park, east to Ipswich and Brisbane, south-east to Harrisville and south to Main Range National Park.

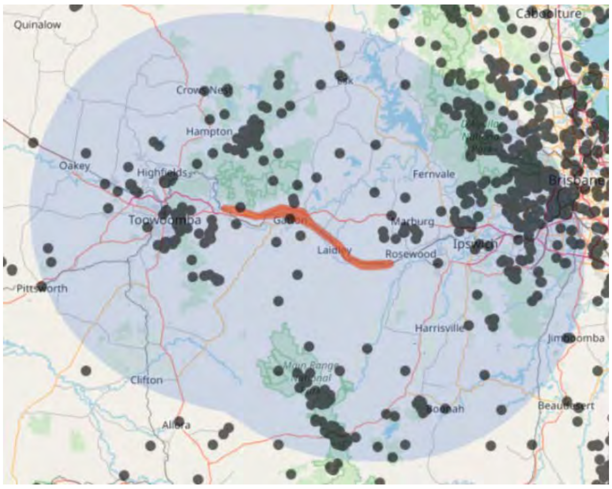

Figure 5.2 **Distribution range of the Black-faced monarch in relation to the Project**

Source: ALA (2020)

5.1.2.4 Biology and reproduction

The Black-faced monarch is known to eat a large variety of arthropods, including: spiders, beetles, grasshoppers, flies, moths etc. They forage at all vertical levels of the forest, though most often at low or middle levels, within 6 m of the ground (Blakers et al. 1984).

The Black-faced monarch breeds in rainforest habitat, and generally nests near the top of trees with large leaves, in the tops of small saplings, or in lower shrubs. They breed from October to March, with eggs recorded mostly from November to mid-January. There is a variation in egg-laying seasons with South-east Queensland eggs laid from October to December and possibly into January and in NSW eggs have been recorded from October to February. The incubation period is thought to be 13 to 15 days and the fledging period approximately 7 days or slightly more. The species appears to have a relatively high rate of fledging failure, with analyses of hatching and fledging success indicating that an average of 0.1 fledged young is yielded per nest per breeding event (BA NRS 2002, Marchant 1986).

5.1.3 Habitat

The Black-faced monarch mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical rainforest, subtropical rainforest, mesophyll thicket/shrubland, warm temperate rainforest, dry rainforest and cool temperate rainforest (Blakers et al. 1984).

The species also occurs in selectively logged and 20 to 30 years old regrowth rainforest and 'marginal' habitats during winter or during migration. Other areas include gullies in mountain areas or coastal foothills, softwood scrub dominated by Brigalow and coastal scrub dominated by Coast Banksia (Blakers et al. 1984; Laurance et al. 1996).

5.1.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Black-faced monarch.

5.1.5 Threat abatement/recovery plans

The following Threat Abatement plan has been identified as being relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

5.1.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

5.1.7 References

Atlas of Living Australia (2020). *Monarcha melanopsis*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21ebd2d3-f706-4997-b04a-79e5d023dcb3#overview [Accessed: 27 August 2020].

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5.2 Black-tailed godwit (*Limosa limosa*)

5.2.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – Special least concern

BC Act – Vulnerable

5.2.2 Biology and ecology

5.2.2.1 Characteristic

The Black-tailed godwit (*Limosa limosa*) is a large wader with a length of about 40 to 44 cm, a wingspan of 63 to 75 cm and a weight of 200 to 300 g. It has a rather small head, long neck and very long legs. It has a long, straight bill that is pink/orange with a black tip (refer Photograph 5.2). The wings have a white wing-bar across the dark flight feathers, and white underwing coverts. There is a sharp demarcation between the white rump and the black tail. The non-breeding plumage, observed in Australia, is greyish-brown above and white below with a grey breast and there is a broad white stripe on the underwing. Females have a slightly larger and longer bill, but a duller breeding plumage as compared to males (DotEE 2018; OEH 2018).

Photograph 5.2 Black-tailed godwit (*Limosa limosa*)

Source: Edmonds (2013)

5.2.2.2 Known distribution

During the nonbreeding season, the Black-tailed godwit is found in all States and Territories of Australia, however, it prefers coastal regions and the largest populations are found on the north coast between Darwin and Weipa (refer Figure 5.3). It is generally found in small numbers elsewhere and there are scattered inland records. The species is found on most other continents during the nonbreeding season. It breeds in widely scattered localities in Europe, Russia and China (Higgins and Davies 1996; Watkins 1993).

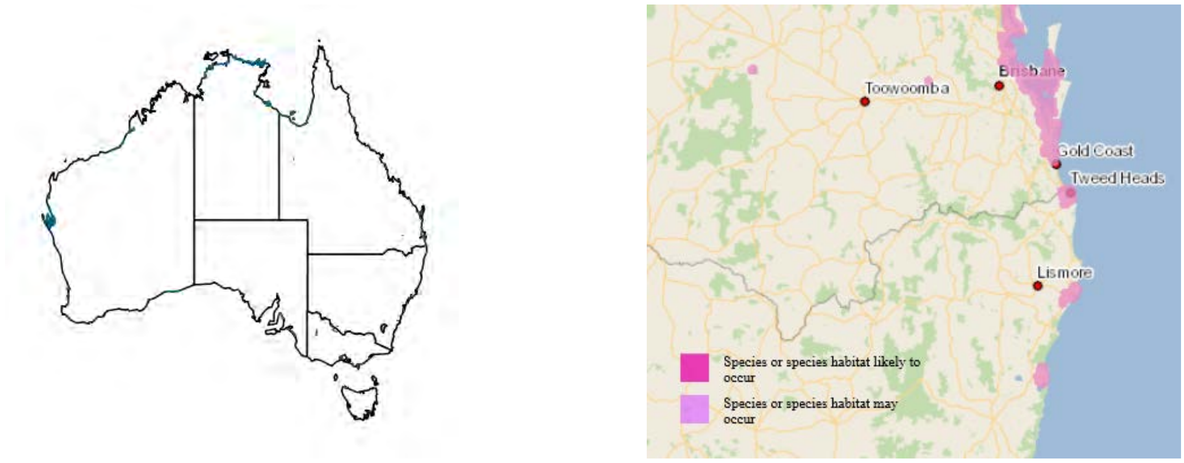

Figure 5.3 Distribution range of the Black-tailed godwit

Source: ALA (2020); DotEE (2018)

5.2.2.3 Distribution in relation to the Project

Limosa limosa has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs from within 5 km of the ecology study area at Gatton dated 1900 and the other from Laidley dated 1966. More recent records (2017 / 2018) occur at Lake Clarendon approximately 15 km from the disturbance footprint. Other records exist from within a 50 km buffer of the disturbance footprint to the west at Oakey, to the north-west near Crows Nest, north at Atkinson Dam, to the east at Ipswich and south-east at Harrisville. Most records occur further east along the coast outside of a 50 km buffer of the disturbance footprint.

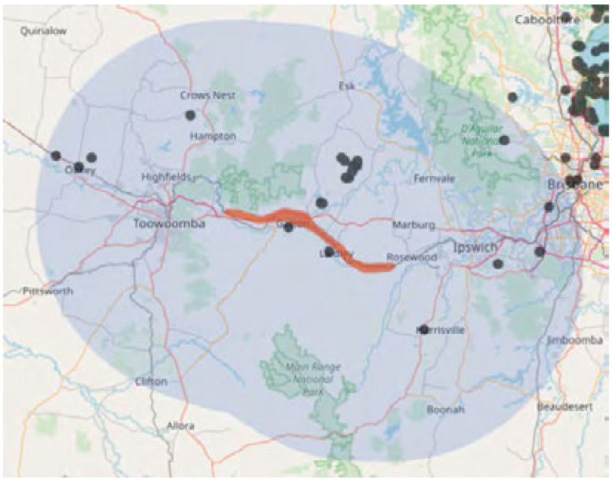

Figure 5.4 Distribution range of the Black-tailed godwit in relation to the Project

Source: ALA (2020)

5.2.2.4 Biology and reproduction

There is little information on the feeding habits of the Black-tailed godwit in Australian, however the species has been recorded eating annelids, crustaceans, arachnids, fish eggs, the spawn and tadpoles of frogs, and occasionally seeds (Higgins and Davies 1996).

The Black-tailed godwit does not breed in Australia. The Black-tailed godwit nests in the Northern Hemisphere summer, with laying from April to mid-June (del Hoyo et al. 1996).

5.2.3 Habitat

In Australia, the species is commonly found in sheltered bays, estuaries, lagoons, intertidal mudflats or sandflats, spits and banks of mud, sand or shell-grit. It is occasionally recorded on rocky coasts or coral islets. It is also found in shallow and sparsely vegetated, near-coastal, wetlands such as saltmarsh, saltflats, river pools, swamps, lagoons and floodplains. They also use lagoons in sewage farms and saltworks (Higgins and Davies 1996).

5.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Black-tailed godwit (DEWHA 2009):

- Habitat loss (i.e. - land clearing, inundation and infilling or draining)
- Habitat degradation (i.e. loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds such as cord grass, water pollution and changes to the water regime, changes to the hydrological regime and exposure of acid sulphate soils)
- Disturbance (i.e. fishing, power boating, four wheel driving, walking dogs, noise and night lighting)
- Direct mortality (DEWHA 2009)

5.2.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan has been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.2.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon

- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.2.7 References

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Higgins, P.J. and Davies S.J.J.F., eds (1996). Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

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Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

5.3 Caspian tern (*Hydroprogne caspia*)

5.3.1 Status

EPBC Act – Marine and Migratory (JAMBA)

NC Act – Not listed

BC Act – Not listed

5.3.2 Biology and ecology

5.3.2.1 Characteristic

The Caspian tern (*Hydroprogne caspia*) is a large tern, 35 to 55 cm in length with a wingspan of 1.1 to 1.4 m. It has a robust scarlet bill with a white forehead, rear crown, streaked brownish ear coverts and consistently grey upperparts and white lower parts (refer Photograph 5.3). It has long, slender backswept wings and a slightly forked tail. It has black legs and a slightly shaggy crest at the rear of the head. In breeding plumage, it also has a black forehead and crown. Juveniles have an orange bill with a dark tip and a crown that is streaked blackish brown as well as mottled upperparts (DotEE 2018; Pizzey and Knight 2007).

Photograph 5.3 Caspian tern (*Hydroprogne caspia*)

Source: Bhardwaj (2009)

5.3.2.2 Known distribution

The Caspian tern can be found in North America, Europe, Africa, Asia, Australia and New Zealand. Within Australia, the Caspian Tern has a widespread occurrence across most States and Territories and can be found in both coastal and inland habitats (Higgins and Davies 1996) (refer Figure 5.5).

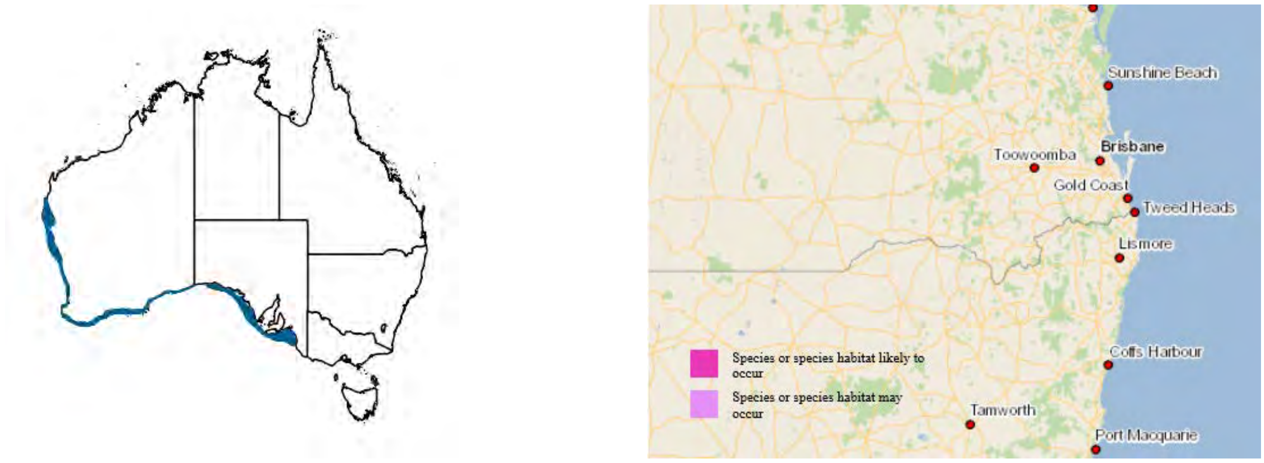

Figure 5.5 Distribution range of the Caspian tern

Source: ALA (2020); DotEE (2018)

5.3.2.3 Distribution in relation to the Project

Hydroprogne caspia has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs from within the ecology study area with two records from 2012 and 2013 at the western end of the disturbance footprint near Helidon. Another record from 2012 occurs to the south of the disturbance footprint within the ecology study area west of Gatton. A number of records from 2014 exist within 1 km to the north of the ecology study area north of Gatton. Other records from within a 50 km buffer of the disturbance footprint occur to the north-west at the Toowoomba Range, records are scattered to the north, north-east and east of the alignment with some records to the south-east near Harrisville and Boonah and south of the ecology study area at Gatton and Laidley.

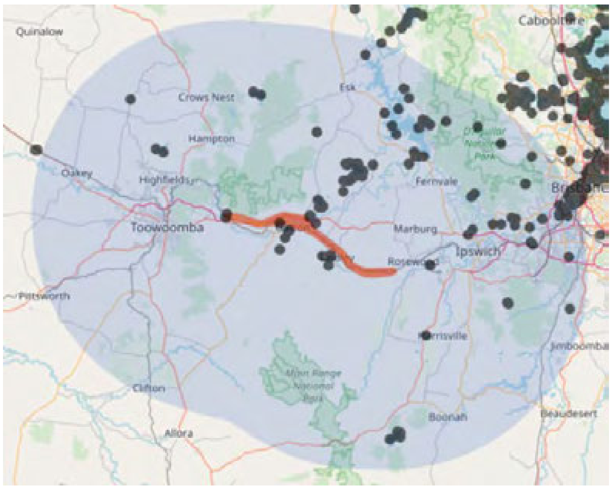

Figure 5.6 **Distribution range of the Caspian tern in relation to the Project**

Source: ALA (2020)

5.3.2.4 Biology and reproduction

They predominantly eat fish (5 to 25 cm in length) but also eggs and young of other birds, carrion, aquatic invertebrates, flying insects and earthworms (DotEE 2018).

Caspian terns reach maturity at about 3 or 4 years and can live for up to 16 years. Caspian terns return to their natal areas to breed. The species breeds between April to June in the Northern Hemisphere and September to December in the Southern Hemisphere, though timing varies in different areas. The nest is a deep scrape on the ground, occasionally sparsely ringed with debris or vegetation. Both sexes share nest-building, incubation and care of the young. Laying is asynchronous within colonies. Clutch sizes average 1 to 2 eggs and incubation takes 22 days with chicks fledging at approximately 35 days (Birdlife Australia 2010; Higgins and Davies 1996; Pizzey and Knight 2007).

5.3.3 Habitat

It is found in coastal, offshore waters as well as beaches, mudflats, estuaries and lakes. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes, waterholes, reservoirs, rivers and creeks. They also use artificial wetlands such as sewage ponds and saltworks (Higgins and Davies 1996; Pizzey and Knight 2007).

5.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Caspian tern:

- Habitat loss
- Degradation through the introduction of exotic plant species
- Predation of chicks by feral species
- Human disturbance and trampling by cattle at breeding

- Entanglement of young birds with fishing line and nets (Birdlife International 2010; DotEE 2018; Minton and Deleyev 2001).

5.3.5 Threat abatement/recovery plan

No threat abatement/recovery plan has been identified as being relevant for this species.

The following Marine Bioregional Plan has been identified has being relevant for this species:

- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). *Marine bioregional plan for the South-west Marine Region*. Prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Available from: http://www.environment.gov.au/topics/marine/marine-bioregional-plans/south-west. In effect under the EPBC Act from 27-Aug-2012
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). Marine bioregional plan for the North Marine Region. Prepared under the Environment Protection and Biodiversity Conservation Act 1999. Available from: http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north. In effect under the EPBC Act from 27-Aug-2012.

5.3.6 Summary of threat abatement/recovery plan

These marine bioregional plans can be summarised as follows:

- Conserve biodiversity and maintain ecosystem health
- Ensure the recovery and protection of threatened species
- Improve understanding of the region's biodiversity and ecosystems and the pressures they face
- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of biodiversity
- Provide regional advice determining the significance of potential impacts
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

5.3.7 References

Atlas of Living Australia (2020). *Hydroprogne caspia*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:83eb10e6-2a4f-4d83-977c-d0eceabb0a3d [Accessed: 7 September 2020].

Bhardwaj, S. (2009). Caspian tern (Hydroprogne caspia). [image] [online] Available from: https://www.flickr.com/photos/tengen/3618283528/in/photolist-6vJDCL-fGy5qX-25MZpgd-dZi1Sh-2etWuK1-24SyD8i-czSikL-cAbRMU-2fRjVSz-czSjCy-cAbSRd-265YS4Y-diY42v-5fGxes-ngDmme-5QBHXq-psDRV3-cAbTvm-CochuD-TkTaty-85QimJ-82cKFC-5QBHto-2eSMKmU-87EL5F-a7ekUz-a7hdku-5LCopQ-25eHKbr-DK3Uhg-dpcyRF-qvAWKa-cYqmiL-dpcJdm-a7gK5E-28taA5V-pdWN3p-a7dRGp-24SyDCM-a7dTxv-9YuJvK-TH3qZj-EwEoC3-TkTaCS-21zqNgw-cy2ico-cYqmbL-a7gKiY-7LTu8n-6wsbkV. [Accessed: 17 September 2019].

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Higgins, P.J. and Davies S.J.J.F., eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds*. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

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Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.4 Common greenshank (*Tringa nebularia*)

5.4.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.4.2 Biology and ecology

5.4.2.1 Characteristic

The Common greenshank (*Tringa nebularia*) is a heavily built, elegant wader, 30 to 35 cm in length, with a wingspan of 55 to 65 cm and weight up to 190 g for both males and females (refer Photograph 5.4). During the nonbreeding period, the bill is long and slightly upturned, and the legs are long and yellowish-green. In flight, all plumages show uniformly dark upper-wing and contrasting white rump extending in a white wedge up the back. The sexes are alike. During the breeding season their head and neck is white with heavy black streaking and the inter-wing coverts are mostly brownish-grey with white fringes. The underbody is white with fine black streaks on chin and throat and there are bold black chevrons on the breast and flank. The underwing is white with faint brownish barring on the covers and the bill is bluish-greenish grey. The juvenile is like the adult non-breeding form, but the head and neck are slightly darker with heavier, darker streaking (Higgins and Davies 1996).

Photograph 5.4 Common greenshank (*Tringa nebularia*)

Source: Matos (2017)

5.4.2.2 Known distribution

During the breeding season they are found in Eurasia, the northern British Isles, Scandinavia, east Estonia, northeast Belarus and Russia. In the nonbreeding season the species is widespread and found in Europe, Africa, Asia, Melanesia and Australasia. The species is found in most States and Territories of Australia (refer Figure 5.7). In Queensland, it has been recorded in most coastal regions, possibly with a gap between north Cape York Peninsula and Cooktown. Inland, there have been a few records south of a line from near Dalby to Mt Guide, and sparsely scattered records elsewhere. In NSW, the species has been recorded in most coastal regions. It is widespread west of the Great Dividing Range, especially between the Lachlan and Murray Rivers and the Darling River drainage basin, including the Macquarie Marshes, and northwest regions (Higgins and Davies 1996).

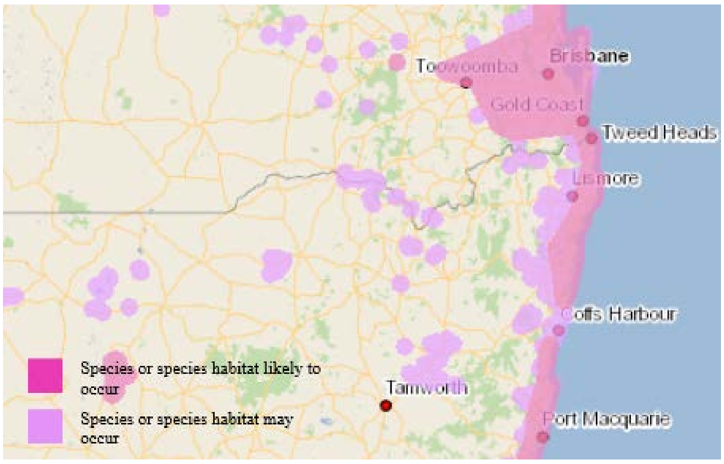

Figure 5.7 **Distribution range of the Common greenshank**

Source: ALA (2020); DotEE (2018)

5.4.2.3 Distribution in relation to the Project

Tringa nebularia has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species has been identified from three records within approximately 2 km from the disturbance footprint north of Gatton with two dated 2005 and one from 2006. Another record occurs approximately 3 km to the south of the disturbance footprint at Gatton dated 2002. Several records occur from 1991 and 2003 to the west of Laidley at Lake Dyer located within approximately 3 km of the disturbance footprint. Other records for this species within a 50 km buffer of the disturbance footprint occur to the west at Oakey, north-west near Crows Nest, north between the Lockyer Reserves and Lowood and to the east near South Ripley. Most records for this species occurring outside of a 50 km buffer exist to the east along the coast.

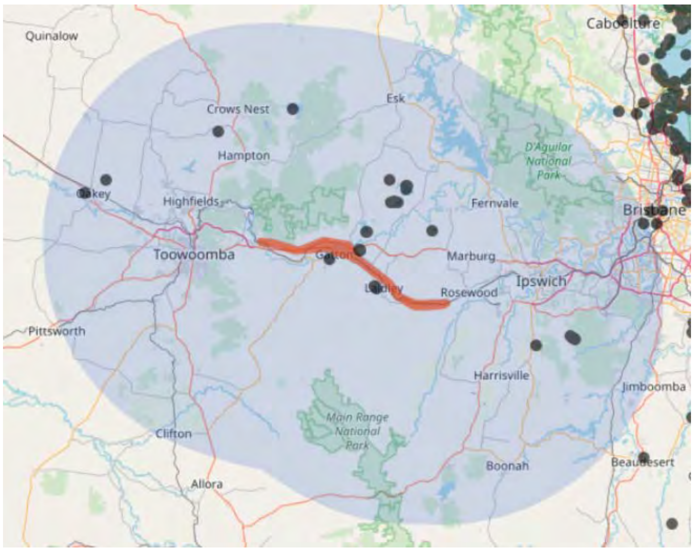

Figure 5.8 **Distribution range of the Common greenshank in relation to the Project**

Source: ALA (2020)

5.4.2.4 Biology and reproduction

The Common greenshank is carnivorous and has been recorded eating molluscs, crustaceans, insects, and occasionally fish and frogs.

The species does not breed in Australia. Common greenshanks migrate to breed in Eurasia, the northern British Isles, Scandinavia, east Estonia, northeast Belarus and Russia from April to June (Higgins and Davies 1996).

5.4.3 Habitat

The Common greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It is found around large mudflats, saltmarsh, mangroves and seagrass. Habitats include embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats. It will also use artificial wetlands including sewage farms, saltworks, dams, inundated rice crops and bores (Higgins and Davies 1996).

5.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Common greenshank:

- Loss/modification of habitat (i.e. residential, farming, industrial and aquaculture/fishing activities) (Straw 1992)
- Increased silt in the water, pollution and weed or pest invasion of habitats can change the quality or quantity of food available from the sites or modify important biophysical aspects (Straw 1992)
- Disturbance (i.e. fishing, power boating, four-wheel driving, walking dogs, noise and night lighting) (DEH 2005).

5.4.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and Marine Bioregional Plans have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016**. In effect under the EPBC Act from 15-Jan-2016
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). *Marine bioregional plan for the North-west Marine Region*. Prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Available from: **http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north-west**. In effect under the EPBC Act from 27-Aug-2012.

5.4.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover include:

- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of biodiversity
- Provide regional advice determining the significance of potential impacts
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

5.4.7 References

Atlas of Living Australia (2020). *Tringa glareola*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:93f685e8-331a-4853-8cc2-792525e4c717#overview [Accessed: 29 August 2020].

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Department of the Environment and Energy (2018). *Tringa nebularia* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=832 [Accessed: 7 September 2018].

Higgins, P.J. and Davies S.J.J.F. (eds) 1996, *Handbook of Australian, New Zealand and Antarctic Birds*. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

Matos, H. (2017). Common greenshank (Tringa nebularia). [image] [online] Available from: https://www.flickr.com/photos/145880133@N04/33210877622/in/photolist-SAJqSj-dJUAsX-7QBXDR-dJUDfp-qmyqQv-ExLPX6-EfWAAv-dJRkeU-278Vob5-V6GR9D-RVaMiZ-dJKUP2-dJRgfb-dJRmcC-dK14DE-dJRhj9-dJRj6Q-9H13Mz-U4MNNi-3ZFrhe-dJKTYn-oTCiPi-fY2cd4-3c7eCV-7dr6zo-oTmA5x-neQUm-4nUdQ1-Eubada-L7xRE8-q59v8z-f5vPxs-6x9orw-TTHgv9-ababct-6x5cXZ-rdQnrz-6x5dbM-222u7Q4-5Ks4m7-5wdtPT-EDeVEK-rhBHGt-rAQvwC-3cbEsE-dK15UC-dJUCE4-dhQSMh-g5RCgS-ayGuF4. [Accessed: 17 September 2019].

Straw, P. (1992). *Relocation of Shorebirds. A Feasibility Study and Management Options*. Sydney, NSW: Unpublished report by the Royal Australasian Ornithologists Union for the Federal Airports Corporation.

5.5 Common sandpiper (*Actitis hypoleucos*)

5.5.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

5.5.2 Biology and ecology

5.5.2.1 Characteristic

The Common sandpiper (*Actitis hypoleucos*) is approximately 19 to 22 cm long. It has a fine, brown bill with a buff base and whitish eyebrows and eye-rings. The legs are grey-green and tinged yellow. It is bronze-brown to grey-brown above with fine dark barring and distinct white hook around the bend of the closed wing leading to a white underside. The sides of the upper breast are washed brown (refer Photograph 5.5). Immature individuals have more distinct darker barring on the upper parts (Pizzey and Knight 2007).

Photograph 5.5 Common sandpiper (*Actitis hypoleucos*)

Source: Shah (2018)

5.5.2.2 Known distribution

The Common Sandpiper breeds in Europe and Asia. In Australasia it visits New Guinea and Australia. In Australia, the species is most commonly found in the north, east and west from August to May (refer Figure 5.9) (Pizzey and Knight 2007).

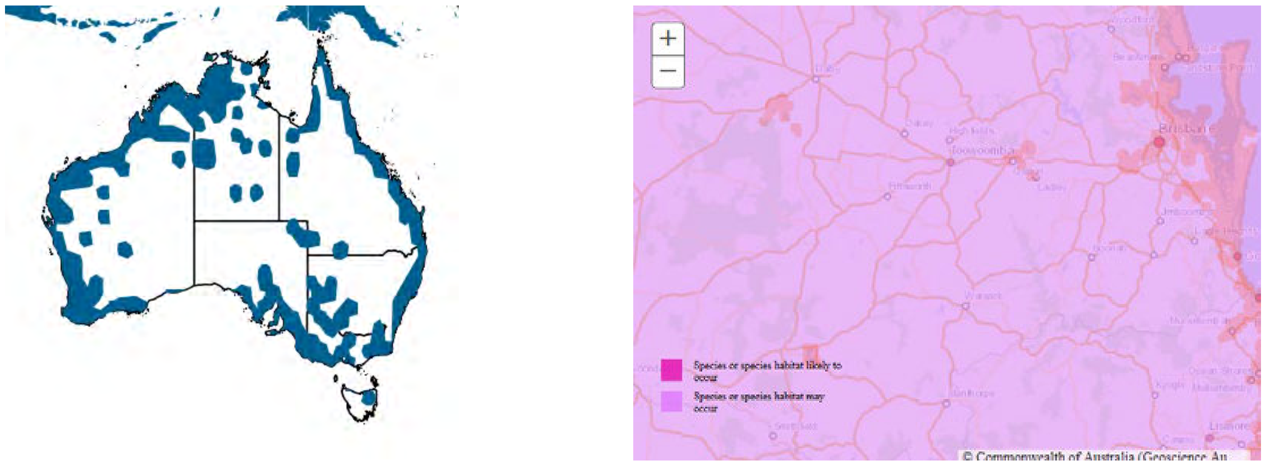

Figure 5.9 Distribution range of the Common sandpiper

Source: ALA (2020), DotEE (2018)

5.5.2.3 Distribution in relation to the Project

Actitis hypoleucos has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species exists from within a record within 1 km north of the ecology study area at Gatton dated 1999. A record from 2017 exists within approximately 5 km of the ecology study area at Laidley to the south of the disturbance footprint. Other records for this species within a 50 km buffer of the disturbance footprint occur to the south of Gatton, north at Atkinson Lagoon, to the north-east at Fernvale and east between Ipswich and Brisbane. Most other records for this species outside of a 50 km buffer occur along the coast to the east.

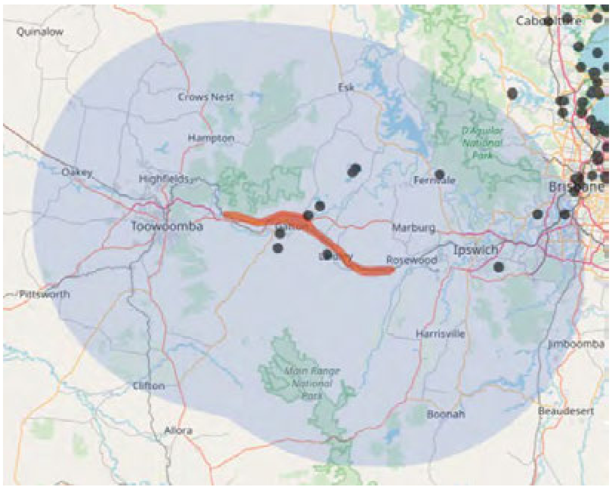

Figure 5.10 **Distribution range of the Common sandpiper in relation to the Project**

Source: ALA (2020)

5.5.2.4 Biology and reproduction

In Australia, the Common sandpiper is typically carnivorous, eating molluscs such as bivalves, crustaceans and a variety of insects (Higgins & Davies 1996).

This species does not breed in Australia. Breeding mostly occurs in the British Isles, Japan and eastern Siberia (Pizzey and Knight 2007).

5.5.3 Habitat

In Australia, Common sandpipers are found in shallow, pebbly, muddy or sandy edges of rivers and streams. They are found in coastal to inland areas, recorded in dams, lakes, sewage ponds, margins of tidal rivers, mangrove forests, saltmarshes, mudflats, beaches and drains (Pizzey and Knight 2007).

5.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Common sandpiper:

- Habitat changes
- Regulation of rivers
- Pollution
- Use of pesticides (reducing prey abundance, especially in breeding periods) (Cramp & Simmons 1983).

5.5.5 Threat abatement/recovery plans

No Recovery Plan has been identified as being relevant for this species.

The following Wildlife Conservation Plan has been identified as being relevant for this species:

- Commonwealth of Australia (2015). Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.5.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.5.7 References

Atlas of Living Australia (2020). *Actitis hypoleucos*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:920b5569-aa29-4311-9f33-13bac4512b1d#overview [Accessed: 23 August 2020].

Cramp, S. & Simmons, K.E.L. eds. (1983). *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic*. Volume 3, Waders to Gulls. Oxford: Oxford University Press.

Department of the Environment and Energy (2018). *Actitis hypoleucos* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies. [Accessed: 24 August 2018].

Higgins, P.J. & Davies, S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

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5.6 Eastern osprey (*Pandion haliaetus*)

5.6.1 Status

EPBC Act – Marine and Migratory (Bonn)

5.6.2 Biology and ecology

5.6.2.1 Characteristic

The Eastern osprey (*Pandion haliaetus*) is a medium-sized raptor with a total length of 50 to 65 cm and wingspan 145 to 170 cm. It should be noted that two species of *Pandion* have recently been identified based on distribution. The Eastern osprey occurring in Australasia is now *P. cristatus* while the Western osprey occurring in Europe, Asia and the Americas is *P. haliaetus*. Typically, adults are mainly dark-brown to blackish-brown above and white below with a white head and neck, streaked blackish-brown, a dark-brown to blackish-brown crest, a black stripe across the eye and ear, a band of reddish-brown, brown or dark-brown streaking across the breast (sparse or absent in males), a white and pale greyish-brown underwing with black carpal patches and black trim, a white to pale greyish- brown undertail, yellow irides, a black bill and white to pale grey legs and feet (refer Photograph 5.6). The sexes are similar but females are typically larger than males (DotEE 2018; Marchant and Higgins 1993).

Photograph 5.6 Eastern osprey (*Pandion haliaetus*)

Source: Knight (2013)

5.6.2.2 Known distribution

The total species range (breeding plus non-breeding) around the northern coast of Australia, extending from Esperance in Western Australia to NSW, is more widespread than southern areas where records become scarcer (i.e. Victoria and Tasmania), where the species is a rare vagrant (refer Figure 5.11). The distribution of the species around the northern coast appears continuous except for a possible gap at Eighty Mile Beach (DotEE 2018).

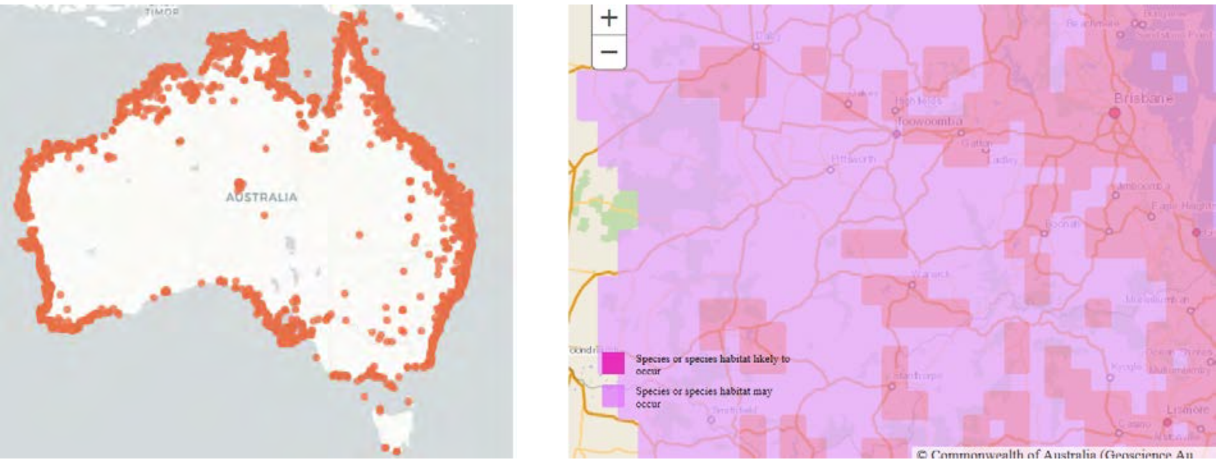

Figure 5.11 Distribution range of the Eastern osprey

Source: ALA (2020), DotEE (2018)

5.6.2.3 Distribution in relation to the Project

Pandion haliaetus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within 1 km at several locations near Gatton with two records located to the north of the disturbance footprint dated 2013 and 2016 and one to the south dated 2007. A record to the south of Helidon dated 2013 occurs within approximately 5 km of the disturbance footprint. Other records for this species from within a 50 km buffer occur to the north-west at the Toowoomba Range, and from the north to the south-east with numerous scattered occurrence records. Most records outside of a 50 km buffer occur along the coast to the east.

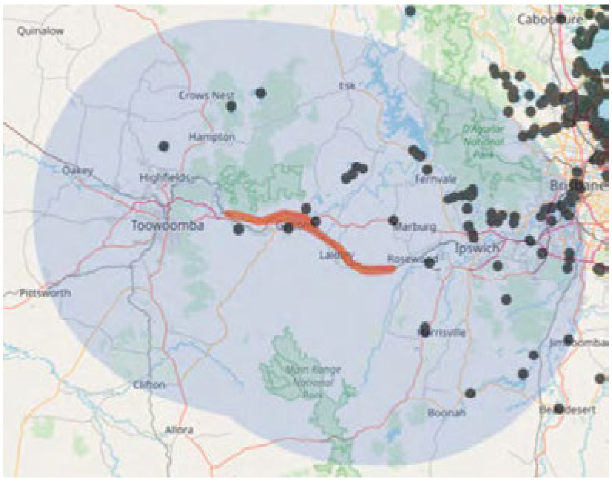

Figure 5.12 **Distribution range of the Eastern osprey in relation to the Project**

Source: ALA (2020)

5.6.2.4 Biology and reproduction

Eastern ospreys mainly feed on fish, especially mullet where available, and occasionally take molluscs, crustaceans, insects, reptiles, birds and mammals (DotEE 2018).

The Eastern osprey breeds from April to February in Australia and form monogamous pairs. Eastern osprey nests vary in size and shape, but they are generally large and are mostly composed of sticks. They are constructed in a variety of natural and artificial sites. Nest sites may be used over many years by one or more pairs. Females lay clutches of one to four eggs which are incubated by both sexes, but mainly by the female, for a period of 33 to 38 days. The nestlings are generally brooded by the female, but the male will take over when the female is absent from the nest. Pairs usually rear one brood but are capable of rearing two broods per season. Breeding attempts may be separated by periods of up to three years, as pairs do not typically breed each year (DotEE 2018; Hollands 2003; Marchant and Higgins 1993).

5.6.3 Habitat

Eastern ospreys occur in coastal habitats and terrestrial wetlands of tropical and temperate Australia. Typically, they are found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia. They frequent a variety of wetland habitats including inshore waters, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes. They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites (DotEE 2018; Marchant and Higgins 1993).

5.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Eastern osprey:

- Loss, degradation or alteration of habitat for urban or tourism development (DotEE 2018)
- Other lesser threats include ingestion of pollutants such as pesticides, heavy metals or fishing tackle as well as competition for food with commercial and recreational fisheries (DotEE 2018).

5.6.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.6.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

5.6.7 References

Atlas of Living Australia (2020). *Pandion cristatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21464fca-984c-4103-ab72-5f6e9e7d5a2b [Accessed: 24 August 2020].

Department of the Environment and Energy (2018). *Pandion cristatus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82411 [Accessed: 24 August 2018].

Hollands, D. (2003). *Eagles, Hawks and Falcons of Australia*. Second Edition. Melbourne: Bloomings Books.

Knight, R. (2013). Eastern osprey (Pandion haliaetus). [image] [online] Available from: https://www.flickr.com/photos/sussexbirder/8778696941/in/photolist-enK7KP-9hWNtc-aouBmJ-9RsuDd-dzKesi-9R61Xp-iE14S1-dBiiSM-iDaE8n-oyB33n-4ugJxT-iE1rPh-aELgbv-dDqrFF-8Pxjk1-2edNt5z-2evJAXo-2fBHy4T-SAqUqL-254PDWy-djfBqd-a7hjEW-dJPZxh-nmVNJC-6TJYVT-9Px6AN-bfw5Sp-829kc8-nDqo6k-nhik9y-2fBHw3P-owPjqu-4oz3ih-2fM4g4h-2fBHxyp-dxov4j-9qKBqk-9t9A66-e81uDd-9RpAGn-9QHiEa-9QLaGq-4ukMH5-9R5P8c-E9b1dS-dD6vDL-9tcziS-9t9A8v-2ecw8QY-9YJfwN. [Accessed: 17 September 2019].

Marchant, S. and Higgins P.J., eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

5.7 Fork-tailed swift (*Apus pacificus*)

5.7.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.7.2 Biology and ecology

5.7.2.1 Characteristic

The Fork-tailed swift (*Apus pacificus*) is a medium to large bird (30 to 40 g), with an approximate length of 18 to 21 cm, and a wingspan of 40 to 42 cm. It has a slim body, with long sickle-shaped wings that taper to finely pointed tips (refer Photograph 5.7). It is characterised by a long and deeply forked tail. The Fork-tailed swift is predominately blackish, with a white band across the rump, and a white patch on the chin and throat. The body, tail and upper wings are black-brown and they have a faint pale scaling to the saddle, and white scalloping to the underbody. The sexes are alike with no seasonal variation, juveniles are also indistinguishable in the field (DotEE 2018, Higgins 1999).

Photograph 5.7 Fork-tailed swift (*Apus pacificus*)

Source: Nicolson (2018)

5.7.2.2 Known distribution

The Fork-tailed swift is a non-breeding visitor to all States and Territories of Australia (Higgins 1999) (refer Figure 5.13).

In Queensland, there are scattered records of the Fork-tailed swift in the Gulf Country, and a few records on Cape York Peninsula. In the northeast region there are many records east of the Great Divide from near Cooktown and south to Townsville. They are also widespread in much of the south south-eastern region, more so west of the Great Divide, and are commonly found west of the line joining Chinchilla and Hughenden (DotEE 2018).

Figure 5.13 **Distribution range of the Fork-tailed swift**

Source: ALA (2020); DotEE (2018)

5.7.2.3 Distribution in relation to the Project

Apus pacificus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species has been recorded recently (2018) within the ecology study area west of Gatton. Records between 2008 to 2013 occur within approximately 5 km of the ecology study area at the western section of the disturbance footprint to the south and west. A number of records occur to the west of the disturbance footprint around Toowoomba and to the east between Ipswich and Brisbane.

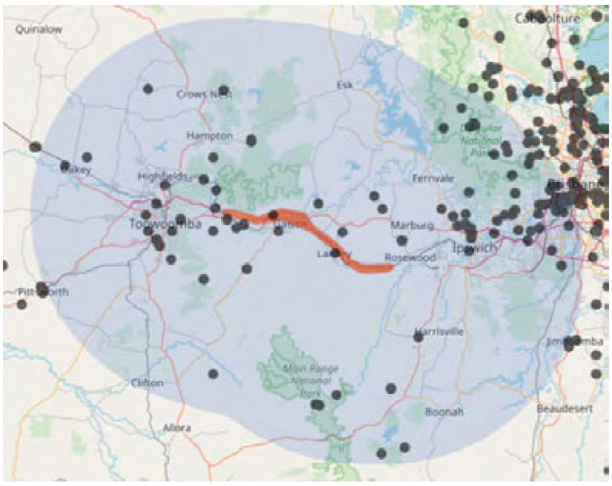

Figure 5.14 **Distribution range of the Fork-tailed swift in relation to the Project**

Source: ALA (2020)

5.7.2.4 Biology and reproduction

The Fork-tailed swift's diet is not well known within Australia. It is known, however, that this species is insectivorous. Studies have recorded the Fork-tailed swift eating small bees, wasps, termites and moths (DotEE 2018).

The Fork-tailed swift does not breed in Australia. It departs its breeding grounds in Siberia from August to – September, typically arriving in Australia in October. In April/May, the Fork-tailed swifts depart Australia, to continue its return trip to the breeding sites in Siberia (DotEE 2018).

5.7.3 Habitat

The Fork-tailed swift is an almost exclusively aerial species, flying from less than 1 m to at least 300 m above ground, and probably much higher. In Australia, Fork-tailed swifts predominately occur over inland plains, but sometimes occur above foothills, or in coastal areas. They often occur over cliffs, beaches, islands, and sometimes far out to sea. This species is also known to occur in the skies above settled areas, including urban areas and cities Sometimes, Fork-tailed swifts may feed among tree-tops in open forests (DotEE 2018, Higgins 1999).

5.7.4 Threatening processes

There are no significant threats to the Fork-tailed Swift in Australia, but potential threats include habitat destruction and predation by feral animals (Birdlife International 2009).

5.7.5 Threat abatement/recovery plans

The following Threat Abatement plan has been identified as being relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: **http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats**. In effect under the EPBC Act from 23-Jul-2015.

5.7.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

5.7.7 References

Atlas of Living Australia (2018). *Apus pacificus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:698f5cfc-4b81-4ed3-aebd-750d1f86a573 [Accessed 24 August 2018].

BirdLife International (2009). *Apus pacificus* **In:** IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. *Apus pacificus*. IUCN Red List.

Department of the Environment and Energy (2018). *Apus pacificus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=678 [Accessed: 24 August 2018].

Higgins, P.J. (ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume Four - Parrots to Dollarbird. Melbourne: Oxford University Press.

Nicolson, K. (2018). Fork-tailed swift (Apus pacificus). [image] [online] Available from: **https://images.ala.org.au/image/details?imageId=64c6d1c6-cbac-456e-9566-fd84d70cfa2b** [Accessed: 17 September 2019].

5.8 Glossy ibis (*Plegadis falcinellus*)

5.8.1 Status

EPBC Act – Marine and Migratory (Bonn)

5.8.2 Biology and ecology

5.8.2.1 Characteristic

The Glossy ibis (*Plegadis falcinellus*) is the smallest Australian ibis. On average, the Glossy ibis is 55 to 65 cm long, with a wingspan of 80 to 95 cm, and weight of approximately 500 to 800 g. The male is typically larger. It is characterised by a reddish-brown neck, a bronze-brown body and wings with a metallic, iridescent sheen. The Glossy ibis exhibits a distinctive long, downwards curved, bill. The facial skin is blue-grey that exhibits a white line, extending around the eyes (refer Photograph 5.8). Plumage in both sexes is similar, both intensifying to a rich chestnut on the neck, mantle, shoulders and under parts during the breeding period. A purple-green sheen appears on the head, upperparts, tail and wings during this time. During the non-breeding period, Juveniles are characterised by a similar dark plumage to adults (DotEE 2018; Marchant and Higgins 1990).

Photograph 5.8 Glossy ibis (*Plegadis falcinellus*)

Source: Keats (20013)

5.8.2.2 Known distribution

Outside of its Australian distribution, the Glossy ibis is known from the eastern region of North America, Caribbean, Europe, Russia, Siberia, central Asia, sub-Saharan Africa, Pakistan, India, and Papua New Guinea. In Australia, it is found in all States and Territories, but typically east of the Kimberley in Western Australia, and east of the Eyre Peninsula in South Australia (refer Figure 5.15). The Glossy ibis is known to have a patchy distribution in Western Australia and is considered a transient visitor to Tasmania (DotEE 2018; Marchant and Higgins 1990).

Figure 5.15 **Distribution range of the Glossy ibis**

Source: ALA (2020)

5.8.2.3 Distribution in relation to the Project

Plegadis falcinellus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate two records within the disturbance footprint at Forest Hill dated 2017. A number of records exist within the ecology study area to the west at Helidon, numerous both to the north and south of the disturbance footprint at Gatton and at Forest Hill. Records within a 50 km buffer of the disturbance footprint occur in all directions except to the south-west. Records are more abundant towards the east of the alignment and the eastern coastline.

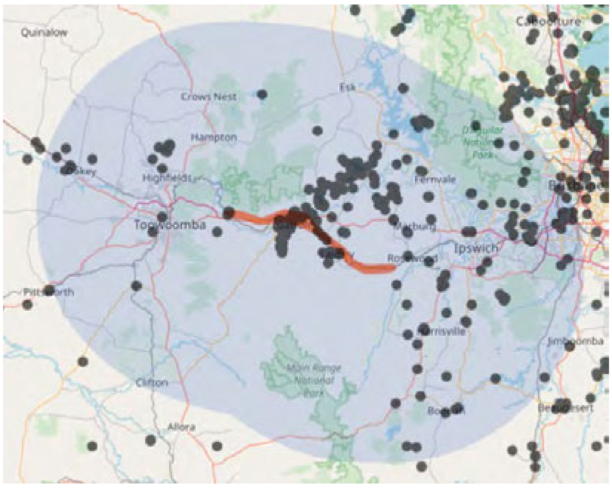

Figure 5.16 **Distribution range of the Glossy ibis in relation to the Project**

Source: ALA (2020)

5.8.2.4 Biology and reproduction

Glossy ibis typically feeds on a variety of aquatic invertebrates/insects. They may also eat fish, frogs, reptiles, and nestling birds (Marchant and Higgins, 1990).

Glossy ibis are known to live for approximately eight years and is matures by one or two years of age. Breeding season for Glossy ibis typically occurs mid-spring to the end of summer, though reproduction may extend from September to April, during favourable conditions (i.e. where there is plentiful food) at breeding sites. Breeding seasons have been recorded as coinciding with annual rain periods in some areas. The Glossy ibis builds a nest platform from twigs and aquatic vegetation. The nest is usually positioned less than one metre above water, in tall dense stands of vegetation. Three to six eggs are laid and both adults care for the young who fledge in approximately 25 to 28 days. Once fledged, adults remain feeding young for several weeks. The Glossy Ibis breeds at only a limited number of locations within Australia, including the Murray Darling Basin in northern NSW (NSW) and Channel Country of Queensland/South Australia (wetlands of the Bulloo, Diamantina and Georgina River systems, occasionally also Cooper Creek) (Birds Australia 2010; DotEE 2018; Marchant and Higgins 1990; Scott 1997).

5.8.3 Habitat

Glossy ibis typically prefer aquatic habitats including water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields, and cultivated land with irrigation. Occasionally, Glossy ibis occur in coastal habitats (eg estuaries, deltas, saltmarshes and lagoons), and has been recorded within mangroves during breeding periods. During periods of drought, this species may retreat to permanent wetlands and/or coastal areas. Glossy ibis typically roost in canopy or shrubs, typically nearby water bodies (Marchant and Higgins 1990).

5.8.4 Threatening processes

Human disturbance is a potential threat but there are currently no known serious threatening processes that have been identified for the Glossy ibis (DotEE 2018).

5.8.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

5.8.6 References

Atlas of Living Australia (2020). *Plegadis falcinellus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:fd74a66c-2566-4a49-b46a-8a2a1699f594 [Accessed 29 August 2020].

Birds Australia (2010). *Birds in Backyards- Glossy Ibis factsheet*. Available from: http://birdsinbackyards.net/species/Plegadis-falcinellus [Accessed: 29 August 2018].

Department of the Environment and Energy (2018). *Plegadis falcinellus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=991 [Accessed 29 August 2018].

Keats, D. (2013). Glossy ibis (*Plegadis falcinellus*). [image] [online] Available from: https://www.flickr.com/photos/dkeats/9720123258/in/photolist-fNWb13-ebrqMa-mGjEjT-bB1XN7-ebrqvr-mGjNHB-dqTHsD-bPVAZR-dhuXNM-9LWLFP-ebrsvZ-cWQy7N-FWHBQw-BTiGgV-s2bYDZ-redkpM-PUrHsP-cWQzDo-cWQA1s-bPVB46-ebrqt4-qjG5h-9sc2Eu-9d32Y5-6Xf9C3-ebx4gE-mGkHBy-cWQhwS-pSxcVc-ebx3Ys-mGjvUr-dhuXvb-cWQgVw-9LWLaz-21sj6PA-ebrr1a-mGhB5x-cWQz53-mGhLJx-S46UqS-ebrr3g-7Vr7TN-9KhdHp-EFLoL-sCtBB-ebrqAc-9o4X41-Y63kfc-ebrqCr-FHfZvC. [Accessed: 17 September 2019].

Marchant, S. and Higgins P.J. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks*. Melbourne, Victoria: Oxford University Press.

Scott, A. (1997). *Relationships between waterbird ecology and river flows in the Murray-Darling Basin. CSIRO Technical report No. 5/97*. Available from: http://www.clw.csiro.au/publications/technical97/tr5-97.pdf. [Accessed: 29 August 2018].

5.9 Gull-billed tern (*Gelochelidon nilotica*)

5.9.1 Status

EPBC Act – Marine and Migratory (CAMBA)

NC Act – Special least concern

BC Act – Not listed

5.9.2 Biology and ecology

5.9.2.1 Characteristic

The Gull-billed tern (*Gelochelidon nilotica*) is approximately 35 cm long, weighing approximately 230 g, has black legs and a black, slightly downcurved bill. Nonbreeding plumage consists of a white head with a large black patch around the eye and across the ear-coverts (refer Photograph 5.9). Breeding plumage consists of a black cap which extends over the eyes. The juvenile form has streaks on its head and has mottled upper feathers (Birdlife Australia 2018; Pizzey and Knight 2007).

Photograph 5.9 Gull-billed tern (*Gelochelidon nilotica*)

Source: Shah (2017)

5.9.2.2 Known distribution

The Gull-billed tern is migratory and occurs on all continents except Antarctica. It has been recorded in every State of Australia, typically seen on the coast (refer Figure 5.17). It is present during all months in coastal eastern Australia, a summer breeding visitor to south-east Australia and a mostly winter visitor to northern Australia and New Guinea (Pizzey and Knight 2007).

Figure 5.17 **Distribution range of the Gull-billed tern**

Source: ALA (2020)

5.9.2.3 Distribution in relation to the Project

Gelochelidon nilotica has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) do not indicate any records from within the disturbance footprint, ecology study area of within a 50 km buffer of the disturbance footprint. The nearest record exists approximately 55 km east of the disturbance footprint at Brisbane however this record has no date and is not considered reliable. Most records occur further east along the coast.

Figure 5.18 **Distribution range of the Gull-billed tern in relation to the Project**

Source: ALA (2020)

5.9.2.4 Biology and reproduction

Gull-billed terns primarily eat insects, frogs, small fish, reptiles, small mammals and crustaceans (ALA 2018). The breeding season of the Gull-billed tern is flexible, depending on location. Generally, they choose to nest in colonies on high, dry ground on small permanent or temporary islands in lakes or marshes. There are few breeding reports north of about 25° S. The nests are shallow depressions scraped in sand or mud, lined with some vegetation. They breed from September to May or when flooding occurs. They clutch is typically 2 to 3 eggs and both sexes incubate the eggs. The incubation period is 23 days and the nestling period is about 35 days (Birdlife Australia 2018; Pizzey and Knight 2007).

5.9.3 Habitat

They are commonly found on beaches, mudflats, fresh and brackish wetlands (including inland wetlands), grasslands, crops, ploughed fields and airfields. They primarily breed in dunes, on sandy barrier islands, or in coastal marshes. (ALA 2020; Pizzey and Knight 2007).

5.9.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Gull-billed tern.

5.9.5 Threat abatement/recovery plans

The following Threat abatement plan and wildlife conservation plan have been identified as being relevant for this species:

- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: **http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox**. In effect under the EPBC Act from 01-Oct-2008

5.9.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

5.9.7 References

Atlas of Living Australia (2020). *Gelochelidon nilotica*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:abf9ee40-02a1-4a66-95fa-318994c6415d#overview [Accessed: 29 August 2020].

Birdlife Australia (2018). Gull-billed tern. Available from: http://www.birdsinbackyards.net/species/Gelochelidon-nilotica [Accessed: 29 August 2018].

Department of the Environment and Energy (2018). *Gelochelidon nilotica* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=806 [Accessed: 29 August 2018].

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Shah, I. (2017). Gull-billed tern (Gelochelidon nilotica). [image] [online] Available from: https://www.flickr.com/photos/gilgit2/28311017127/in/photolist-SyQfo5-DPQpbc-rtej1C-TNVd9w-K8Kn3X-U2FjWY-U1aXzL-rdkukJ-Sz5ML6-RQ4W7u-NtfekF-qvAWKa-qtLWoQ-ngGnKE-pde1yN-XoVL3d-pTD4gM-2dyVa1T-c2WsKS-A2UANJ-dMAjUN-N8rr6d-QY98uZ-nipZkD-eKmP3i-X7M8RQ-cy2ico-6e5ZWF-6ea9Zw-6e5ZRH-6e613v-9sLUch-9zsBiY-9zsBns-9zpCLK-xhuSXQ-9zsBhJ-w94ew6-9zsBdj-LwSbxx-2dm3iJe-2dm3hLT-2dSR1Yu-SQD7LG. [Accessed: 17 September 2019].

5.10 Latham's snipe (*Gallinago hardwickii*)

5.10.1 Status

EPBC Act – Marine and Migratory (Bonn, JAMBA, ROKAMBA)

NC Act – Special Least Concern

BC Act – Not listed

5.10.2 Biology and ecology

5.10.2.1 Characteristic

Latham's snipe (*Gallinago hardwickii*) is a medium sized wader, and the largest snipe in Australia. This species typically measures 29 to 33 cm in length, and a 50 to 54 cm wingspan. It has a long straight bill, short broad pointed wings, a long tail, and short legs (DotEE 2018; Higgins and Davies 1996; Simpson and Day 2004) (refer Photograph 5.10).

The Latham's snipe's plumage is intricately marked, with barring and chevrons of buff, black and various shades of brown. Blackish-brown stripes occur across the crown, and cream streaks occur down the back. The belly and parts of the head are white, and the tail is rufous, with a white tip. The sexes are similar in appearance, with no seasonal variation in the plumage. Non-breeding Latham's snipe have a plainer, less contrast colouring (Higgins and Davies 1996, Pizzey and Knight 1997; Simpson and Day 2004).

Photograph 5.10 Latham's snipe (*Gallinago hardwickii*)

Source: Dunens (2018)

5.10.2.2 Known distribution

Latham's snipe breed in Japan, and far eastern Russia during the summer months of the Northern Hemisphere. They migrate south after the breeding season, travelling across Papua New Guinea to winter in eastern Australia. Latham's snipe has also been recorded as vagrants in New Zealand (DotEE 2018, Naarding 1986, Nechaev 1994).

Latham's snipe is a non-breeding visitor to south-eastern Australia (refer Figure 5.19). It is a passage migrant through northern Australia (i.e. it travels through northern Australia to reach non-breeding areas located further south). The species has been recorded along the east coast of Australia from Cape York Peninsula, through to south-eastern South Australia. Its range extends inland over the eastern tablelands in south-eastern Queensland, and to west of the Great Dividing Range in NSW (Barrett et al. 2003, Blakers et al. 1984, DotEE 2018, Frith et al. 1977, Higgins and Davies 1996).

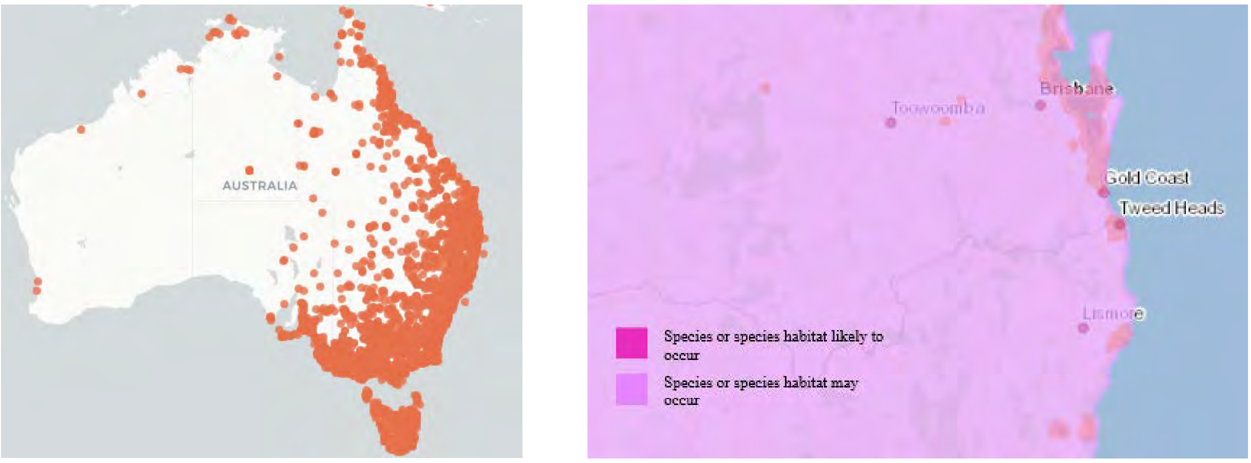

Figure 5.19 **Distribution range of the Latham's Snipe**

Source: ALA (2020); DotEE (2018)

5.10.2.3 Distribution in relation to the Project

Gallinago hardwickii has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area with a specimen backed record dated 2000 approximately 200 m south of the disturbance footprint at Helidon. Two records dated 2000 occur within the ecology study area at Gatton to the south of the disturbance footprint. Numerous records occur between 2001 to 2018 to the west of Laidley at Lake Dyer located approximately 3 km south of the disturbance footprint. Other records within a 50 km buffer of the disturbance footprint are scattered in most directions around the disturbance footprint with most occurring to the east. The majority of records outside of a 50 km buffer are mostly concentrated around the coast to the east.

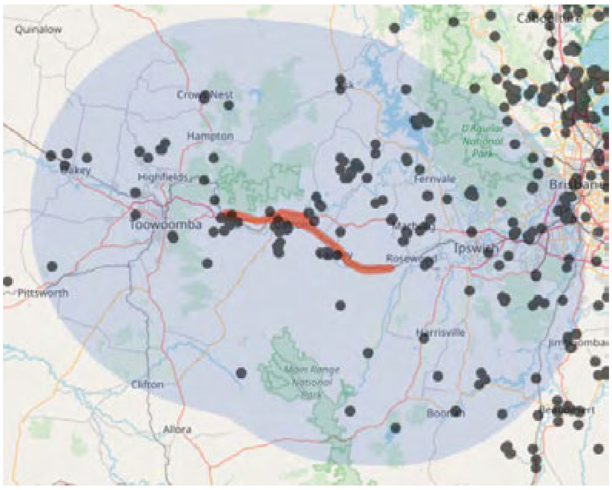

Figure 5.20 **Distribution range of the Latham's Snipe in relation to the Project**

Source: ALA (2020)

5.10.2.4 Biology and reproduction

Latham's snipe is an omnivorous species. It typically feeds on seeds and other plant material (mainly from *Cyperaceae, Poaceae, Juncaceae, Polygonaceae, Ranunculaceae* and *Fabaceae* families), and on invertebrates, including insects (mainly flies and beetles), earthworms and spiders, and occasionally molluscs, isopods and centipedes (Frith et al. 1977, Todd 2000).

Latham's snipe does not breed in Australia; instead it breeds in Japan and eastern Russia (DotEE 2018).

5.10.3 Habitat

In Australia, Latham's snipe occurs in permanent and ephemeral wetlands up to 2,000 m above sea- level. They typically inhabit open, freshwater wetlands with low, dense vegetation (eg swamps, flooded grasslands or heathlands, around bogs and other water bodies. However, they are also known to occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (DotEE 2018, Frith et al. 1977; Naarding 1983).

The foraging habitats of Latham's snipe are typically characterised by areas of mud (either exposed or beneath a very shallow covering of water), and some form of cover (eg low, dense vegetation) (Frith et al. 1977, Todd 2000).

The Latham's snipe roosts on the ground near (or sometimes in) their foraging areas, usually in sites that provide some degree of shelter (eg beside or under clumps of vegetation, among dense tea-tree, in forests, in drainage ditches or plough marks, among boulders, or in shallow water if cover is unavailable) (Frith et al. 1977, Naarding 1981, 1983).

Latham's snipe could potentially occur in Bluegrass (*Dichanthium*) dominant grasslands of the Brigalow Belt Bioregions (north and south), if this community is subject to flooding (DotEE 2018).

5.10.4 Threatening processes

The following have been identified as potentially threatening processes to the Latham's snipe:

- Loss of habitat caused by the drainage, modification of wetlands, agriculture and development of land (Frith et al. 1977, Naarding 1985)
- Easily disturbed by the intrusion of humans or cattle into their habitats (Naarding 1983)
- Pollution of wetlands.

5.10.5 Threat abatement/recovery plans

The following Threat abatement plan and Wildlife Conservation Plan have been identified as being relevant for this species:

- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.
- Commonwealth of Australia (2015). Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.10.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.10.7 References

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5.11 Marsh sandpiper (*Tringa stagnatilis*)

5.11.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.11.2 Biology and ecology

5.11.2.1 Characteristic

The Marsh sandpiper (*Tringa stagnatilis*) is a medium sized sandpiper approximating 22 to 26 cm in length with a wingspan of 40 to 45 cm and a weight approximating 70 g. They have a straight, black needle-like bill with a white face and proportionately larger, stilt-like legs of yellow-green colouring (refer Photograph 5.11). In all plumages, the species shows a contrasting outer-wing with black shoulders and flight feathers, a very pale whitish tail and a bold white wedge up the back (Higgins and Davies 1996, Pizzey and Knight 2007).

During breeding their upper body feathers have dark brown centres and buff-grey edges, notches and bars with dark streaks on the neck and v-bars on their flanks (Pizzey and Knight 2007).

Photograph 5.11 Marsh sandpiper (*Tringa stagnatilis*)

Source: Keats (2018)

5.11.2.2 Known distribution

The Marsh sandpiper is found on coastal and inland wetlands throughout Australia (refer Figure 5.21). The species is widespread in coastal Queensland, but few records exist north of Cooktown. They migrate through Africa, India, -South-east Asia and Australasia from August to May but breed in the Northern Hemisphere near Austria through to Mongolia (DotEE 2018).

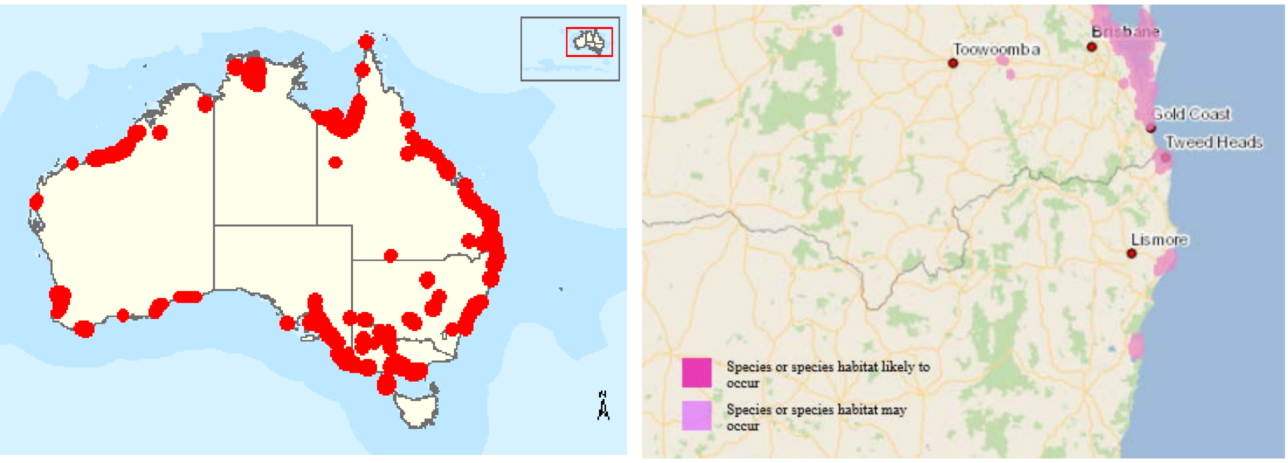

Figure 5.21 Distribution range of the Marsh sandpiper

Source: DotEE (2018)

5.11.2.3 Distribution in relation to the Project

Tringa stagnatilis has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area two records from 2010 and 2014 south of the disturbance footprint and west of Gatton. Several records occur within the ecology study area between Forest Hill and Laidley from 2001, 2002 and 2003. Numerous records occur within approximately 5 km of the disturbance footprint at Gatton and Laidley. Occurrence records from within a 50 km buffer of the disturbance footprint are largely absent to the south and south-west with scattered records in all other directions. Records outside of 50 km from the disturbance footprint are concentrated around the coast to the east.

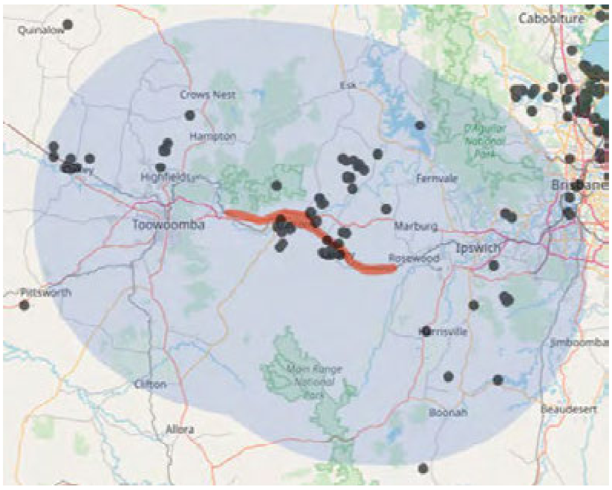

Figure 5.22 **Distribution range of the Marsh sandpiper in relation to the Project**

Source: ALA (2020)

5.11.2.4 Biology and reproduction

The Marsh sandpiper is carnivorous and feeds on insects, molluscs and crustacean. Plant material has been found in stomachs, but this may have been ingested incidentally (DotEE 2018, Higgins and Davies 1996).

The Marsh sandpiper does not breed in Australia. They breed in the Northern Hemisphere near Austria through to Mongolia (DotEE 2018).

5.11.3 Habitat

Preferred habitat of the Marsh sandpiper includes permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. They are found infrequently around mangroves (DotEE 2018, Higgins and Davies 1996, Pizzey and Knight 2007).

The Marsh sandpiper typically forages in shallow water at the edge of wetlands by probing wet mud of mudflats or feed among marshy vegetation (Higgins and Davies 1996).

5.11.4 Threatening processes

The following have been identified as potentially threatening processes to the Marsh sandpiper:

- Within Australia, there are a number of threats common to the Marsh sandpiper, including land clearing, inundation, infilling or draining and changes in water quality, hydrology or structural changes near roosting and foraging sites. Some sites are important all year round for juveniles who may stay in Australia throughout the breeding season until they reach maturity (DEWHA 2009).

- Other threats may be the invasion of intertidal mudflats by weeds, exposure of acid sulphate soils, hence changing the chemical balance at the site and direct human impacts like fishing, power boating, four-wheel driving, walking dogs, noise and night lighting (DEWHA 2009).

5.11.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016**. In effect under the EPBC Act from 15-Jan-2016.

5.11.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.11.7 References

Atlas of Living Australia, (2020). *Tringa stagnatilis* – Marsh sandpiper, available https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:9b16d860-d0ec-4b6a-8489-948d85e32016. [Accessed: 28 August 2020].

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Lane, B.A. (1987). *Shorebirds in Australia*. Sydney, NSW: Reed.

5.12 Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.Oriental cuckoo (*Cuculus optatus*)

5.12.1 Status

EPBC Act – Migratory (CAMBA)

5.12.2 Biology and ecology

5.12.2.1 Characteristic

The Oriental cuckoo (*Cuculus optatus*) measures approximately 28 to 34 cm in length. The sexes are similar in appearance, the male being slightly larger than the female. The upper parts of the bird are grey, with a bronze gloss, and the tail is dark grey and black, spotted, and tipped white (refer Photograph 5.12). The flight feathers are grey, with pale bars. The chin, throat and upper breast is grey, and strongly barred with black (Schodde and Tidemann 2010).

Photograph 5.12 Oriental cuckoo (*Cuculus optatus*)

Source: eBird Australia (2015)

5.12.2.2 Known distribution

Oriental cuckoos are non-breeding migrants from Asia, wintering across northern Australia from the Kimberley region in Western Australia, to Brisbane in Queensland, and occasionally south to Narooma, NSW (Schodde and Tidemann 2010) (refer Figure 5.23).

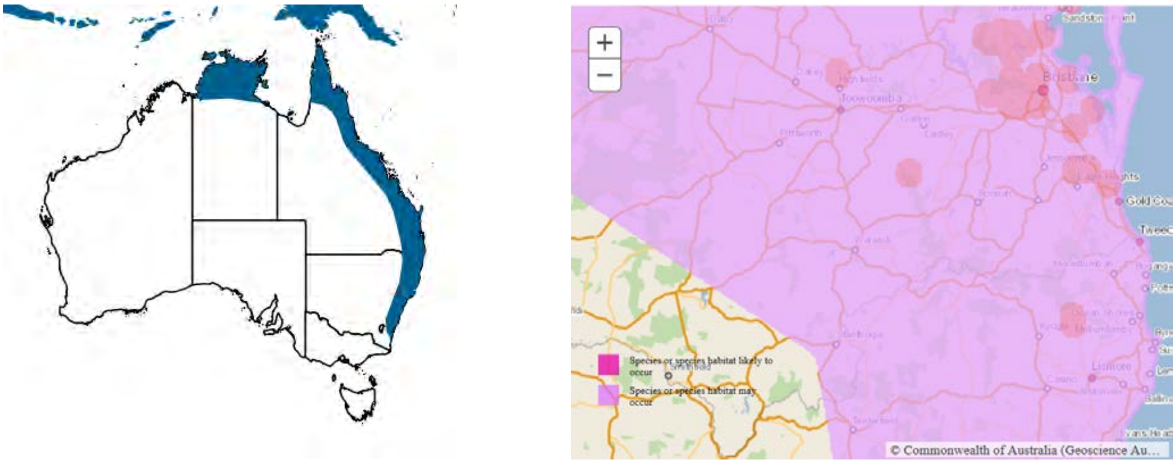

Figure 5.23 **Distribution range of the Oriental cuckoo**

Source: ALA (2020), DotEE (2018)

5.12.2.3 Distribution in relation to the Project

Cuculus optatus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within approximately 2 km south of the disturbance footprint with two records at Helidon dated 2014. Occurrence records within a 50 km buffer of the disturbance footprint occur to the west at Toowoomba Range, north between Laidley and Esk, north-east from Rosewood to D'Aguilar National Park and east to Brisbane with a few scattered records to the south between the alignment and Main Range National Park. Records outside of 50 km from the disturbance footprint occur to the east along the coast.

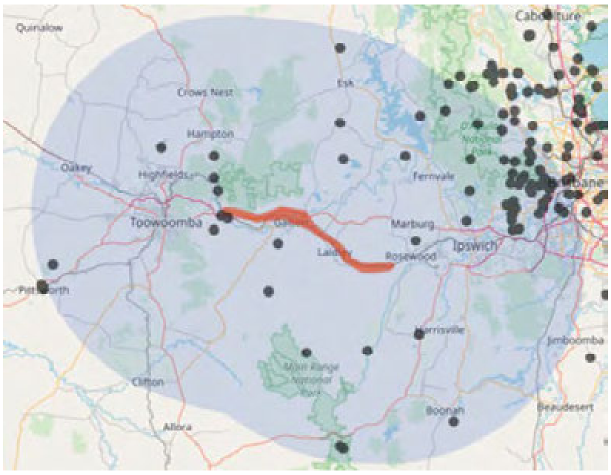

Figure 5.24 **Distribution range of the Oriental cuckoo in relation to the Project**

Source: ALA (2020)

5.12.2.4 Biology and reproduction

Oriental cuckoos feed predominately on caterpillars, stick insects, ants and beetles. They forage in trees, bushes, and the ground. Once the prey has been captured, this species typically flies to a tree branch to batter and consume its prey (Schodde and Tidemann 2010).

The Oriental cuckoo migrates from its breeding grounds in Eurasia each Autumn, to non-breeding winter grounds in southern Asia, Indonesia, New Guinea and Australia. It arrives along the northern Australian coast in November to -December, departing again in April (Schodde, and Tidemann, 2010).

5.12.3 Habitat

Oriental cuckoos inhabit monsoon forests, wet sclerophylla forests, paperbark swamps, dense open forests, scrubby gullies, and mangroves and is also known to use rainforest edges, leafy trees in paddocks, river flats and roadsides. This species prefers dense vegetation with a closed canopy (Pizzey and Knight 2007; Schodde and Tidemann 2010).

5.12.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Oriental cuckoo.

5.12.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.12.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat.

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

5.12.7 References

Atlas of Living Australia (2020). *Cuculus optatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:b34cd2f6-79b3-4eee-9cf3-18a489d5d5fc [Accessed: 24 August 2020].

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Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.13 Oriental plover (*Charadrius veredus*)

5.13.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – Special Least Concern

BC Act – Not listed

5.13.2 Biology and ecology

5.13.2.1 Characteristic

Oriental plover (*Charadrius veredus*) is a medium sized (length approximately 12 to 25 cm) plover with slender long legs weighing approximately 95 g. The Oriental plover has a white head, faint brown cap and ear coverts. There is a black line between chestnut breast with a white belly (refer Photograph 5.13). The female is duller and has a fawn breast that is well defined. The Oriental plover has a fine black bill, brown eyes and legs and feet varying from a yellow or orange to neutral tones or greenish (Simpson and Day 2004).

In non-breeding plumage, both sexes have a brown crown and nape, a pale brown hindneck, and the rest of the upperparts are brown. The face is buff with slightly paler forehead and the chin and throat are pale buff, and the breast is pale brownish, with the rest of the underparts white. Juveniles are similar to adults in non-breeding plumage except that they have more noticeable buff scaling on the fringes of the feathers of the upperparts and a mottled breast (Haymen et al. 1986; Marchant and Higgins 1993).

Photograph 5.13 Oriental plover (*Charadrius veredus*)

Source: Knight (2006)

5.13.2.2 Known distribution

The Oriental plover is a non-breeding visitor to Australia, commonly found in both coastal and inland areas in northern Australia. Majority of records are along the north-western coast, between Exmouth Gulf and Derby in Western Australia. A few scattered records exist mainly along the northern coast, such as in the Top End, The Gulf of Carpentaria and on Cape York Peninsula (refer Figure 5.25). The species also occur further inland on the ‘blacksoil’ plains of northern Western Australia, the Northern Territory and north-western Queensland. The Oriental plover has also been recorded on Lord Howe Island and Christmas Island (DotEE 2018; McAllan et al. 2004).

The Oriental plover breeds in scattered locations in northern and eastern Mongolia, from the Dzavhan Gol River and Khangai Ranges, east to the Kerulen River and south to the eastern Gobi Desert, and also in adjacent regions of north-western Manchuria and south-eastern Siberia (DotEE 2018).

The species passes through China with occasional records of birds on passage through the Korean Peninsula, Japan, Hong Kong, Philippines, South-east Asia, Micronesia and Melanesia (DotEE 2018).

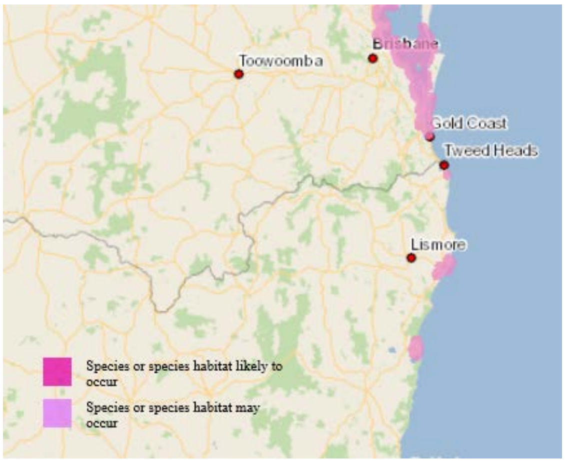

Figure 5.25 Distribution range of the Oriental plover

Source: ALA (2020); DotEE (2018)

5.13.2.3 Distribution in relation to the Project

Charadrius veredus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area with a record from 1991 located south of the disturbance footprint to the west of Gatton. The next nearest record from 2013 occurs within approximately 5 km of the disturbance footprint south of Gatton. Specimen backed records from within a 50 km buffer of the disturbance footprint occur to the north with several records at Atkinson Lagoon and Seven Mile Lagoon. Several records also occur at Archerfield, south Brisbane more than 45 km from the disturbance footprint.

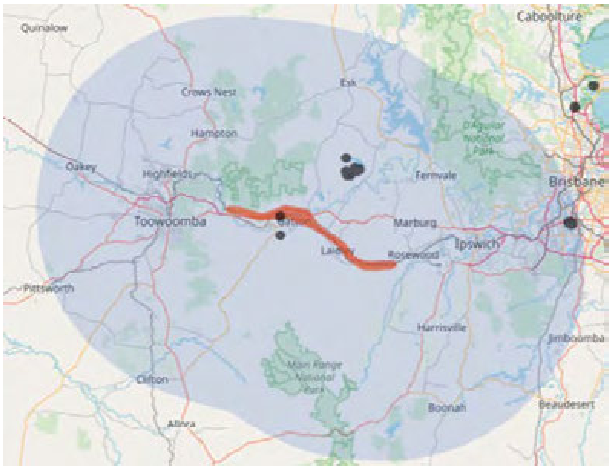

Figure 5.26 Distribution range of the Oriental plover in relation to the Project

Source: ALA (2020)

5.13.2.4 Biology and reproduction

The Oriental plover has little information regarding diet, but it is believed to feed primarily on insects, snails and seeds extracted from mud flats and coastal areas. The species usually feeds in small groups or in larger flocks of hundreds or even thousands of individuals, often mixing with other shorebirds. The Oriental plover is believed to forage for food mainly at night, typically by running and stopping to peck at the substrate to probe for food (Brazil 2009; del Hoyo et al. 1996, DotEE 2018).

Little is known about the reproduction of the Oriental plover, other than the species breeds from April to July and the female tends to the chicks alone. Information regarding age of sexual maturity and life expectancy are unknown. The closely related Caspian plover *(Charadrius asiaticus)* reaches sexual maturity at approximately two years old, is it thought that the Oriental plover would be similar (DotEE 2018; Wiersma 1996).

5.13.3 Habitat

When first arriving in Australia, Oriental plovers are known to spend a few weeks in coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland. Thereafter the species is known to inhabit flat, open, semi-arid or arid grasslands, where the grass is short and sparse, and scattered with hard, bare ground such as claypans, dry paddocks, playing fields, lawns, cattle camps or open areas recently affected by fire. During the wet season, the Oriental plover is known to move into lightly wooded grassland, estuarine and coastal environments. A few sightings have been recorded around terrestrial wetlands, flooded paddocks and saltmarsh areas in South Australia (Bigg 1981; Chatto 2003; Park 1983).

When foraging for food the Oriental plover is found in areas of short grass, hard stony ground, mudflats or among beachcast seaweed on beaches. The species roosts on soft wet mud or in shallow water of beaches and tidal flats and also occasionally in dry, open habitats such as saltmarsh or paddocks (Bigg 1981; McCrie 1984).

The Oriental plover does not breed in Australia, but in the northern, eastern and western parts of Mongolia. The chosen breeding habitat is in arid elevated areas on extensive open upland flats, mountain ridges or areas where sparse vegetation such as moss, short grass in found. This species does not rely on a listed threatened ecological community (Wiersma 1996).

5.13.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Oriental plover.

5.13.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan has been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.13.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.13.7 References

Atlas of Living Australia, (2020), *Charadrius veredus* - Oriental plover, Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:20a102bc-20b2-4832-8da5-a1e532180d26. [Accessed: 28 August 2020]

Bigg, R. (1981). Oriental Plovers near Newcastle. Australian Birds. 15:54.

BirdLife International (2018) Species factsheet: *Charadrius veredus*. Available from: http://www.birdlife.org [Accessed: 22 August 2018].

Brazil, M. (2009) Birds of East Asia. AandC Black Publishers, London.

Chatto, R. (2003). The Distribution and Status of Shorebirds Around the Coast and Coastal Wetlands of the Northern Territory. Northern Territory Parks and Wildlife Commission Technical Report 73.

del Hoyo, J., Elliott, A. and Sargatal, J. (1996) Handbook of the Birds of the World. Volume 3: Hoatzin to Auks. Lynx Edicions, Barcelona

Department of the Environment and Energy (DEE), (2018), Species Profile and Threats Database – *Charadrius veredus* – Oriental Plover, Available from: www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=882. [Accessed: 22 August 2018].

Hayman, P., J. Marchant and T. Prater, (1986) Shorebirds. An identification guide to the waders of the world. London and Sydney: Croom Helm.

Knight, R. (2006). Oriental plover (Charadrius veredus). [image] [online] Available from: https://www.flickr.com/photos/sussexbirder/8074121362/in/photolist-ditYZ1-qDnHs6-257YM3g. [Accessed: 17 September 2019].

Marchant, S. and P.J. Higgins, eds. (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapings. Melbourne, Victoria: Oxford University Press.

McAllan, I.A.W., B.R. Curtis, I. Hutton & R.M. Cooper, 2004. The birds of the Lord Howe Island Group: a review of records. Australian Field Ornithology 21 (suppl.): 1–82.

McCrie, N. (1984). Further records of the Oriental Plover and a reassessment of some problems in field identification. South Australian Ornithologist. 29:106-107.

Park, P. (1983). Orielton Lagoon and Sorell wader areas. Occasional Stint. 2:15-33

Simpson, K., and Day, N. (2004), Field Guide to the Birds of Australia, 7th ed. Australia: Penguin, 100.

Wiersma, P. (1996). Charadriidae (Plovers) species accounts. In: del Hoyo, J., A. Elliott and J. Sargatal, eds. Handbook of the Birds of the World. Volume 3. Hoatzin to Auks. Page(s) 411-442. Barcelona: Lynx Edicions.

5.14 Pacific golden plover (*Pluvialis fulva*)

5.14.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.14.2 Biology and ecology

5.14.2.1 Characteristic

The Pacific golden plover (*Pluvialis fulva*) is a medium -sized bird, with long legs and a typical upright stance. This species measures approximately 23 to 26 cm in length and weighs approximately 120 to 175 g in weight. The sexes appear almost identical in their appearance. In non-breeding plumage, the Pacific golden plover's crown is dark brown, with golden streaks. Its nape and hindneck are slightly paler, and the forehead, lores, supercilium, chin, throat and sides of the head are all golden or creamy. The birds' upperparts are dark brown, are strongly pronounced with bright golden scaly-shaped spots. The secondary coverts exhibit white spots, which contrasts with the golden spots of both the mantle and scapulars. The fore neck and breast are both golden with grey-brown streaks, whilst the belly, flanks and under tail are white. The flanks have fine grey-brown streaks (refer Photograph 5.14). Adult breeding plumage displays bold golden spots on the crown and hindneck. This species also exhibits a white forehead, which extends as a broad supercilium, curving around the ear coverts to the sides of the neck. Its upperparts are brownish, and boldly spotted with gold. The tail is dark brown, with golden-buff bars (DotEE 2018; Marchant and Higgins 1993).

Photograph 5.14 Pacific golden plover (*Pluvialis fulva*)

Source: Kavanagh (2018)

5.14.2.2 Known distribution

The Pacific golden plover breeds mainly in northern Siberia and the western parts of Alaska. During the nonbreeding season, Pacific golden plovers are considered widespread in coastal habitats of Asia, Australasia, Melanesia and Polynesia. In Australia, the Pacific golden plover is widespread in coastal regions and recorded across all States and Territories (refer Figure 5.27). Most Pacific golden plovers occur along the east coast and are considered widespread along the Queensland and NSW coastlines (DotEE 2018; Marchant and Higgins 1993).

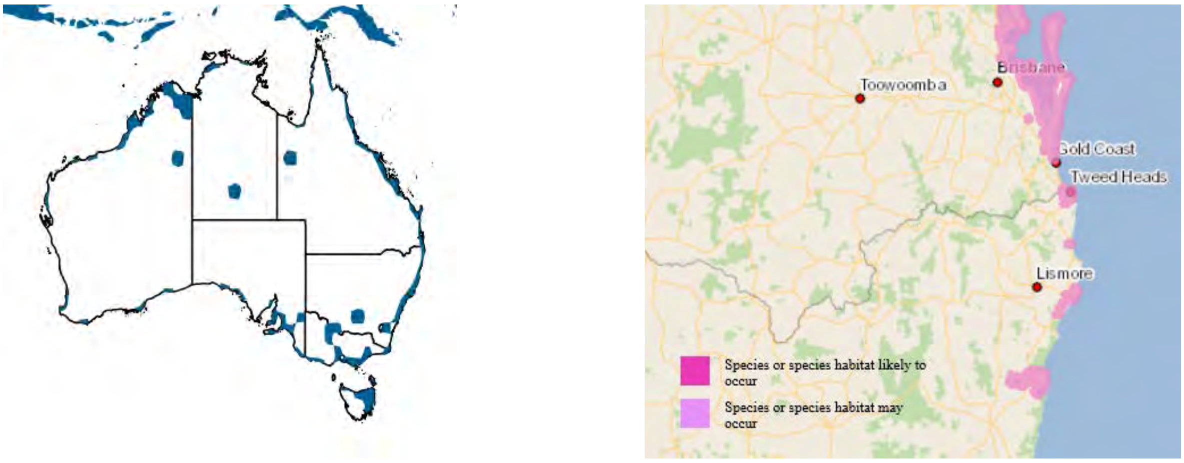

Figure 5.27 **Distribution range of the Pacific golden plover**

Source: ALA (2020); DotEE (2018)

5.14.2.3 Distribution in relation to the Project

Pluvialis fulva has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within 5 km south of the disturbance footprint at Gatton from 1998. A record from 2016 occurs within 5 km south of the disturbance footprint at Lake Dyer to the west of Laidley. Other records within a 50 km buffer of the disturbance footprint occur to the west at Toowoomba Range, to the north between Gatton and Lake Wivenhoe and to the east between Rosewood and Brisbane. Most records outside of 50 km occur to the east along the coast.

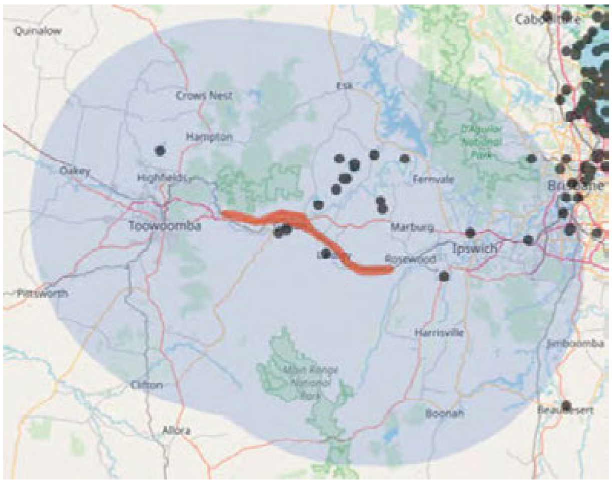

Figure 5.28 **Distribution range of the Pacific golden plover in relation to the Project**

Source: ALA (2020)

5.14.2.4 Biology and reproduction

Molluscs, polychaete worms, insects, larvae, spiders and crustaceans form the typical diet of a Pacific golden plover during the nonbreeding season (Evans 1975).

The species does not breed in Australia. Pacific golden plovers leave their breeding grounds in Siberia and Alaska in mid-July to -October (Marchant and Higgins 1993).

5.14.3 Habitat

Pacific golden plovers typically occur in coastal habitats, though it is known to occasionally occur around inland wetlands. They usually occur on beaches, mudflats and sandflats, mainly in sheltered areas (eg harbours, estuaries, lagoons, evaporation ponds in saltworks). In a terrestrial setting, this species is known to inhabit short grassed paddocks, crops or airstrips, sewage ponds, sports fields, and ploughed or recently burnt areas (DotEE 2018; Marchant and Higgins 1993; Pizzey and Knight 2007).

5.14.4 Threatening processes

The following have been identified as potentially threatening processes to the Pacific golden plover:

- Pollution, with subsequent eutrophication, adversely affects food sources
- Accumulation of heavy metals, insecticides and herbicides
- Tourist visitation and urban development leading to increased levels of habitat loss and disturbance
- The spread of introduced plants (DotEE 2018).

5.14.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016**. In effect under the EPBC Act from 15-Jan-2016
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). *Marine bioregional plan for the North-west Marine Region*. Prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Available from: **http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north-west**. In effect under the EPBC Act from 27-Aug-2012.

5.14.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon

- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover include:

- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of biodiversity
- Provide regional advice determining the significance of potential impacts
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

5.14.7 References

Atlas of Living Australia (2020). *Pluvialis fulva*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:2f48f306-4ad9-4ec5-bb24-4d4b02e38805 [Accessed: 29 August 2020].

Department of the Environment and Energy (2018). *Pluvialis fulva* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=25545 [Accessed: 29 August 2018].

Evans, P.R. (1975). Notes on the feeding of shorebirds on Heron Island. *Sunbird*. 6:25-30.

Kavanagh, P. (2018). Pacific golden plover (Pluvialis fulva). [image] [online] Available from: https://www.flickr.com/photos/patrick_k59/47015094681/in/photolist-dj9bwr-2eCyDEH-ZLjxE9-Y6eDy4-28dkmVE-qDnHs6-4M9hXQ-6eVioz-qRs49a-4M56Jn-8FQfWn-dajDcf-RZnVEc-3ZFi6x-3QeV5d-3ZKuR1-BB1j1-dKWSCj-moV4Zu-qV9BH9-moTgKZ-pBpTTB-aesa2A-ZSY4Ds-qCERDf-8FTrXh-GbrLuy-GjAQRg-rvePSd-8Spcni-kDfdcY-Hs2MCJ-Hmt4Zd-pt1J6y-NgvQ8h-NAeiPa-8SpcAt. [Accessed: 17 September 2019].

Marchant, S. and Higgins, P.J. eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds.* Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.15 Pectoral sandpiper (*Calidris melanotos*)

5.15.1 Status

EPBC Act – Marine and Migratory (Bonn, JAMBA, ROKAMBA)

5.15.2 Biology and ecology

5.15.2.1 Characteristic

The Pectoral sandpiper (*Calidris melanotos*) has a length of approximately 19 to 23 cm and males tend to be larger. They are similar to Sharp-tailed sandpiper (*Calidris acuminata*) (refer Section 5.20) but plainer, browner and with a longer neck. It has a straight or slightly decurved bill that is only just longer than its head. The legs are dull olive-yellow, yellow or olive-grey, that are usually brighter than the Sharp-tailed sandpiper. The long feathers of the upperparts have pointed dark centres with pale brown margins. The underparts are whitish buff and sparsely streaked with dark brown or black streaking/mottling on the neck and breast (refer Photograph 5.15). (Pizzey and Knight 2007).

Photograph 5.15 Pectoral sandpiper (*Calidris melanotos*)

Source: Cannizzaro (2016)

5.15.2.2 Known distribution

The Pectoral sandpiper breeds in northern Russia and North America. During the non-breeding season, the species migrates south from August to May. In Australia, it is widespread but most common in eastern Queensland and south-eastern Australia (refer Figure 5.29) (Pizzey and Knight 2007).

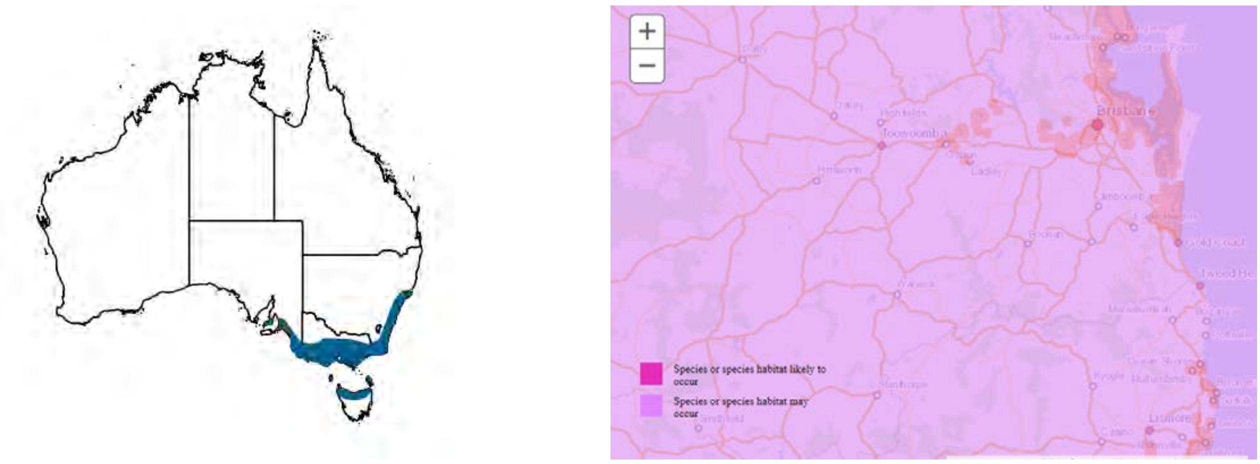

Figure 5.29 Distribution range of the Pectoral sandpiper

Source: ALA (2020), DotEE 2018

5.15.2.3 Distribution in relation to the Project

Calidris melanotos has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within approximately 3 km north of the disturbance footprint at Gatton with three records from 2009 and 2010 another record to the south-west at the University of Queensland is dated 2013. The next nearest records are more recent (2018) from Lake Clarendon located within approximately 10 km form the disturbance footprint. Other records for this species from within a 50 km buffer occur to the west at Oakey, north between Atkinsons Lagoon and Lowood and to the east near Ipswich. Other records outside of a 50 km buffer occur to the east near the coast.

Figure 5.30 **Distribution range of the Pectoral sandpiper in relation to the Project**

Source: ALA (2020)

5.15.2.4 Biology and reproduction

In Australia, the Pectoral sandpiper is omnivorous, consuming algae, seeds, crustaceans, arachnids and insects (Higgins and Davies 1996).

This species does not breed in Australia and they migrate to north-eastern Siberia and North America to breed and nest (Higgins and Davies 1996).

5.15.3 Habitat

In Australia, the Pectoral sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. It is occasionally found further inland within wetlands and inundated vegetation (Higgins & Davies 1996).

5.15.4 Threatening processes

The following have been identified as potentially threatening processes to the Pectoral sandpiper:

- Habitat loss reducing the availability of foraging and roosting sites
- Habitat degradation including loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds, water pollution and changes to the hydrological regime and exposure of acid sulphate soils
- Disturbance from residential and recreational activities (DEWHA 2009).

5.15.5 Threat abatement/recovery plans

No abatement/recovery Plan has been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.15.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.15.7 References

Atlas of Living Australia (2020). *Calidris melanotos*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:186ec2cd-8267-4162-8c0a-7c6bc51262c2 [Accessed: 20 September 2020].

Cannizzaro, A. (2016). Pectoral sandpiper (*Calidris melanotos*). [image] [online] Available from: https://www.flickr.com/photos/acryptozoo/29119997223/in/photolist-qSpBqG-BhZinu-cRHTMG-pHjnZN-g1AAkj-g1APDA-oL5iJU-oNv7pC-LneADD-au69FW-eUyr8Q-UTHojX-cXywrQ-Uxjt8E-rDgqWE-bBcp48-VH3Z3A-p84mDi-vYJU2Y. [Accessed: 17 September 2019].

Department of the Environment and Energy (2018). *Calidris melanotos* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=858. [Accessed: 24 August 2018].

Department of the Environment, Water, Heritage and the Arts (2009). Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html. [Accessed: 24 August 2018].

Higgins, P.J. and Davies S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.16 Red-necked phalarope (*Phalaropus lobatus*)

5.16.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.16.2 Biology and ecology

5.16.2.1 Characteristic

The Red-necked phalarope (*Phalaropus lobatus*) has a length of 18 to 19 cm, a wingspan of 31 to 34 cm and a weight of 34 g. It has a small head, slender neck, short straight needle-like bill, short legs and feet with lobed toes. All plumages show a bold white wing-bar with white sides to a dark-centred rump and uppertail coverts (refer Photograph 5.16). The species has white underwings with a contrasting dark trailing edge and markings on the coverts. It also has a black mark that curves through the eye onto the ear-coverts. During the breeding season they have a rust-colored throat patch with the female being somewhat more brightly colored than the male. The juvenile form is darker than the nonbreeding adult form with a dark forehead that connects to the black eye marks, a pinkish buff breast and neck and golden-buff fringing on the upperparts (Higgins and Davies 1996).

Photograph 5.16 Red-necked phalarope (*Phalaropus lobatus*)

Source: Shah (2018)

5.16.2.2 Known distribution

The Red-necked phalarope breeds in the Arctic and subarctic North America, Europe and Russia. During the nonbreeding season they are found in northern South America, southern Arabian Peninsula, SE Asia and Australia. In Australia, they are found across all States and Territories (refer Figure 5.31). In Queensland the species has been found near Lake Moondarra, Mount Isa, Hood's Lagoon and Helidon and near Guyra in NSW (Higgins and Davies 1996).

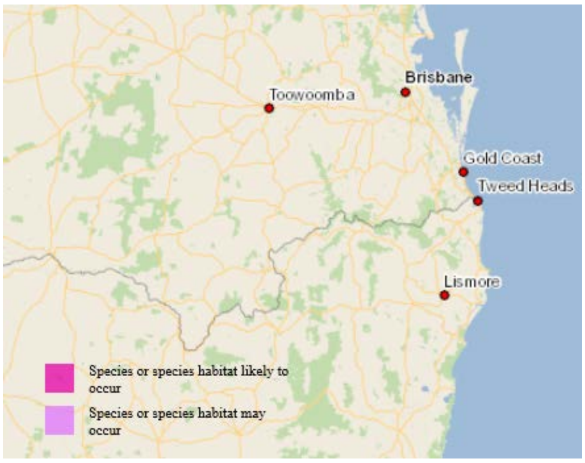

Figure 5.31 **Distribution range of the Red-necked phalarope**

Source: ALA (2020); DotEE (2018)

5.16.2.3 Distribution in relation to the Project

Phalaropus lobatus has been identified as potentially occurring within the ecology study area. Two database records (i.e. AoLA) indicate this species occurs within the ecology study area to the west of the disturbance footprint at Helidon. A single record also occurs at Helidon within approximately 2 km south of the disturbance footprint. All of these records are dated 1988 and are not recent. No other records exist for this species from within a 50 km buffer of the disturbance footprint. The next closest record outside of 50 km buffer occurs to the east approximately 100 km from the disturbance footprint.

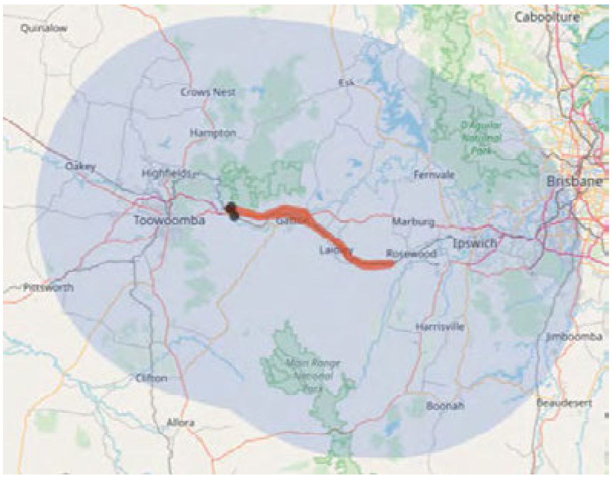

Figure 5.32 **Distribution range of the Red-necked phalarope in relation to the Project**

Source: ALA (2020)

5.16.2.4 Biology and reproduction

There is limited information on the feeding habits of the Red-neck phalarope. The species is known to eat invertebrates in the open water, and very rarely on mudflats (Higgins and Davies 1996).

Red-necked phalaropes do not breed in Australia. They breed in the Arctic and subarctic North America, Europe and Russia. They migrate to Australia from mid-October to early-April (Higgins and Davies 1996).

5.16.3 Habitat

During non-breeding period the Red-necked phalarope occurs mainly at sea. In Australia it is recorded at both inland and coastal lakes/swamps, including highly saline waters and artificial wetlands (Higgins and Davies 1996).

5.16.4 Threatening processes

The following have been identified as potentially threatening processes to the Red-necked phalarope:

- Habitat loss (i.e. land clearing, inundation and infilling or draining)
- Habitat degradation (i.e. loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds such as cord grass, water pollution and changes to the water regime, changes to the hydrological regime and exposure of acid sulphate soils)
- Disturbance (i.e. fishing, power boating, four-wheel driving, walking dogs, noise and night lighting)
- Direct mortality (DEWHA 2009).

5.16.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016**. In effect under the EPBC Act from 15-Jan-2016.

5.16.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.16.7 References

Atlas of Living Australia (2020). *Phalaropus lobatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:8f9d4df2-c40d-4bee-b676-f5c52c8c2688#overview [Accessed: 29 August 2020].

Department of the Environment, Water, Heritage and the Arts (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html [Accessed: 24 August 2018].

Department of the Environment and Energy (2018). *Phalaropus lobatus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=838. [Accessed: 24 August 2018].

Higgins, P.J. and Davies S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Shah, I. (2018). Red-necked phalarope (*Phalaropus lobatus*). [image] [online] Available from: https://www.flickr.com/photos/gilgit2/32377651848/in/photolist-29dtJwj-RSK92b-BQr4ft-Ts2diV-2aLo1ce-Rk6VSG-Y82KVC-2czorkX-LLVv9B-JrutvK-222shQ8-DUS6tc-BZTCtd-CzBiXk-212q5o3-zeHrGa-a38CM2-YkuCnz-oUXior-a9X2v2-fHL1oE-aba6dB-6WKZuA-5kSEBs-fUJbox-7XPdT7-QWYDee-7XKWzF-NuZFxE-7XKWsD-M9t9CE-eogBuB-MZy4pV-7XKWR4-P1jVkL-mwywse-8Ak86R-4PhM5D-pzvaVi-5hpMgm-eogEvD-ajgGMH-fw4kjF-fHL3ro-v6YAZ9-nwwCWR-vb6czu-wHLquq-nH2Gan-34wvXt. [Accessed: 17 September 2019].

5.17 Red-necked stint (*Calidris ruficollis*)

5.17.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – Special least concern

BC Act – Not listed

5.17.2 Biology and ecology

5.17.2.1 Characteristic

The Red-necked stint (*Calidris ruficollis*) is approximately 13 to 16 cm in length, weighs 25 g and has a wingspan between 29 and 33 cm. The legs are short and dark and the bill is straight or slightly decurved, with a bulbous tip. In non-breeding plumage, the upper parts are brown and grey-brown, with most feathers pale-edged, giving a mottled effect (refer Photograph 5.17). It also has a pale eye-stripe. The rump and tail are black and the outer tail-feathers and sides of the rump are white. The underparts are white with some grey on the sides of the breast. In breeding plumage, it has a deep salmon-pink on the head and nape suffusing into pink on the mantle and wing-coverts. Immature birds are similar to non-breeding adults but browner and the crown is dull rufous (Birdlife Australia 2018).

Photograph 5.17 Red-necked stint (*Calidris ruficollis*)

Source: Kavanagh (2018)

5.17.2.2 Known distribution

The Red-necked stint breeds in Siberia and sporadically in north and west Alaska. During the nonbreeding season they are found in South-east Asia and Australasia (refer Figure 5.33). It is distributed along most of the Australian coastline and is found inland in all States when conditions are suitable (Watkins 1993).

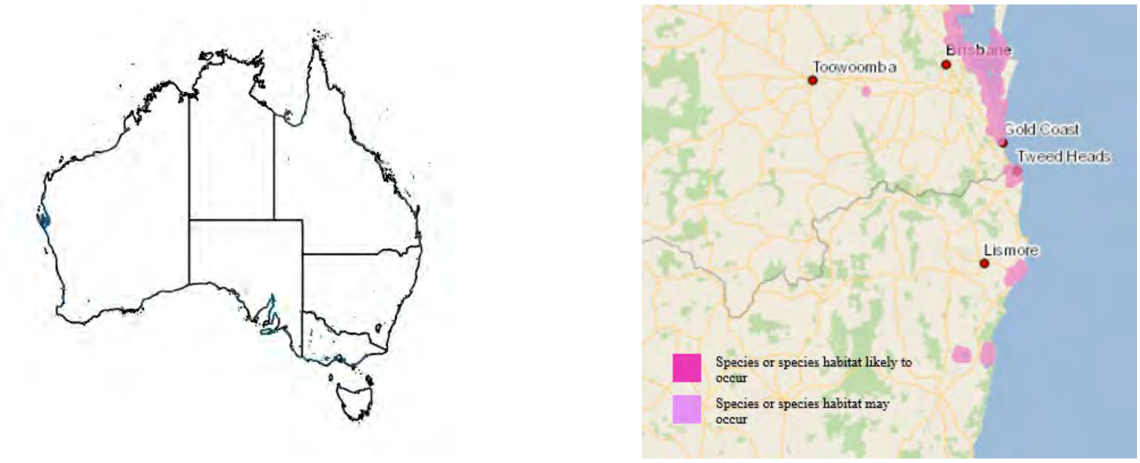

Figure 5.33 Distribution range of the Red-necked stint

Source: ALA (2020); DotEE (2018)

5.17.2.3 Distribution in relation to the Project

Calidris ruficollis has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area recently (2014) to the south of the disturbance footprint to the west of Gatton. Two records occur within approximately 3 km of the disturbance footprint at Lake Dyer to the west of Laidley dated 2000 and 2003. Other records from within a 50 km buffer of the disturbance footprint occur south of Gatton, west of the alignment at Oakey, north-east near Crows Nest, north-east between Gatton and Lake Wivenhoe and to the east with a record at D'Aguilar National Park and the Teviot Range. Most records outside of a 50 km buffer of the disturbance footprint occur to the east along the coast.

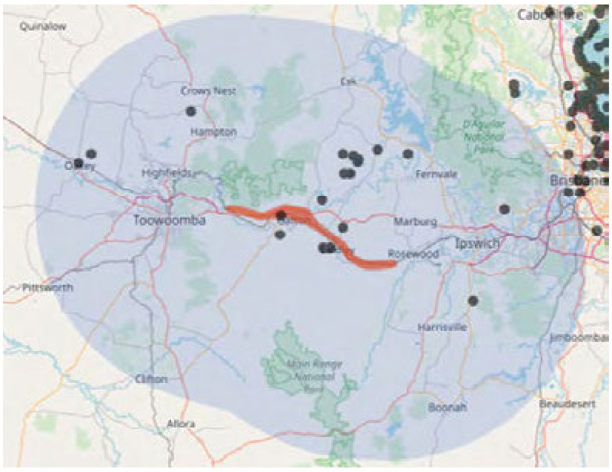

Figure 5.34 **Distribution range of the Red-necked stint in relation to the Project**

Source: ALA (2020)

5.17.2.4 Biology and reproduction

The Red-necked stint forages on plant seeds (such as from *Ruppia* spp. and *Polygonum* spp.) and on a range of invertebrates such as marine worms, molluscs, shrimps, spiders, insects. It will also eat grit (Higgins and Davies 1996).

Red-necked stints do not breed in Australia. They breed in Siberia and west Alaska, laying eggs in June. they migrate to Australia from August to April (Pizzey and Knight 2007).

5.17.3 Habitat

In Australasia, the Red-necked stint is mostly found in coastal areas, including sheltered inlets, bays, lagoons and estuaries with intertidal mudflats. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland (Higgins & Davies 1996).

5.17.4 Threatening processes

The following have been identified as potentially threatening processes to the Red-necked phalarope:

- Habitat loss (i.e. land clearing, inundation and infilling or draining)
- Habitat degradation (i.e. loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds such as cord grass, water pollution and changes to the water regime, changes to the hydrological regime and exposure of acid sulphate soils)
- Disturbance (i.e. fishing, power boating, four-wheel driving, walking dogs, noise and night lighting)
- Direct mortality (DEWHA 2009).

5.17.5 Threat abatement/recovery plans

No threat abatement/recovery plans were identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan were identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016

- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). *Marine bioregional plan for the North-west Marine Region*. Prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Available from: **http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north-west**. In effect under the EPBC Act from 27-Aug-2012.

5.17.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for Red-necked stint include:

- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of the biodiversity
- Provide regional advice determining the significance of potential impact
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

5.17.7 References

Atlas of Living Australia (2020). *Calidris ruficollis*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ba624e08-5847-4c34-96cf-c3b414f00117 [Accessed 16 October 2020].

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Department of the Environment, Water, Heritage and the Arts (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html [Accessed: 16 October 2018].

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Higgins, P.J. and Davies S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Kavanagh, P. (2018). Red-necked stint (*Calidris ruficollis*). [image] [online] Available from: https://www.flickr.com/photos/patrick_k59/47255157842/in/photolist-q7W5xh-pdsrhP-pde1yN-bpWu2W-2cuHRTj-pSE1WQ-CCL9hJ-2eZM35J-mZuD2a-2de3Q8U-28Tdmo9-4UwQxJ-8FDNru-8FDNi7-pddXjw-pSDdbU-pddRsb-q9qwu4-pSEbdW-YnUDKN-mZuzh6-291YB8f-5aqD9C-Ds1Bjg-22td3yU-8FDNoq-TjC2XC-2emUzX1-291YAnC-DnvyPK-291YAJj-ditXU4. [Accessed: 17 September 2019].

Nicolson, K. (2018). *Calidris ruficollis* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ba624e08-5847-4c34-96cf-c3b414f00117 [Accessed 16 October 2018].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

5.18 Rufous fantail (*Rhipidura rufifrons*)

5.18.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act – Special least concern

BC Act – Not listed

5.18.2 Biology and ecology

5.18.2.1 Characteristic

Adult Rufous fantail (*Rhipidura rufifrons*) are medium sized birds, typically ranging in size from 14.5 to 18.5 cm in length, with a wingspan averaging of 21 cm. Both male and female specimens appear identical except for size, with males being slightly larger than females. The forehead is a rich reddish-brown colour across the eyes. The eyes have a white arc underneath. The top of the head, back of the neck and the upper back, transition from an olive to reddish-brown colour, which then blends into a blackish-brown, long, fan-shaped tail. This blackish-brown tail, contrasts with the base of the tail, which is tipped with a paler colour, often white (DotEE 2018, Higgins et al. 2006) (refer Photograph 5.18).

The Rufous fantail has black feathers over the ears and the throat is white. A black bar is present across the upper breast, below which the lower breast is off-white with black scale-like spots which transitions into an off-white colour towards the centre of the abdomen. The eyes, bill and feet of the bird are all a brown colour. The plumage in the immature birds is similar to that of adults. Adults moult annually prior to the breeding season, and this basic plumage does not vary (Higgins et al. 2006).

Photograph 5.18 **Rufous fantail (*Rhipidura rufifrons*)**

Source: Lostandcold (2009)

5.18.2.2 Known distribution

The Rufous fantail occurs in coastal and near coastal districts of northern and eastern Australia. They also migrate north into much of SE Asia (Lindsey 1992) (refer Figure 5.35).

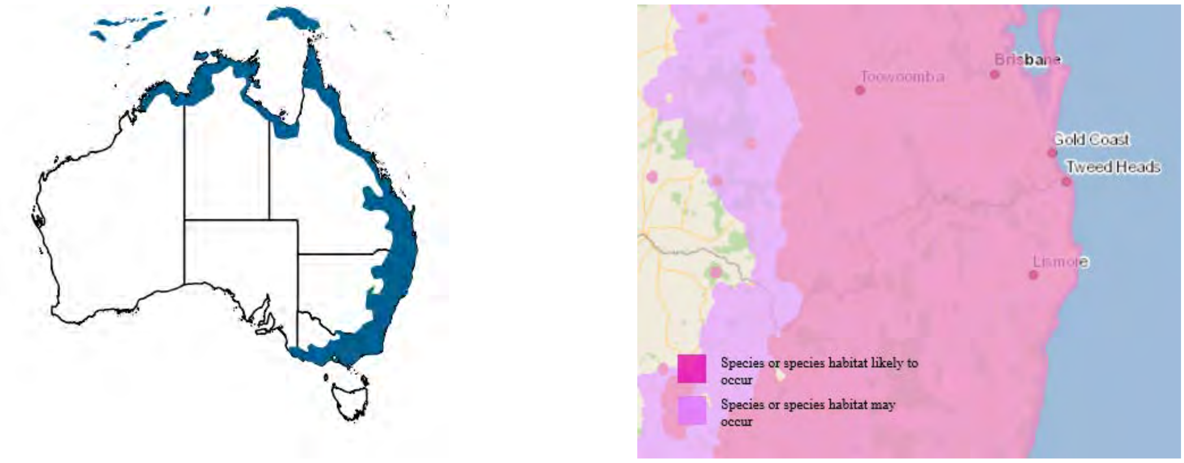

Figure 5.35 **Distribution range of the Rufous fantail**

Source: ALA (2020); DotEE (2018)

5.18.2.3 Distribution in relation to the Project

Calidris ruficollis has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study area with two records to the south of the disturbance footprint at Helidon dated 1999 and 2000. Another record from Gatton occurs within the ecology study area however this is an old record dated 1974. Multiple records for this species occur in all directions around the disturbance footprint indicating this is an abundant species.

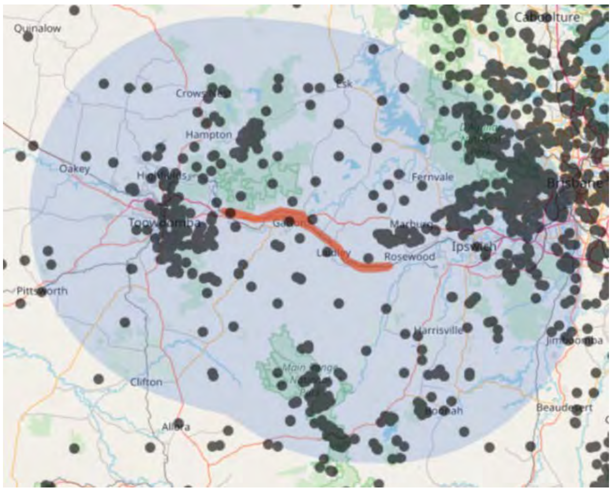

Figure 5.36 Distribution range of the Rufous fantail in relation to the Project

Source: ALA (2020)

5.18.2.4 Biology and reproduction

The Rufous fantail is an insectivorous species and typically gleaning and sallying in the low to middle strata of forests (Higgins et al., 2006).

The Rufous fantail is usually seen singly or in pairs, but occasionally in small groups. On winter passage, they have been observed in small flocks. The Rufous fantail generally breeds between September to February, with most individuals producing clutches between November to December. Clutch size approximates between two or three eggs, but as many as four have been recorded. Eggs are laid in a small cup-shaped nest which is usually constructed from grass, roots, fine strips of bark, plant-fibre, decayed wood, moss and spider web. The nest is placed in a tree, shrub or vine about 1.6 m above the ground (Draffan et al. 1983, Higgins et al. 2006).

5.18.3 Habitat

In east and south-east Australia, the Rufous fantail typically inhabits wet sclerophyll forests, often in gullies dominated by Eucalypts such as Tallowwood (*Eucalyptus microcorys*), Mountain grey gum (*E. cypellocarpa*), Narrow-leaved peppermint (*E. radiata*), Mountain ash (*E. regnans*), Alpine ash (*E. delegatensis*), Blackbutt (*E. pilularis*) or Red mahogany (*E. resinifera*). These areas usually have a dense shrubby understorey often including ferns. The species also occasionally occurs in secondary regrowth, following logging or disturbance in forests or rainforests. This species has also been recorded from parks and gardens during movement events (DotEE 2018).

5.18.4 Threatening processes

The following have been identified as potentially threatening processes to the Rufous fantail (Huggett 2000):

- Fragmentation
- Loss of core moist forest breeding habitat through land clearing and urbanisation; especially forest remnants and corridors along the species' migration routes (Huggett 2000).

5.18.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.18.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

5.18.7 References

Atlas of Living Australia (2020). *Rhipidura rufifrons*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:025b08d1-0e50-4723-b581-9be91d8d09ed [Accessed: 27 August 2020].

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Draffan, R.D.W., Garnett S.T. and Malone G.J. (1983). Birds of the Torres Strait: an annotated list and biogeographic analysis. *Emu*. 83:207-234.

Higgins, P.J., Peter J.M. and Cowling S.J. (2006). Handbook of Australian, New Zealand and Antarctic Birds. In: *Part A. Boatbill to Larks*. Volume 7. Melbourne, Victoria: Oxford University Press.

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Lindsey, T.R. (1992). Encyclopedia of Australian Animals: Birds. Page(s) 313. Collins-Angus and Robertson Publishers Pty Ltd.

Lostandcold. (2009). Rufous fantail (*Rhipidura rufifrons*). [image] [online] Available from: **https://www.flickr.com/photos/lostandcold/4065996836/in/photolist-7ciicJ-bzzXAH-RGE7Zm-Hi6Ykc**. [Accessed: 17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.19 Satin flycatcher (*Myiagra cyanoleuca*)

5.19.1 Status

EPBC Act – Marine and Migratory (Bonn)

5.19.2 Biology and ecology

5.19.2.1 Characteristic

The Satin flycatcher (*Myiagra cyanoleuca*) ranges in size from 15 to 17 cm. This species is blue-black and white bird with a small crest. The sexes are dimorphic. Males are glossy blue-black dorsally, with a blue-black chest and white below. Females are duskier blue-black dorsally, with an orange-red chin, throat and breast, and white underparts and pale-edged wing and tail feathers. Immature birds are dark brown-grey above, with pale streaks and buff edges to the wing feathers, and a mottled brown-orange throat and chest (DotEE 2018; Pizzey and Knight 2007) (refer Photograph 5.19).

Photograph 5.19 Satin flycatcher (*Myiagra cyanoleuca*)

Source: Musser (2014), Harris (2016)

5.19.2.2 Known distribution

The Satin flycatcher occurs along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia (refer Figure 5.37). In Queensland, it is widespread but scattered in the east. The Satin flycatcher is a migratory species, moving northwards in winter to northern Queensland and Papua New Guinea, returning south to breed in spring (BirdLife Australia 2012; Pizzey and Knight 2007).

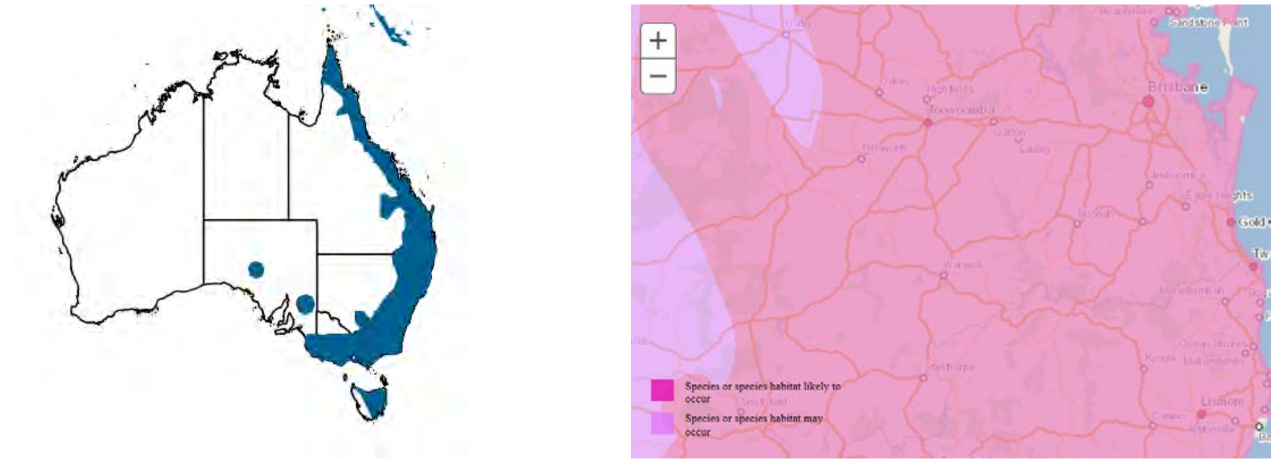

Figure 5.37 Distribution range of the Satin flycatcher

Source: ALA (2020), DotEE (2018)

5.19.2.3 Distribution in relation to the Project

Myiagra cyanoleuca has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs approximately 3 km south of the disturbance footprint south-east of Gatton dated 1999. The next nearest record occurs within approximately 5 km of the disturbance footprint south-east of Helidon also dated 1999. Records exist for this species in all directions around the disturbance footprint within a 50 km buffer except to the south-east where there are fewer records. Most records outside of 50 km occur to the east towards to coast.

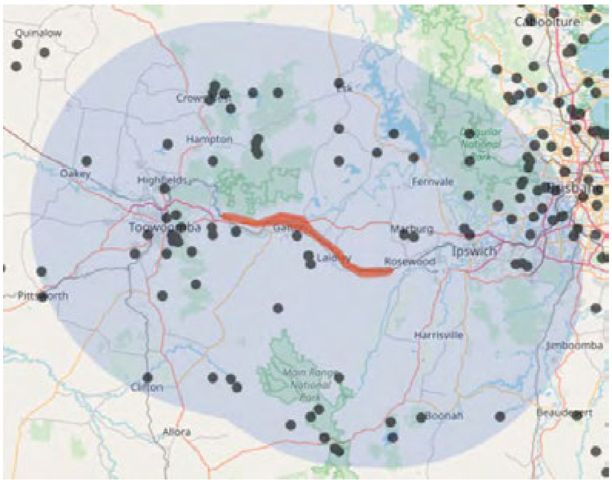

Figure 5.38 **Distribution range of the Satin flycatcher in relation to the Project**

Source: ALA (2020)

5.19.2.4 Biology and reproduction

Satin flycatchers are mainly insectivorous although very occasionally they will also eat seeds.

The Satin flycatcher builds a neat cup of bark strips, moss and spiders webs on a horizontal dead branch located 5 to 25 m above the ground under living foliage. This species has been reported to nest in loose groups with each individual pair spaced between 20 to 50 m apart. Both sexes build the nest, incubate the eggs and feed the young. Clutch size ranges from two to three eggs and breeding occurs between October and February (Pizzey and Knight 2007).

5.19.3 Habitat

The Satin flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests. This species is known to inhabit heavily vegetated gullies in Eucalypt dominated forests and taller woodlands usually above the shrub layer. On migration, this species occurs in coastal forests, woodlands, mangroves and drier woodlands and open forests as well as trees in open country and gardens (BirdLife Australia 2012; Blakers et al. 1984; Pizzey and Knight 2007).

5.19.4 Threatening processes

The following have been identified as potentially threatening processes to the Satin flycatcher (Blakers et al. 1984):

- Clearing and logging of forests, particularly mature forests, in south-eastern Australia (Blakers et al. 1984)

5.19.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.19.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

5.19.7 References

Atlas of Living Australia (2020). *Myiagra cyanoleuca*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:77929aae-e7de-48dd-aac9-ba1080d28783 [Accessed: 27 August 2020].

BirdLife Australia (2012). BirdLife Australia Database, Available: http://BirdLife.org.au/ [Accessed: 27 August 2018].

Birds Australia (2010). *Birds in Backyards- Satin flycatcher factsheet*. [Online]. Available from: http://www.birdsinbackyards.net/species/Myiagra-cyanoleuca

Blakers, M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

Department of the Environment and Energy (2018). *Myiagra cyanoleuca* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82411 [Accessed: 27 August 2018].

Harris, K. (2016). Satin flycatcher (*Myiagra cyanoleuca*). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=e294aee2-7cf5-4d47-af1d-0e8740369565. [Accessed: 17 September 2019].

Musser, A. (2017). Satin flycatcher (*Myiagra cyanoleuca*). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=c6460cde-1d8a-4cca-95de-f0450bf2963d. [Accessed: 17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.20 Sharp-tailed sandpiper (*Calidris acuminata*)

5.20.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

5.20.2 Biology and ecology

5.20.2.1 Characteristic

The Sharp-tailed sandpiper (*Calidris acuminata*) grow to 17 to 21 cm long, with males being usually larger. It has a small straight or slightly decurved bill that is longer than its head. The legs are dull olive-yellow, yellow or olive-grey. It has a dull chestnut crown with dark eyelines that becomes browner on ear-coverts. The long feathers of the upperparts have pointed dark centres with pale brown margins. The underparts are whitish buff and sparsely streaked (refer Photograph 5.20). During the breeding season the upperparts are rufous with buff-white edges and they have an upperbreast which is buffish and heavily streaked on the flanks (Pizzey and Knight 2007).

Photograph 5.20 Sharp-tailed sandpiper (*Calidris acuminata*)

Source: Kavanagh (2019)

5.20.2.2 Known distribution

The Common sandpiper breeds in northern Siberia, from the delta of the Lena River, east to Chaun Gulf and east of the Kolyma River delta. It visits Australia from August to May and commonly found in the south-east but widespread across Australia in both inland and coastal locations (refer Figure 5.39) (Higgins & Davies 1996).

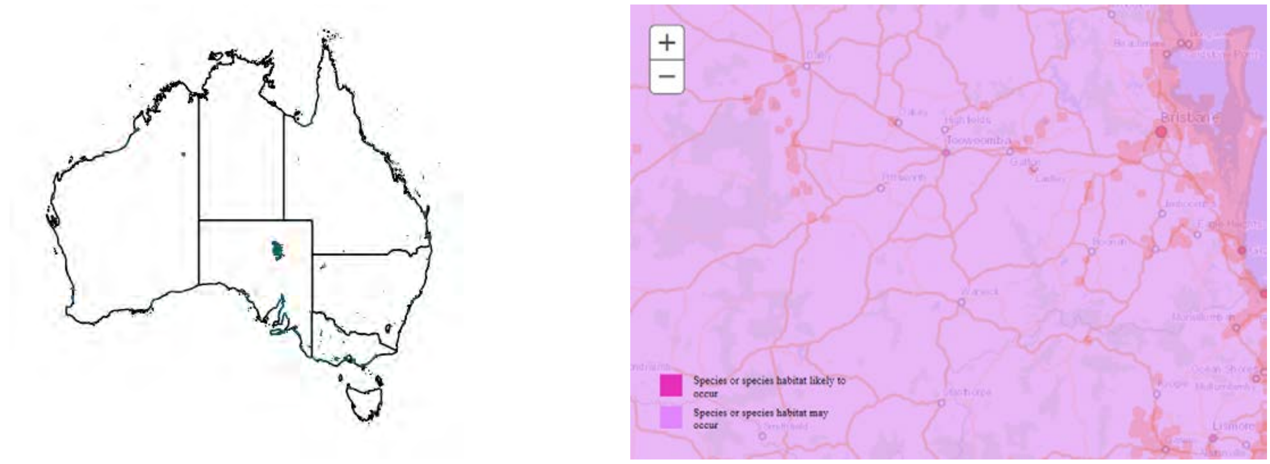

Figure 5.39 Distribution range of the Sharp-tailed sandpiper

Source: ALA (2020), DotEE (2018)

5.20.2.3 Distribution in relation to the Project

Calidris acuminata has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within the ecology study to the west of Gatton with three records from 2010, 2013 and 2014. Another record occurs within the ecology study area at Gatton, however this is an old record dated 1973. Numerous occurrence records exist within approximately 3 km of the disturbance footprint near Laidley with some recent (2019). Numerous records exist to the north of Gatton within approximately 5 km north of the disturbance footprint dated as recent as 2018. Other records from within a 50 km buffer of the disturbance footprint occur to the west near Oakey and Toowoomba Range, to the north between Gatton and Atkinsons Lagoon, east between Rosewood and Brisbane and to the south-east towards Boonah.

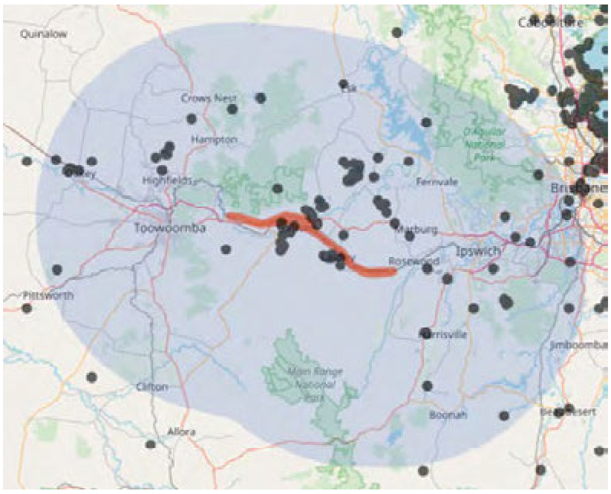

Figure 5.40 **Distribution range of the Sharp-tailed sandpiper in relation to the Project**

Source: ALA (2020)

5.20.2.4 Biology and reproduction

In Australia, the Sharp-tailed sandpiper forages on seeds, worms, molluscs, crustaceans and insects (Higgins & Davies 1996).

This species does not breed in Australia and they migrate to northern Siberia to breed and nest (Higgins & Davies 1996).

5.20.3 Habitat

In Australia, the Sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation including lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland. They use flooded paddocks, sedge lands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets and estuaries or seashores (Higgins & Davies 1996).

5.20.4 Threatening processes

The following have been identified as potentially threatening processes to the Sharp-tailed sandpiper:

- Habitat loss reducing the availability of foraging and roosting sites
- Habitat degradation including loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds, water pollution and changes to the hydrological regime and exposure of acid sulphate soils (DEWHA 2009).

5.20.5 Threat abatement/recovery plans

No Recovery Plan has been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

5.20.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

5.20.7 References

Atlas of Living Australia (2020). *Calidris acuminata*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:75106fa7-7d65-4724-814d-dce6306c79d9 [Accessed: 20 September 2020].

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5.21 Spectacled monarch (*Symposiachrus trivirgatus*)

5.21.1 Status

EPBC Act – Migratory (Bonn)

5.21.2 Biology and ecology

5.21.2.1 Characteristic

The Spectacled monarch (*Symposiachrus trivirgatus*) approximates 15 cm in size and is blue-grey above, with a black face mask that extends across both eyes. The breast is rufous in colour and the underparts are pale. The tail is black with white outer tips. Immature birds lack the black face and have a grey throat (Pizzey and Knight 2007) (refer Photograph 5.21).

Photograph 5.21 Spectacled monarch (*Symposiarchrus trivigatus*)

Source: Mike's Birds (2017)

5.21.2.2 Known distribution

The Spectacled monarch is found in coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, NSW (refer Figure 5.41). It is much less common in the south. It is also found in Papua New Guinea, the Moluccas and Timor (Blakers et al. 1984; DotEE 2018).

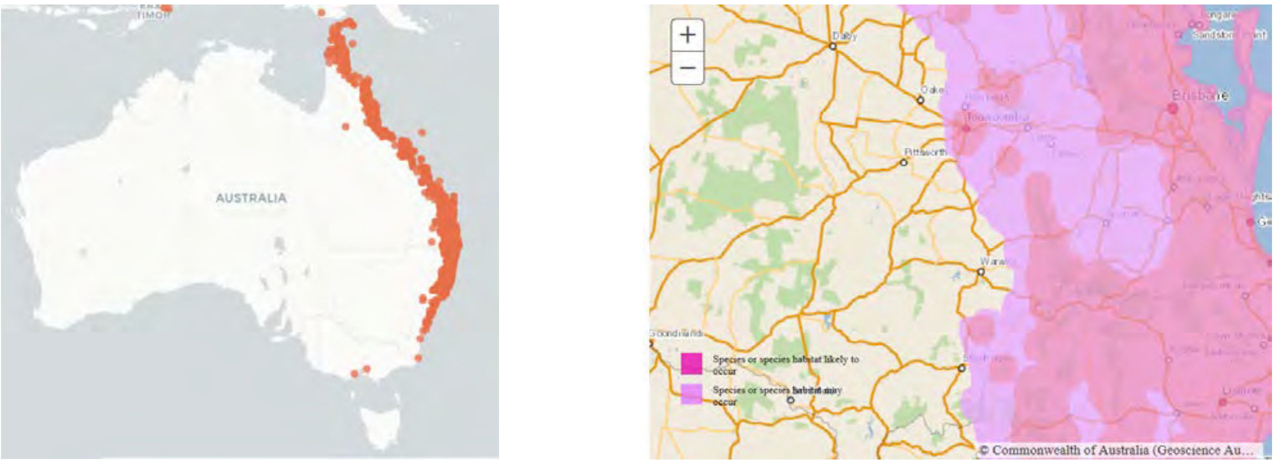

Figure 5.41 **Distribution range of the Spectacled monarch**

Source: ALA (2020), DotEE (2018)

5.21.2.3 Distribution in relation to the Project

Symposiachrus trivirgatus has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species occurs within approximately 7 km of the disturbance footprint to the north of Gatton near the Lockyer Reserves with two records dated 2013 and 2017. Another record exists within approximately 5 km of the disturbance footprint to the south of Helidon dated 2014. Records for this species with a 50 km buffer of the disturbance footprint occur to the west at the Toowoomba Range, to the north, north-east and east from Atkinsons Lagoon to D'Aguilar National Park and Brisbane and scattered records to the south-east and south from the Teviot Range to Main Range.

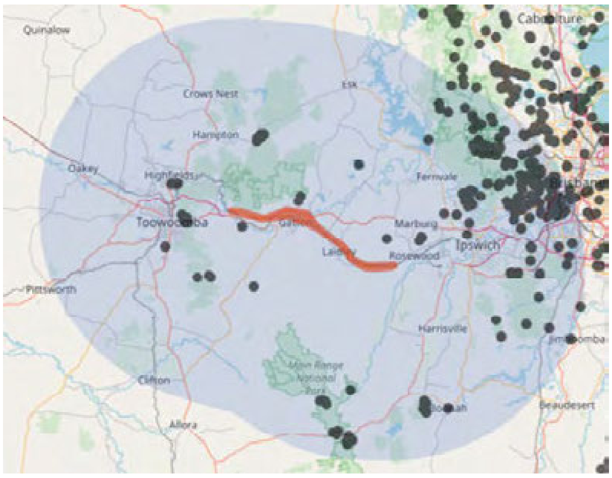

Figure 5.42 **Distribution range of the Spectacled monarch in relation to the Project**

Source: ALA (2020)

5.21.2.4 Biology and reproduction

The Spectacled monarch forages for insects among foliage, or catches flying insects on the wing (Pizzey and Knight 2007).

The Spectacled monarch is a resident in the north of its range (i.e. from Rockhampton in QLD Queensland northward), but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March. It may also migrate to Papua New Guinea in autumn and winter. The Spectacled monarch builds a small cup nest of fine bark, plant fibres, moss and spider web generally in a tree fork or in hanging vine 1 to 6 m above the ground. Nests are often located near water. Only the female builds the nest, but both sexes incubate the eggs and feed the young. Clutch size consists of two eggs. Reproduction occurs between October and February (DotEE 2018; Pizzey and Knight 2007).

5.21.3 Habitat

The Spectacled monarch inhabits both dense low vegetation and habitats with fairly open understoreys. The species prefers the understorey of mountain and lowland rainforests, thickly wooded gullies and waterside vegetation (Pizzey and Knight 2007).

5.21.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Spectacled monarch.

5.21.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.21.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat.

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

5.21.7 References

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5.22 Yellow wagtail (*Motacilla flava*)

5.22.1 Status

EPBC Act – Marine and Migratory (CAMBA, JAMBA, ROKAMBA)

5.22.2 Biology and ecology

5.22.2.1 Characteristic

The Yellow wagtail (*Motacilla flava*) is approximately 16.4 to 18 cm long with dark legs and uniform grey-green rump. In the nonbreeding season adults have greyish brown upperparts with white or yellowish eyebrows, dark ear-coverts and a buff-white breast. They have dark wings with white or yellow margins in a netted pattern on the upper wings (refer Photograph 5.22). In breeding plumage, they have bright yellow underparts from breast to vent. Juvenile forms are browner than the nonbreeding form with bolder spotted necklaces or yellow patches. They also make a high pitched ‘sweet’ or ‘tzeep’ sound (Pizzey and Knight 2007).

Photograph 5.22 Yellow wagtail (*Motacilla flava*)

Source: Pestana (2011)

5.22.2.2 Known distribution

They breed from Europe to Siberia and migrate south to Africa, SE Asia and Australia. In Australia, they are found in mostly coastal northern areas but also further south in NSW and southern WA Western Australia from November to April (Pizzey and Knight 2007) (refer Figure 5.43).

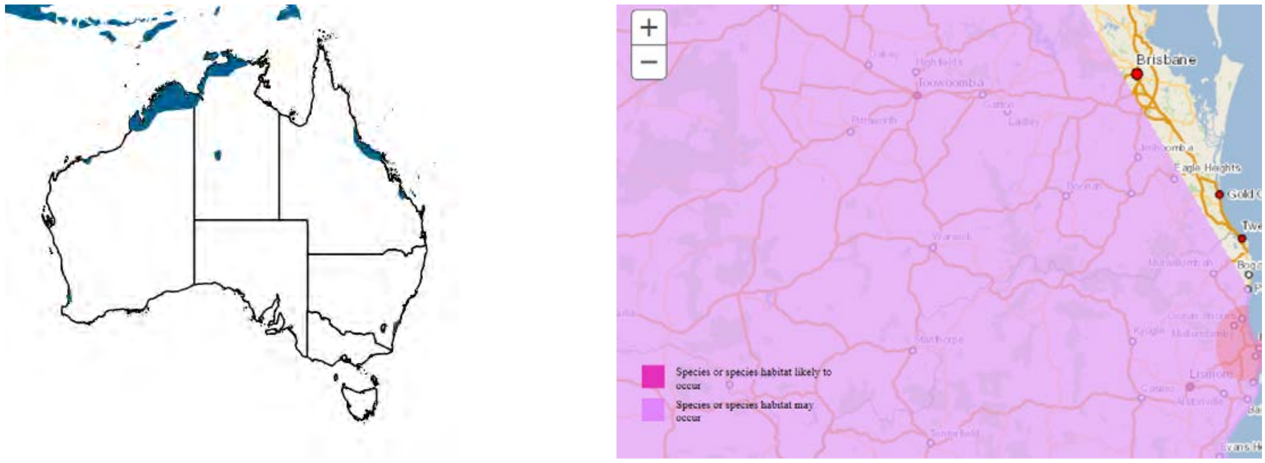

Figure 5.43 **Distribution range of the Yellow wagtail**

Source: ALA (2020), DotEE (2018)

5.22.2.3 Distribution in relation to the Project

Motacilla flava has been identified as potentially occurring within the ecology study area. Database records (i.e. AoLA) indicate this species does not occur within the ecology study area or within a 50 km buffer of the disturbance footprint. The nearest database records occur approximately 75 to 100 km to the north-east of the Project between Brisbane and Bribie Island.

Figure 5.44 **Distribution range of the Yellow wagtail in relation to the Project**

Source: ALA (2020)

5.22.2.4 Biology and reproduction

It feeds on a wide variety of terrestrial and aquatic invertebrates as well as some plant material, particularly seeds (BirdLife International (2017).

Yellow wagtails do not breed in Australia and migrate north from April to August (Pizzey and Knight 2007).

5.22.3 Habitat

Yellow wagtails can be found in and around short grass, bare ground, swamp margins, sewage ponds, saltmarshes, sports fields, airfields, ploughed land and urban lawns (Pizzey and Knight 2007).

5.22.4 Threatening processes

The following have been identified as potentially threatening processes to the Yellow wagtail (BirdLife International (2017):

- Agricultural intensification
- Wetland drainage
- Use of pesticides (BirdLife International 2017).

5.22.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

5.22.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

The Yellow wagtail is one of the five non-breeding species outlined in the referral guideline. As they are considered to be extremely uncommon migrants the number of individuals at any one site are so small relative to their global population that no small group of individuals is likely to be significant for the species in Australia or the ecological attributes for a site. For these species it is sufficient to lodge records with the Commonwealth to satisfy the recommendation.

5.22.7 References

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