APPENDIX

J

Terrestrial and Aquatic Ecology Technical Report

PART 1 OF 4

Main Report

CALVERT TO KAGARU 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 Calvert to Kagaru EIS

Appendix J – Terrestrial and Aquatic Ecology Technical Report

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Abbreviations

Abbreviation	Explanation
°C	Degrees Celsius
ACDC Act	Agricultural Chemicals Distribution Control Act 1966 (Qld)
ANZECC	Australia and New Zealand Environment and Conservation Council
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARTC	Australian Rail Track Corporation
AUSRIVAS	Australian River Assessment System
BAMM	Biodiversity Assessment and Mapping Methodology
Biosecurity Act	*Biosecurity Act 2014* (Qld)
BPA	Biodiversity Planning Assessment
C2K	Calvert to Kagaru
CAMBA	China-Australia Migratory Bird Agreement
CEMP	Construction Environmental Management Plan
Ch	Chainage
Cth	Commonwealth
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and Environment (Cth)
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
DNRME	Department of Natural Resource Management and Energy (former)
DotEE	Department of the Environment and Energy (former) (Cth)
DSDMIP	Department of State Development, Manufacturing, Infrastructure and Planning
DTMR	Department of Transport and Main Roads
EAM	Environmental Assessment and Management
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994* (Qld)
EP Reg	Environmental Protection Regulation 2008 (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERA	Environmentally Relevant Activity
EVNT	Endangered, Vulnerable and Near-threatened
FFJV	Future Freight Joint Venture
FHA	Fish Habitat Area
Fisheries Act	*Fisheries Act 1994* (Qld)
GDE	Groundwater dependent ecosystem
GIS	Geographic information system
H2C	Helidon to Calvert
ha	hectare
HES	High Ecological Significance
HVR	High Value Regrowth

Abbreviation	Explanation
Inland Rail	Melbourne to Brisbane Inland Rail
JAMBA	Japan-Australia Migratory Bird Agreement
K2ARB	Kagaru to Acacia Ridge and Bromelton
km	kilometre
Koala Plan	The Nature Conservation (Koala) Conservation Plan 2017
LOR	Limit of reporting
m	metre
mg/L	milligrams per litre
MLES	Matters of local environmental significance
mm	millimetre
MNES	Matters of national environmental significance
MSES	Matters of state environmental significance
NC Act	*Nature Conservation Act 1992* (Qld)
NRM	Natural Resource Management
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
Offsets Act	*Environmental Offsets Act 2014* (Qld)
PDA	Priority Development Area
Planning Act	*Planning Act 2016* (Qld)
Project	Calvert to Kagaru Project
Public Health Act	*Public Health Act 2005* (Qld)
QEOP	Queensland Environmental Offsets Policy
QLD	Queensland
QR	Queensland Rail
RCP	reinforced concrete pipe
RE	Regional Ecosystem
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RPI Act	*Regional Planning Interests Act 2014* (Qld)
SDA	State Development Area
SDAP	State Development Assessment Provisions
SDPWO Act	*State Development and Public Works Organisation Act 1971* (Qld)
SEQ	South-east Queensland
SFRC	Southern Freight Rail Corridor
sp.	species
SPP	State Planning Policy 2017
spp.	multiple species
subsp.	subspecies
TEC	Threatened Ecological Community
ToR	Terms of Reference
VM Act	*Vegetation Management Act 1999* (Qld)
Water Act	*Water Act 2000* (Qld)
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 Calvert to Kagaru disturbance footprint is located in southeast 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 2019b). The BPAs draw upon the 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 and in relation to Environmentally Sensitive areas (ESA's) the DES classifies a RE as Endangered if: ▪ Less than 10% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss, or ▪ 10 to 30% 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 uncommon RE subject to a threatening process. For biodiversity planning purposes and in relation to ESA's, DES classifies a RE as Of concern if: ▪ 10 to 30% of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss For biodiversity planning purposes and in relation to ESA's 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 bioregion subject to this report is the South East Queensland bioregion.

Term	Explanation
*Biosecurity Act 2014 (Qld) (*Biosecurity Act)	The Biosecurity Act lists declared plants and animals that have, or could have, serious economic, environmental or social impacts and are targeted for control. There are legal obligations associated with the control supply, sale, keeping and transport of declared species. Where these exotic pests and weeds are encountered, landholders have an obligation under the Biosecurity Act to control the declared weeds and pest animals, in accordance with relevant guidelines and local government area pest management plans. 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, Near threatened or Special Least Concern (cultural) 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 and the NC Act.
Critical priority	Rating associated with the Back on Track species prioritisation framework. Constitutes the highest total score/priority.
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 impact assessment area	The cumulative impact assessment area encompasses the disturbance footprint and extends 50 km beyond the disturbance footprint boundary.
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 sensitive environmental receptor (e.g. land clearing resulting in vegetation and habitat loss).
Disturbance footprint	The disturbance footprint (both temporary and permanent) associated with the Project. The disturbance footprint for the purpose of the ecology assessment is the area subject to direct disturbance i.e. this does not include the tunnel footprint within the Teviot Range.
Ecological community	An assemblage of species occupying a particular area.
Ecology study area	The ecology study area study area adopts the EIS investigation corridor, being an approximate 2 km wide study area, 1 km either side of the proposed rail alignment. The study area 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 study area is slightly wider around Chainage 38 to Chainage 45 to accommodate for the options analysis that was undertaken for the Teviot Range crossing (refer Figure 1.1).
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 the specific meaning of Endangered under each specific Act.
Environmental impact statement (EIS) Investigation Corridor	This is based on the preferred alignment and broader study area proposed in the EPBC Act referral.
Environmentally Sensitive Area (ESA)	▪ As defined under the Environmental Protection Regulation 2008 (Qld), 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

Term	Explanation
	– 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 Designated Landscape Areas (DLAs) other than Stanbroke – Special Forestry Areas – Fish Habitat Areas – Coordinated Conservation Areas – 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 (TECs) are assigned a conservation status of Extinct in the wild, Critically endangered, Endangered or Vulnerable. Definitions of these terms under the EPBC 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).

Term	Explanation
Essential habitat	As defined by DES, essential 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. Essential habitat is identified on the approved DES RE mapping. Term also used in relation to predictive habitat mapping undertaken as part of the current scope of works, as defined in Section 3.3.4.10.
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 with a specific set of stringent mitigation measures.
High priority	Rating associated with the Back on Track species prioritisation framework. Constitutes the second highest prioritisation total score/priority.
High Value Regrowth	High Value Regrowth vegetation is mature native vegetation that has not been cleared in the last 15 years. According to the Department of Natural Resources, Mines and Energy (DNRME) (2018), regulated regrowth vegetation includes vegetation that falls into one of the following categories: ▪ Vegetation identified on a regulated vegetation map as High Value Regrowth vegetation (Category C) ▪ Vegetation located within 50 m of watercourses in priority reef catchment areas (Category R) ▪ Vegetation that is a Least concern, Of concern or Endangered RE.
Important habitat	Consists of habitat that: ▪ Is utilised by a species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or ▪ Is of critical importance to the species at particular life-cycle stages, and/or ▪ Is utilised by a species which is at the limit of the species range, and/or ▪ Is within an area where the species is declining.
Indirect impacts	Impacts that are not a direct result of Project activities but 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 local environmental significance (MLES)	A Matter of local environmental significance is a matter that is prescribed under a local planning instrument as a prescribed environmental matter. This includes MSES that are not prescribed environmental matters in urban areas (for example, remnant 'of concern' regional ecosystems) or “least concern” remnant vegetation.
Matters of national environmental significance (MNES)	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.

Term	Explanation
Matters of state environmental significance (MSES)	Matters of state environmental significance includes environmental values protected under various state legislative Acts. These are identified as prescribed environmental matters and are defined under the State Planning Policy (SPP) and Schedule 2 of the Queensland Environmental Offsets Regulation 2014.
Medium priority	Rating associated with the Back on Track species prioritisation framework. Constitutes the third highest prioritisation total score/priority.
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.
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.
NC Act conservation status	Under the NC Act, protected species are assigned a conservation status of Extinct in the wild, Endangered, Vulnerable, Near threatened, Least concern or Special 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

Term	Explanation
	Special least concern ■ In regard to plants - Least concern plants are prescribed as Special least concern if the taking or use of the plant is at risk of not being ecologically sustainable (e.g. high commercial demand or parts thereof, the biological traits of the plant). Species are defined in the Nature Conservation (Plants) Regulation 2020 (Qld). ■ In regard to animals – means any of the following: – The Echidna (*Tachyglossus aculeatus*) or Platypus (*Ornithorhynchus anatinus*) (cultural status) – A least concern bird that is listed as migratory under the EPBC Act as part of a migratory agreement (ie JAMBA, CAMBA, Bonn conventions).
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 sensitive environmental receptor.
No concern at present	A RE is listed as 'least concern' under the VM Act if: ■ Remnant vegetation is over 30% of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 ha. In addition to the criteria listed for 'least concern' regional ecosystems under the VM Act, for biodiversity planning purposes (under the EP Act) a regional ecosystem is listed with a biodiversity status of 'no concern at present' if: ■ The degradation criteria listed above for 'endangered' or 'of concern' regional ecosystems are not met.
No habitat present	The presence of habitat to support self-sustaining populations of a species is absent.
Non-remnant vegetation	Vegetation that is not mapped as remnant vegetation by DES and/or which fails to meet DES 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. 2012).
Of concern	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 VM Act
Permanent impact	The impact will last indefinitely.
Pre-clearing Regional Ecosystems (Pre-clearance REs)	Pre-clearing Regional Ecosystems are defined as the vegetation or regional ecosystem present before clearing. This generally equates to terms such as 'pre-1750' or 'pre-European' used elsewhere.
Poikilothermic	An organism which regulates metabolic activity in relation to ambient environmental temperature (i.e. a form of 'cold-blooded')
Quaternary level vegetation survey	Quaternary level vegetation surveys are used primarily as a record of field traverses and to verify regional ecosystem/vegetation mapping. These sites are generally collected throughout the field survey and entered on spread sheets or databases. Quaternary sites may be collected at regular intervals along a traverse, and/or made where REs/vegetation communities change. Quaternary sites are recorded via a proforma, on topographic maps, aerial photographs, LANDSAT images, notebooks and/or tape recorder.
Ramsar	The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat is an international treaty for the conservation and sustainable use of wetlands. It is also known as the Convention on Wetlands. It is named after the city of Ramsar in Iran, where the Convention was signed in 1971.
Regional Ecosystem (RE)	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil (Young et al. 1999). REs are mapped by the Queensland Government and are defined by the Regional Ecosystem Description Database (REDD). The RE codes are applicable to mapping from Remnant vegetation, High value regrowth and pre-clearing REs that are not considered remnant. 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 VM 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% of height of an equivalent community of undisturbed vegetation or 50% of what would be undisturbed foliage cover and a mix of species represented in undisturbed communities. High value regrowth (HVR) vegetation is defined as Category C regulated vegetation under the VM Act.
Regulated vegetation	All vegetation depicted on a regulated management map produced by DES. Includes remnant vegetation (i.e. Category B) and high value regrowth (Category C) as regulated under the provisions of the VM Act.
Remnant vegetation	Remnant woody vegetation is defined as vegetation where the dominant canopy has >70% of the height and >50% 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).
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	In accordance with the EPBC Act, 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.
Significant residual impact	In accordance with the EPBC Act, a Significant residual impact is the impact expected after a Project's avoidance and mitigation measures (identified in the environmental impact assessment) have been put in place.
Spatial extent	Impacts are considered with respect to the biologically meaningful spatial extents of local, regional, State, and national/international.
Special least concern	**Fauna**: Means the following - ▪ The Short-beaked echidna (*Tachyglossus aculeatus*) and Platypus (*Ornithorhynchus anatinus*) ▪ Non-threatened migratory bird species listed under the EPBC Act **Flora**: A category for flora and as prescribed by Schedule 3A of the Nature Conservation (Wildlife Management) Regulations 2006
Tertiary level vegetation survey	Tertiary level vegetation surveys are used instead of secondary sites where seasonal conditions such as drought make a full assessment of species impractical or where third parties (who may not have the skills to compile a complete floristic inventory of non-woody vegetation) collect the data. Data collected include all location, environmental and overall structural information (median height and cover of each layer) as well as a comprehensive list of woody species, individual woody species cover by layer and basal area measure of abundance.
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 VM Act are provided below **Endangered** ▪ Less than 10% of pre-clearing extent of remnant vegetation (see following definition) exists in the bioregion, or 10% to 30% of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha **Of concern** ▪ 10% to 30% of pre-clearing extent of remnant vegetation exists in the bioregion, or more than 30% of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha **Least concern** ▪ More than 30% 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 DES 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.

Term	Explanation
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
Weeds of National Environmental Significance (WoNS)	Thirty-two (32) species of weeds are declared to be WoNS, 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 (2007) provides a framework for establishing consistency between all stakeholders and identifies priorities for national weed management with the aim of minimizing 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.
Wetland	■ Areas shown on the Map of Referable Wetlands which is a document approved by the Chief Executive 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 that 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 - Calvert to Kagaru Project (the 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 K: Matters of National Environmental Significance Technical Report to address Sections 11.1 to 11.35 of the Terms of Reference (ToR). 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.

Australian Rail Track Corporation (ARTC) proposes to construct and operate the Calvert to Kagaru Project (the Project), which is an approximately 53 kilometre (km) single track dual gauge greenfield 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 1,015 m long tunnel through the Teviot Range to facilitate the required gradient across the undulating topography.

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 Southeast 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 on 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.

The ecology study area provides suitable habitat for a six non-MNES (i.e. species listed under the EPBC Act), and *Nature Conservation Act 1992* (Qld) (NC Act) listed conservation significant species (i.e. three plants and three animals) as well as potential habitat for 11 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* (Qld) (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 sensitive environmental receptors are those that constitute:

- Non-threatened MNES
- Matters of state environmental significance (MSES) which included environmental values protected under various state legislative Act (e.g. regulated vegetation, threatened species as listed under the provisions of the NC Act).

Matters of local environmental significance (MLES) which includes matter that is prescribed under a local planning instrument as a prescribed environmental matter. This includes MSES that are not prescribed environmental matters in urban areas (e.g. remnant 'of concern' regional ecosystems, 'Least concern' regional ecosystems when not a defined distance from a waterway/wetland, 'Least concern' flora and fauna species, locally defined movement corridor (i.e. BPA) and Locally defined koala habitat). Thirty-one (31) 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 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 5.2.2. 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, there are **no significant impacts expected** for the following non-threatened EPBC Act listed migratory species:

- Osprey (*Pandion haliaetus*)
- Oriental cuckoo (*Cuculus optatus*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Rufous fantail (*Rhipidura rufifrons*)

- Black-faced monarch (*Monarcha melanopsis*)
- Spectacled monarch (*Symposiachrus trivirgatus*)
- Yellow wagtail (*Motacilla flava*)
- Common sandpiper (*Actitis hypoleucos*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Latham's snipe (*Gallinago hardwickii*)
- Glossy ibis (*Plegadis falcinellus*).

Assessment of prescribed MSES 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 the following sensitive environmental receptors:

- Endangered or Of concern REs
- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature)
- Remnant vegetation intersection with a VM Act wetland
- Essential Habitat
- Connectivity areas
- Protected wildlife habitat for the following species:
  - Bailey's cypress (*Callitris baileyi*)
  - Slender milkvine (*Marsdenia coronata*)
  - Swamp tea-tree (*Melaleuca irbyana*)
  - Glossy-black cockatoo (*Calyptorhynchus lathami*)
  - Powerful owl (*Ninox strenua*).

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 six other similar projects that occur within 50 km of the Project boundary, are likely to be higher on the following sensitive environmental receptors:

- NC Act listed flora and fauna species habitat:
  - Bailey's cypress (*Callitris baileyi*) – cumulative removal of 3,591.15 ha of habitat, of which the Project contributes up to 0.32 per cent
  - Slender milkvine (*Marsdenia coronata*) – cumulative removal of 126.04 ha of habitat, of which the Project contributes up to 49.07 per cent
  - Swamp tea-tree (*Melaleuca irbyana*) - cumulative removal of 5,087.61 ha of habitat, of which the Project contributes up to 4.67 per cent
  - Tusked frog (*Adelotus brevis*) - cumulative removal of 522.48 ha of habitat, of which the Project contributes up to 1.95 per cent
  - Powerful owl (*Ninox strenua*) - cumulative removal of 115.10 ha of habitat, of which the Project contributes up to 18.71 per cent

- Glossy-black cockatoo (*Calyptorhynchus lathami*) - cumulative removal of 81.92 ha of habitat, of which the Project contributes up to 61.81 per cent

- Matters of state significance (MSES) wildlife habitat
- Habitat for EVNT taxa as identified from the BPA
- State and Regional ecological corridors as identified from the BPA.

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. This report includes an Environmental Offset Delivery Strategy – Qld for the Project.

1 Introduction

1.1 Project overview and objectives

The Australian Government has committed to delivering Inland Rail, an interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland (QLD). Inland Rail is a significant piece of national transport infrastructure which will enhance Australia's existing rail network and serve the interstate freight market. The Inland Rail Program consists of 13 separate sections.

Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the Calvert to Kagaru (C2K) (the Project) section of Inland Rail Program. The Project consists of 53 kilometre (km) long single track dual gauge greenfield 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 1,015 m long tunnel through the Teviot 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 June 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 21 June 2017, the Commonwealth Minister for Environment determined the Inland Rail – Calvert to Kagaru Project is a 'controlled action' under the EPBC Act (reference number EPBC 2017/7944).

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 - Calvert to Kagaru Project* (Department of State Development 2017) issued on 8 December 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 K: 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. Further details of the Project approval pathway are provided in EIS Chapter 3: Project Approvals.

For the purposes of the Project and this technical report, the investigations and assessment were focussed on the disturbance footprint and the ecology study area presented in Figure 1.1 and Section 1.5.

This technical report outlines the legislative framework and methodology for undertaking the environmental assessment and subsequent assessment of environmental impacts related to the Project. This report describes the terrestrial and aquatic ecological values of the ecology study area, providing a summary of matters of national, state and local significance that have not been identified as controlling provisions of the project (i.e. EPBC Act listed migratory species), vegetation communities, habitats as well as weed and pest presence.

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 Matters of State Environmental Significance (MSES) Guidelines) (Department of Environment and Heritage Protection (DEHP) 2014).

Potential impacts to sensitive environmental receptors resulting from construction and operation 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, as summarised 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 K: 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

Terms of Reference requirement			Report section
Flora and fauna			
Existing environment			
11.96	Identify and describe 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 EIS Chapter 11: Flora and Fauna, Section 11.5
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:		Refer sub-sections below
	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 (refer to Appendix 1).	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7

Terms of Reference requirement			Report section
	b)	terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interaction and areas surrounding watercourses and wetlands	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7 EIS Chapter 13: Surface Water and Hydrology, Sections 13.5 and 13.6 EIS Chapter 14: Groundwater, Section 14.5.6
	c)	biological diversity including listed flora and fauna species and regional ecosystems, connectivity and essential habitat	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7
	d)	the existing integrity of ecological processes, including habitats of threatened, near-threatened or special least-concern species	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7
	e)	the integrity of landscapes and places, including wilderness and similar natural places	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7 EIS Chapter 10: Landscape and Visual Amenity, Section 10.6
	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	EIS Chapter 3: Project Approvals, Sections 3.4.14, 3.4.19, 3.4.21, 3.4.33, 3.4.35, and Table 3.3
	g)	any exposure to contaminants or the bio-accumulation of contaminants	Sections 5.1.2.11 EIS Chapter 11: Flora and Fauna, Sections 11.7.2.11
	h)	impacts on native fauna due to proximity to the site and site impacts (e.g. lighting, noise, waste and fencing)	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5, 11.7.2.9, 11.7.2.10 and 11.7.2.13
	i)	impacts to movement of native fauna due to barrier effect of linear infrastructure	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7.2.8
	j)	impacts on vegetation category areas identified on the regulated vegetation management maps under Queensland's vegetation management framework	Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.7

Terms of Reference requirement		Report section
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 and 5.2.3 Significant impact assessment – Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.8 and 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.	Aquatic habitat values – Section 4.5.5 Proposed mitigation measures - Sections 5.2.1, 5.2.2 and 5.2.3 Significant impact assessment – Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.8 and 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 5.2.1, 5.2.2 and 5.2.3 Significant impact assessment – Section 5.3 EIS Chapter 11: Flora and Fauna, Sections 11.8 and 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 (refer to Appendix 1).	Biodiversity offsets – Sections 5.3 and 5.4 EIS Chapter 11: Flora and Fauna, Sections 11.10 and 11.11
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.	Legislative, policy standards and guidelines - Section 2 Desktop studies – Section 4.4.18 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2.and 5.2.3 EIS Chapter 3: Project Approvals, Sections 3.4.21 and 3.4.33 EIS Chapter 11: Flora and Fauna, Section 11.8
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.	
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 4.4.4, Weed species - Section 4.5.1.3 Invasive animals - Section 4.5.2.3 EIS Chapter 11: Flora and Fauna, Sections 11.5.2.4 and 11.5.3.2
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 EIS Chapter 11: Flora and Fauna, Sections 11.7.2 and 11.9

Terms of Reference requirement		Report section
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 - Sections 5.2.2, 5.2.3 and 5.3 EIS Chapter 11: Flora and Fauna, Section 11.8
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 Project is located within the Ipswich City Council, Logan City Council and Scenic Rim Regional Council local government areas in south-east Queensland (SEQ). The Project is the second most northern package of the Inland Rail Program. The location of the Project and its regional context is shown in Figure 1.1.

Where possible, the Project will be located within the existing Southern Freight Rail Corridor (SFRC), which was protected in November 2010 as future railway land under Section 242(1) of the *Transport Infrastructure Act 1994* (Qld). The Project connects the adjacent Inland Rail alignments of Helidon to Calvert Project (H2C) in the north-west and Kagaru to Acacia Ridge and Bromelton Project (K2ARB) to the south-east.

Moving from west to east, the land use in the Calvert area is typically of a rural nature, with most properties within the ecology study area consisting of large-lot grazing areas. Ebenezer (east of Calvert) is characterised by predominantly rural and rural residential land uses, with a considerable amount of remnant vegetation. Jeebropilly coal mine and former Ebenezer coal mines are located in proximity to the Project. The Project also crosses an existing high voltage transmission line and the Santos Moonie-Brisbane high pressure oil pipeline.

The area south of Purga towards Peak Crossing contains a mixture of land uses, including a number of rural residential properties and agricultural estates, poultry farms, Purga Quarry, Gibb Brothers farming operations, Ivory's Rock Conventions and Events Centre and the township of Peak Crossing. Washpool is characterised by predominantly vegetated mountainous areas in the east and rural land uses in the west. The Purga Nature Reserve is also located in this region.

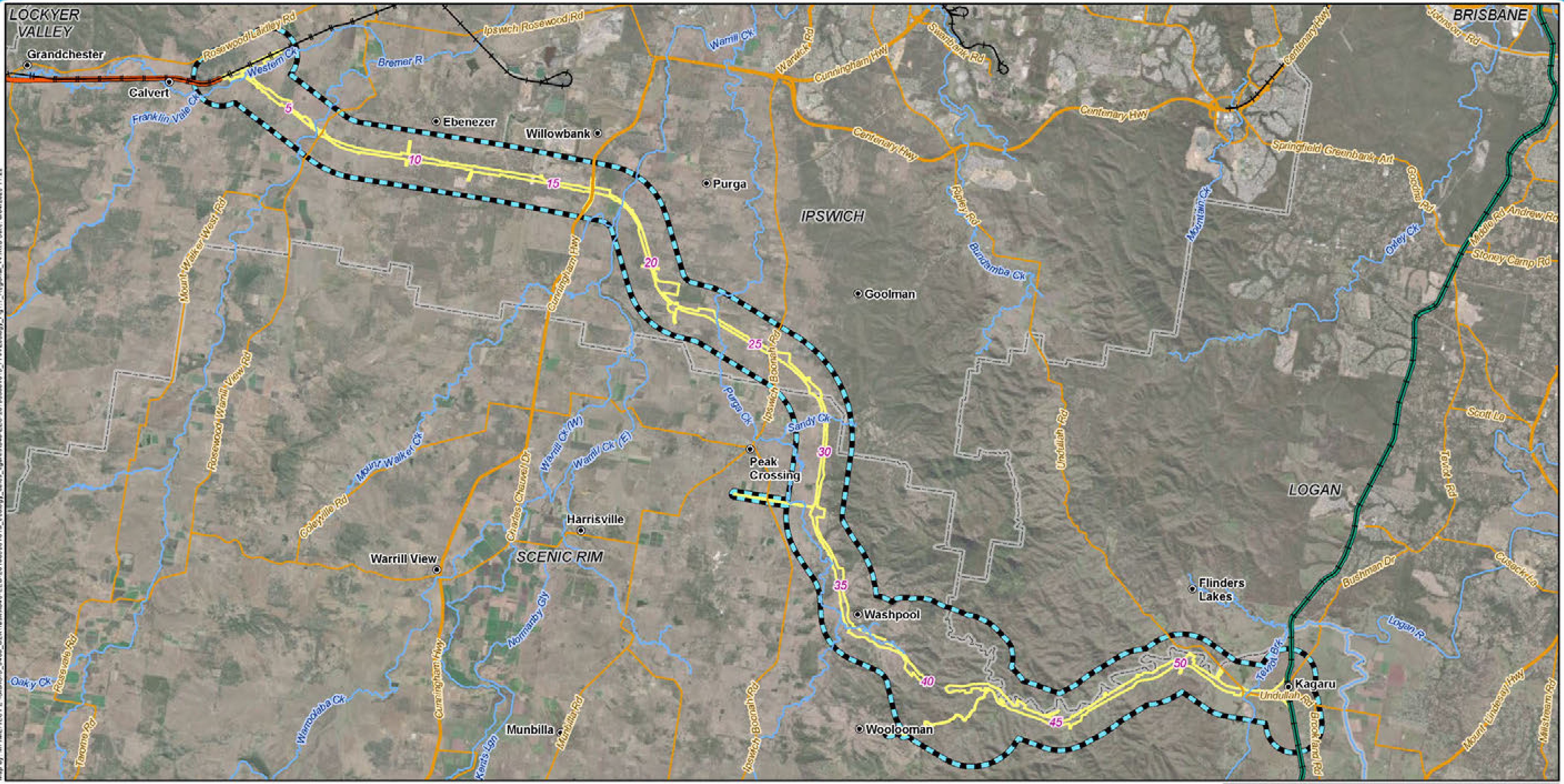
Throughout the Woolooman area and the Teviot Range (Flinders Peak Conservation Park), terrain is of a rugged nature and there is minimal development. Wyaralong Dam is located to the south, upstream of the Project. Kagaru is predominantly rural and is located within the Bromelton State Development Area (SDA). Flagstone Priority Development Area (PDA) is located north of the Project.

The intended land use for the Project is rail and associated infrastructure, including road realignments, grade separations and ancillary infrastructure.

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. The ecology study area is slightly wider around Chainage 38 to Chainage 45 to accommodate for the options analysis that was undertaken for the Teviot Range crossing. 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 Teviot 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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

SEQ 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: 8/04/2020 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 1.1: Location of project, 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. Further refinement of the Project design will occur during the detailed design phase.

The key components of the Project include:

- Approximately 53 km single track dual gauge greenfield rail line with four crossing loops
- Generally located within the existing South Freight Rail Corridor (SFRC) which was protected in November 2010
- An approximately 1,015 m Teviot Range tunnel, and bridges to accommodate topography and crossings of waterways and other infrastructure
- Tie-ins to the existing West Moreton Railway Line at the Project boundary near Calvert
- Allowance for a future connection to the Ebenezer Industrial Area at Willowbank
- The construction of associated rail infrastructure including maintenance sidings and signalling infrastructure to support the Advanced Train Management Systems
- Rail crossings, including level crossings, grade separations, road overbridges, occupational/private crossings and fauna crossing structures
- Tie-ins to the existing operational Sydney to Brisbane Interstate Railway line at Kagaru
- Significant embankments and cuttings will be required along the length of the alignment
- Ancillary works, including road and public utility crossings, and realignments (excluding those undertaken as enabling works)
- Construction workspace and access roads.

Ancillary work would include works to roads, signalling and communications, signage, fencing, services and utilities within the disturbance footprint.

The disturbance footprint is a rail corridor with minimum width of 40 m, widened to accommodate earthworks, drainage structures, rail infrastructure, access tracks and fencing. The rail corridor will be of sufficient width to accommodate the infrastructure currently proposed for construction which includes trains up to 1,800 m long, as well as future expansion (subject to future approvals), including possible future requirement for 3,600 m trains.

Subject to obtaining all the necessary environmental approvals for the Project, construction of the Project is planned to start in 2021 and is expected to be completed in 2026.

1.6.1 Rail line

The Project is greenfield, with a new single line of track, standard (1,435 millimetre (mm)) and narrow (1,067 mm) gauge, connecting the QR West Moreton Rail Line with the ARTC interstate coastal line. The track structure consists of continuously welded 60 kilogram/metre (kg/m) rail, resilient fasteners, rail pads and concrete dual gauge full-depth sleepers at minimum 600 mm centres. For the initial phase of operation, design is for 21 total axle load intermodal trains and 25 total axle load coal trains.

1.6.2 Tunnel infrastructure

The Project proposes a tunnel through the Teviot Range. The tunnel portal areas will require a substation building for power supply and distribution to electrical equipment, fire water tanks and a pump station for the tunnel hydrant system and an emergency services staging area. A tunnel control centre will be required at one of the portals and will be predominantly unmanned.

The alignment grades are currently such that stormwater runoff in the portal areas will be directed away from the tunnel. Any water collected inside the tunnel (e.g. groundwater, washdown, firefighting, etc.) will be collected in sumps at each end of the tunnel. This water will likely be processed through a water treatment plant which will include hydrocarbon separation.

The tunnel will have internal jet fans near the portal that will provide forced ventilation for maintenance activities only. No other ventilation requirements are proposed.

In case of the train stopping in the tunnel due to fire or other emergency, a fire rated longitudinal egress passage will be provided with access every 120 m. Communication facilities to the operator will be provided.

The tunnel will likely have minimal internal lighting, with only low-level lighting and emergency lighting expected.

1.6.3 Crossing loops

Four crossing loops are proposed for the Project. The loops would be constructed as new sections of track parallel to the main track. They will range in length to accommodate the surrounding area, topography and to accommodate the design length of the trains (1,800 m).

1.6.4 Turnouts

Turnouts allow the train to be guided from one track to another. A narrow-gauge turnout (1 in 16 proposed) will be provided to connect the Project to the QR West Moreton Rail Line between Calvert and Rosewood in an easterly direction towards Rosewood.

Two turnouts will be incorporated into existing track near Kagaru where the Project joins into the ARTC Sydney to Brisbane coastal line. A 1 in 16 dual gauge turnout will join the Project to the ARTC line heading north towards Acacia Ridge. A standard gauge turnout will be installed for a connection in the southerly direction towards Bromelton. There will be a 1 in 16 dual gauge turnout at each end of the four crossing loops. An additional turnout (1 in 10) will be required for a maintenance siding at each crossing loop.

1.6.5 Bridges

No existing bridges require reinstatement or reconstruction along the alignment as a result of the Project.

The Project requires 27 new bridges over waterways and/or floodplains. The bridges are of various lengths and spans to suit the alignment and topography.

1.6.6 Drainage infrastructure

A number of waterway crossings span over ‘QLD Waterways for Waterway Barrier Works’ as identified by the Department of Agriculture and Fisheries (DAF) (DAF 2018). These waterways for waterway barrier works are classified along their length according to the risk of adverse impact from instream barriers on fish movement. There are 17 marked waterways for water barrier works waterways which are intersected 34 times by the Project. These intersections (made up of culvert crossings and bridge crossings) include:

- Eight major risk crossings
- Four high risk crossings

- Eleven moderate risk crossings
- Eleven low risk crossings.

There are no existing culverts along the Project alignment. Culverts are structures that allow water (in a watercourse or drain) to pass under the rail line. Culverts will be used to maintain the existing flow paths and minimise the potential impact to flood depths upstream and downstream of the culverts. The culverts have been designed in accordance with relevant industry standards.

The design of the culverts has been informed by a hydrologic and hydraulic (flooding etc) assessment of the Project, a geotechnical assessment and a preliminary assessment of the existing structures.

The drainage features at cuttings have been designed in accordance with relevant industry standards. Existing drainage paths above cuttings have been diverted to the nearest cross drainage structure, through a catch drain where practical, to minimise flow into the cutting and subsequent size of cutting drainage. This minimises the size of the cuttings and higher flows to reduce the risk of scour on the cutting benches and batter chutes. There are drainage channels connected to batter chutes along the cutting benches which flow to the base of the cutting. There is a larger cutting drain in the base of each cut adjacent to the rail embankment.

1.6.7 Level crossings

The Project proposes six active crossings and one passive level crossing along the alignment.

1.6.8 Fencing

Fencing will be provided for the extent of the rail corridor (excepted where noted otherwise) and its primary purpose is to limit access to the railway during operations. Fencing is to extend between the corridor and lands of owners or occupiers adjoining the railway, with any specific requirements to be designed in consultation with the adjoining landholder.

The Project alignment will be fenced with three-strand or four-strand barbed-wire fencing where the alignment occurs within the existing rail corridor. The barbed-wire fencing is reflective of the largely agricultural land use of this section of the alignment and seeks to ensure that stock and people do not enter the rail corridor. The barbed-wire fencing will maintain the current barriers of the existing landscape will also allow animals to move along the alignment, maintaining current movement opportunities across the existing corridor. Most of the Project alignment will maintain this style of fencing.

1.6.9 Fauna fencing

Fauna fencing is constructed in association with fauna crossings to facilitate safe and effective movement of fauna to maintain existing movement corridors and animal behaviours within the vicinity of infrastructure where it is deemed that there is a risk of population fragmentation. Fencing and tie-ins with fauna crossings are designed to deter or effectively prevent animals entering the operating rail environment, and is an important aspect aimed at guiding animals towards the preferred fauna-crossing structure or passage.
The elevation of fencing to fauna exclusion fencing is proposed where the alignment is considered likely to represent a moderate to high risk of fauna entering the rail alignment and become trapped within the active track area. A 3 m buffer clear of vegetation on the habitat side of the fauna exclusion fence is required to ensure that species cannot use vegetation to climb onto the exclusion fencing. Vegetation within the alignment will also be removed in these areas identified as moderate to high risk to ensure that fauna is not encouraged into the active track area.

The fauna corridor fencing strategy seeks to focus on areas of greenfield development where existing fauna movement may be impacted by the Project. All proposed fauna crossings are within areas of greenfield development for the Project. Three options for fauna fencing are:

- General fauna exclusion fencing where relevant
- Koala fencing only where koalas are considered likely to occur following completion of fauna surveys
- Barbed-wire fencing where relevant and consistent with existing landscape features of alignment.

1.6.10 Fish passage

Fish passage is an essential requirement for the survival and productivity of many species of QLD fish. Due to the construction of instream structures (such as dams and culverts) on waterways, the loss of access to habitat has caused the decline in distribution of native fish populations.

The *Fisheries Act 1994* (Qld) and the *Planning Act 2016* (Qld) legislate that works within waterways that are considered to be the development of new, or raising of existing waterway barriers, in addition to maintenance of existing structures, must be designed, constructed, maintained and operated to provide adequate fish passage.

Confirmation of the design of culverts, bridges (under both rail and road) and any other cross drainage structures and how they meet fish passage requirements is to be undertaken for the detailed design.

2 Legislative, policy standards and guidelines

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 environmental assessment has been undertaken
- Statutory approvals required as a result of potential impacts to terrestrial and aquatic ecology
- The approach to ecological offsets for significant residual impacts.

An overview of the Commonwealth and State legislation that is relevant to flora and fauna aspects of the Project is presented in Table 2.1.

Table 2.1 Legislative approvals, licences, permits and authorities relevant to the environmental aspects of 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 as 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 Environment and Energy (DotEE) (now Department of Agriculture, Water and 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 DotEE (now DAWE) in May 2017 (EPBC 2017/7944). The Minster for the Environment determined that the Project is a 'controlled action' on 21 June 2017 requiring the preparation of an EIS. 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 K: 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 the EIS Appendix K: Matters of National Environmental Significance Assessment Technical Report. ARTC's Environmental Offset Delivery Strategy – Qld is contained in Appendix K 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 2012) The Australian Government defines offsets as measures that compensate for the residual adverse impacts of an action on the environment (Australian Government 2012).	
Matters of National Environmental Significance: *Significant impact guidelines 1.1 – Environment Protection and Biodiversity Conservation Act 1999* (MNES Guidelines)	MNES	The purpose of the MNES Guidelines 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 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 K: 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 (DotEE 2015)	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)	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 which may influence ecology aspects (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* (DILGP, 2014). The biodiversity State interest requires development to be located in areas to avoid significant impacts to MNES, avoid and minimise impacts to 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.
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. 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.
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 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

Legislation/policy	Legislative jurisdiction	Intent	Applicability
		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 (Qld), 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 (Qld), 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 (Qld) 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.	▪ 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) 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 K: Matters of National Environmental Significance Technical Report and has subsequently been excluded from this document to avoid repetition
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 4.4.14.

Legislation/policy	Legislative jurisdiction	Intent	Applicability
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 Zones 1 and 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 4.4.4.
Agricultural Chemicals Distribution Control Act 1966 (Qld) (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. 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 EIS 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 Construction Environmental Management Plan (CEMP), the Australian Pesticides and Veterinary Medicines Authority will regulate the lawful application of pesticides and herbicides for targeted pest and weed management activities.

Legislation/policy	Legislative jurisdiction	Intent	Applicability
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 5.2.
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).

Legislation/policy	Legislative jurisdiction	Intent	Applicability
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. 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, December 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.	The Project will be required to deliver environmental offsets consistent with 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. Information related to the provisions of offsets are provided in Section 5.4. ARTC's Environmental Offset Delivery Strategy – Qld is also contained in Appendix K of this report.
Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DSDIP 2014) (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 involves disturbance to features protected by 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, 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.	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.

Legislation/policy	Legislative jurisdiction	Intent	Applicability
		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 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. 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	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
		– 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).*	
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 (ESD) 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 Project will deliver environmental offsets consistent with the QEOP. Information related to the provisions of offsets are provided in Section 5.4. ARTC's Environmental Offset Delivery Strategy – Qld (Strategy) is contained as Appendix K in this report. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans.

Legislation/policy	Legislative jurisdiction	Intent	Applicability
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 (DERM 2010c). Sections 4.4.1.2 and 4.4.2.2 list the NRM State Back on Track species and their rank for the NRM.
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) (DEHP 2014). 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: 1. State significance — areas assessed as being significant for biodiversity at the bioregional or State scales 2. Regional significance — areas assessed as being significant for biodiversity at the sub-bioregional scale 3. 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, (DEHP 2016). The following reports outline the BPAs conducted within the ecology study area: ▪ Biodiversity Planning Assessment for the southeast Queensland Bioregion: Fauna Expert Panel Report (Version 4.1) (DEHP 2016a) ▪ Biodiversity Planning Assessment for the southeast Queensland Bioregion: Flora Expert Panel Report (Version 4.1) (DEHP 2016b) ▪ Biodiversity Planning Assessment for the southeast 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 the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) for the riverine and non-riverine wetland of South-East Queensland (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).

Predictive habitat modelling for each flora and fauna species that constituted a sensitive environmental receptor (refer Section 3.3.4, as well as Appendix A) and associated constraints mapping, was developed based on the desktop and field survey results.

A range of survey methods were carried out over the ecology study area over a number of years and seasons. While detailed onsite surveys for all threatened fauna species were not undertaken as per the relevant survey guidelines for each species, the historic survey effort is considered appropriate to detecting the potential presence of sensitive environmental receptors (i.e. fauna/flora) that may occur in the area. Sections 3.4.2 and 3.4.3 outlines the methods used during Project associated surveys.

The threatened species habitat modelling has been based on a conservative approach to mapping habitat. In the absence of sufficient and robust scientific information to support a species being excluded from the area, the species has been assumed to be present if habitat for the species is present, or there are local records to this species.

The approach is even more conservative as 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 the measures to avoid, minimise and mitigate impacts. This assessment has determined the maximum potential area of disturbance using the predictive habitat modelling to provide the total maximum extent of habitat to be cleared irrespective of habitat category (e.g. Core habitat, Essential habitat, Important habitat, General habitat or Unlikely habitat, refer Section 3.3.4) or quality.

A key outcome of the significant impact assessment is the determination as to whether the maximum clearing extent for 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 and represents the maximum extent of clearing. 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). It is expected through this process that the actual extent of clearing, and therefore the impacts on sensitive environmental receptors, will be reduced compared to this assessment.

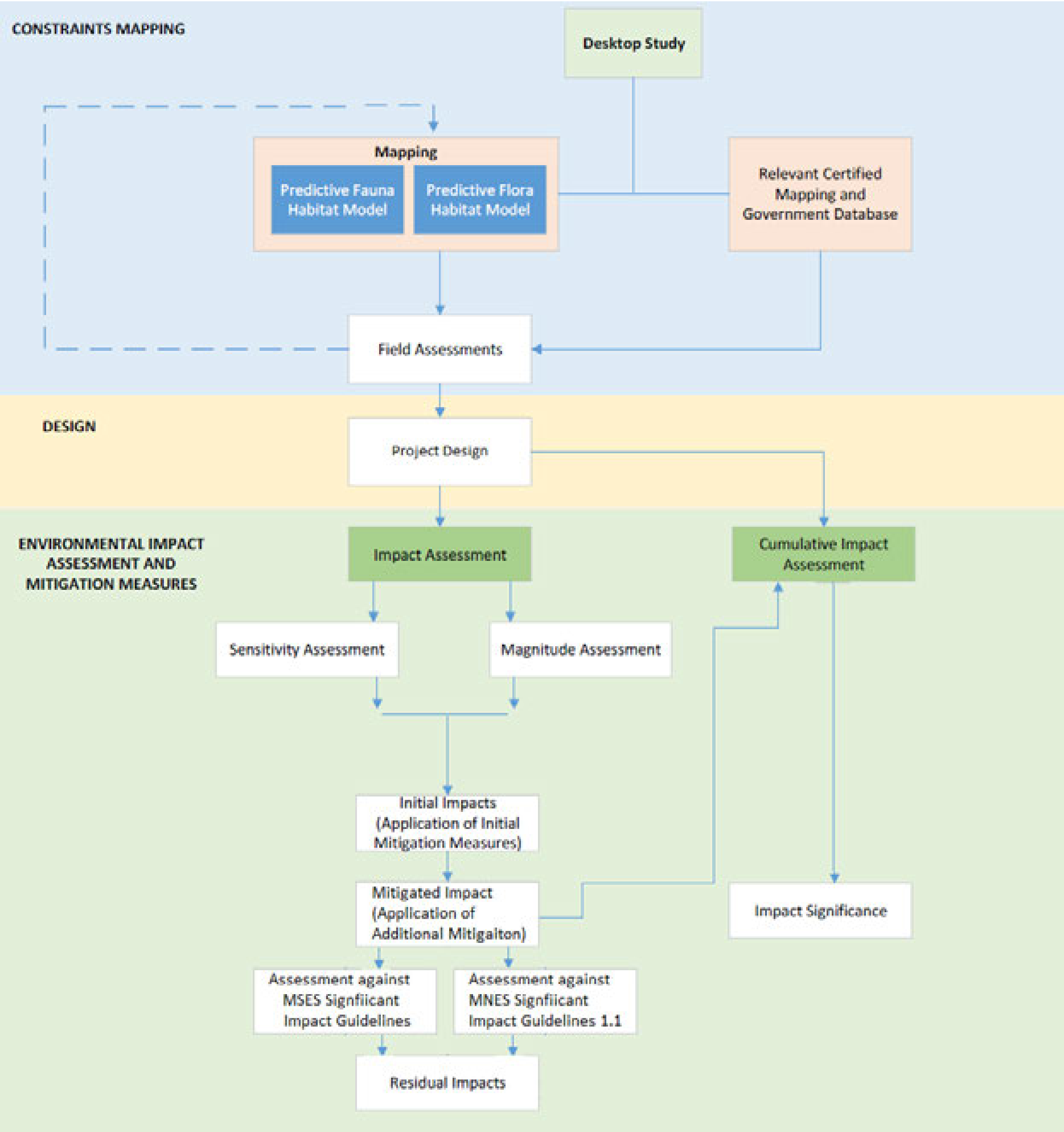


Figure 3.1 **Assessment methodology**

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 includes habitat for fauna, retention of *Melaleuca irbyana* trees 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 recognised 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 sensitive environmental receptors located within the ecology study area 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 field component of the Project EIS. In addition, this section provides details related to the creation of predictive geographic information system (GIS) models which specifically identify areas of habitat capable of supporting species identified as sensitive environmental receptors (i.e. species listed as threatened and near-threatened under the provisions of the NC Act) within the ecology study area.

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, 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.

Table 3.1 Database review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia	29/03/2020	Disturbance footprint with 50 km buffer applied	Records of flora and fauna, including conservation significant species listed under the EPBC Act and/or NC Act and those identified as MLES.
Flying Fox Monitoring Program	24/03/2020	Disturbance footprint with 15 km buffer applied	Show the general location of flying-fox roosts in Queensland recorded by DES/DAWE and include 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	06/02/2020	Disturbance footprint with 15 km buffer applied	Show the general location of flying-fox roosts in Queensland recorded by DES and include continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Birds Australia	29/03/2019	Ecology study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act and/or NC Act.
BPA mapping (Queensland Government 21/2/2018)	06/02/2020	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 Section 3.3.4.1).

Database/data source name	Database search date	Database search areas	Data type
Back on Track species prioritisation framework (DEHP 2010)	06/02/2020	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 Section 4.4.1.2 (flora) and Section 4.4.2.2 (fauna).
EPBC Act Protected Matters Search Tool (DAWE 2020a)	06/02/2020	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 (BoM 2019)	06/02/2020	Ecology study area	Provides information related to 3 types of groundwater dependant ecosystems (GDEs): aquatic, terrestrial and subterranean.
Wildlife Habitat Map (Queensland Government 2019a)	06/02/2020	Ecology study area	Modelled habitat under the VM Act for a conservation significant species listed under the EPBC Act and/or the NC Act.
Regulated Vegetation Management Map (DNRME 2019a)	06/02/2020	Ecology study area	Mapping of REs and High Value Regrowth that provide habitat for conservation significant species under the EPBC Act and/or NC Act and may be considered a TEC under EPBC Act.
Register of critical habitat (Australian Government)	06/02/2020	Australian extent	Critical habitat listed under the EPBC Act.
Map of Referable Wetlands (Queensland Government 2018)	06/02/2020	Regional extent	Includes State significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland REs.
Wildnet database (DES 2019a) incorporating WildNet and Herbrecs datasets	06/02/2020	Ecology study area	Records of flora and fauna, including conservation significant species listed under the EPBC Act and/or NC Act and MLES.
Queensland waterways for waterway barrier works (DAF 2019)	06/02/2020	Ecology study area	Waterways where proposed waterway barrier works require assessment and approval under the *Fisheries Act 1994.*
Watercourse Identification Mapping (DNRME 2019b)	06/02/2020	Ecology study area	Known extent of watercourses and drainage features that are managed under the *Water Act 2000.*
Wetland Info database (DES 2019b)	06/02/2020	Ecology study area	Provides interactive maps, species records, case studies and legislation associated with Queensland wetlands. Also provides access to Queensland AquaBAMM assessments.
Fish Habitat Areas (Queensland Government 2018c)	06/02/2020	Ecology study area	Boundaries of gazetted, declared fish habitat areas.

Database/data source name	Database search date	Database search areas	Data type
Queensland Springs Database (DES 2018a)	06/02/2020	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression GDEs.
Matters of State Environmental Significance (DES 2019d)	06/02/2020	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 in from 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 the Commonwealth's threatened species survey guidelines.

In addition, seasonal variation was also captured in the modelling approach (refer Section 3.3.4) 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 recovery programs and conservation advice (refer Section 3.3.4, 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)	AECOM (2010)	▪ Confirmation of the presence of the Swamp tea-tree (*Melaleuca irbyana*) during field investigations ▪ Detection of the Powerful owl (*Ninox strenua*) during nocturnal call-playback ▪ Analysis and conformation of Remnant vegetation as listed under the VM Act within the study area.

Document title	Reference	Summary of significant findings related to sensitive environmental receptors
Calvert to Kagaru Flora and Fauna Technical Report	Jacobs-GHD (2016a)	▪ Confirmation of the presence of the Swamp tea-tree (*Melaleuca irbyana*) during field investigations ▪ Observations of feeding signs (i.e. orts) of Glossy-black cockatoos (*Calyptorhynchus lathami*) during field investigations
Woolooman Tunnel Geotechnical Access – Ecological Assessment Report	GHD (2017)	▪ No observations of MSES species (excluding those also listed as an MNES)
Australian Rail Track Corporation/Transport - Land/ southwest of Ipswich/Queensland/ Inland Rail Calvert to Kagaru Project (EPBC Referral number 2017/7944)	ARTC (2017)	▪ Provides initial details on how the project is likely to impact upon MSES. This includes, identification of potential impacts to threatened species, remnant vegetation and migratory species.
Initial Advice Statement: Inland Rail – Calvert to Kagaru – 10 May 2017.	ARTC (2017)	▪ Confirmation of the presence of the Swamp tea-tree (*Melaleuca irbyana*) during field investigations ▪ Observations of feeding signs (i.e. orts) of Glossy-black cockatoos (*Calyptorhynchus lathami*) during field investigations
Inland Rail – Gowrie to Kagaru Geotechnical investigations. MNES assessment report – 23 July 2018	EMM (2018a)	▪ Confirmation of the presence of the Swamp Tea-tree (*Melaleuca irbyana*), particularly around Ebenezer and Willowbank
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2018 and 2019) Preclearance survey reports (2018 and 2019)	EMM (2018b-e; 2019a-c)	▪ No observations of MSES flora species within the C2K alignment
Inland Rail – Calvert to Kagaru Geotechnical investigations. Protected plants flora survey reports (8 May 2019, 20 June 2019) Preclearance survey report (11 June 2019)	ELA (2019a-c)	▪ No observations of MSES flora species

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 H, Appendix I and Appendix J) and used to refine the predictive habitat mapping (refer Figure 3.1 and Appendix A). 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, Appendix A and Appendix G).

Species of conservation significance considered possibly 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 for some species and intertidal saltmarshes and estuarine wetlands for other species)
- Are considered locally extinct.

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

- Have infrequently been recorded previously in, or within 1 km of 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. Note that species that can be identified as sporadically utilising areas of the ecology study area are assigned to the “likely” category

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

- Have been recently recorded in, or within 1 km of the ecology study area (i.e. 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, which are in good condition (with condition based on based desktop works, literature review and, where available and possible, supplementary field assessments)
- 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. potential habitat) and open woodland and habitat (i.e. considered critical to the survival of the species). 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 Section 3.3.1) 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 Figure 3.1).

3.3.4.1 Habitat mapping for species listed under the NC Act

The habitat in the predictive species habitat model 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 proximal 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 (DotEE 2015).

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

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.

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 observation. Species specific assumptions that define the Potential habitat category are identified in Appendix A.

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 (DotEE 2015).

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

3.4 Field assessments

This section outlines the field assessment methodologies adopted in recognition of relevant guidelines or policies (i.e. survey guidelines, species recovery plans and the MNES Guidelines). Field surveys were undertaken with due consideration of 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 REs 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 2016).

As noted previously, detailed onsite surveys for threatened flora and fauna have not necessarily been carried out as per the relevant State survey guidelines. For example under the *Terrestrial Vertebrate Fauna Survey guidelines for Queensland* (Eyre et al 2018), surveys to detect small mammals require the use of 20 “Type A” Elliot traps per each sample location, placed 10 m apart in two parallel lines, baited with vegetable or meat-based products, and operate for a period of four consecutive nights, being checked within 2 hours of sunrise. 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 the presence of species of conservation significance and habitat modelling for species of conservation significance 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 approvals phase, detailed site-based surveys for threatened species will be required as the Project progresses, and the 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 Appendix A), 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 reduce the areas that were accessible to ecological investigations.

Whist not specifically detailed within this document, results of previous field work conducted by Jacobs - GHD (2016) and findings associated with ecological investigations to support approval processes for the Calvert to Kagaru geotechnical program (i.e. undertaken by EMM and ELA in 2018 and 2019) which occurred concurrently with the EIS investigations reported in this document, have been incorporated within the EIS reporting. Refer to Figure 3.2 for the locations of areas investigated 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 2016) and in addition, habitat assessments (including breeding and foraging habitat for threatened species), focussing on those listed as threatened (e.g. Glossy-black cockatoo). This data has been used to assist in the predictive habitat mapping and refinement of *Melaleuca irbyana* habitat located within the ecology study area. In relation to the Teviot range, limited accessibility hindered site based EIS investigations in this area. However, to account for this, the results of Jacobs - GHD's investigations have been incorporated into the assessment of potential impacts (refer Section 5.2.3)

3.4.1 Field assessment locations and timing

A representative sampling approach was employed as part of the field sampling methodology. Seasonal sampling (i.e. Spring (mid-September to mid-December) and Autumn (late February to April)) are recommended for the Southeast Queensland (SEQ) bioregion (Eyre et al. 2014). The use of publicly available datasets, surveys undertaken by GHD 2016 (i.e. Autumn 2016), surveys undertaken by Future Freight Joint Venture (FFJV) (i.e. Spring 2017) and surveys undertaken by AECOM (early Autumn 2008) fulfil this seasonal requirement. These 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 3.3.4.2) 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 the Project

Table 3.3 presents the survey timing and survey activities associated with previous Project associated ecological investigations, including the Jacobs-GHD works in 2016, and geotechnical field investigations undertaken by ELA and EMM (2018 and 2019). It is noted the disturbance footprint has changed somewhat since the surveys carried out by GHD, particularly in the Teviot Range area. Figure 3.2a-e presents the survey location points. Note, there is substantial overlap in the location of surveys undertaken during programs presented in Table 3.3 and Figure 3.2a-e with those undertaken as part of targeted surveys associated with the EIS in 2017 (refer Figure 3.3a-b), 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.

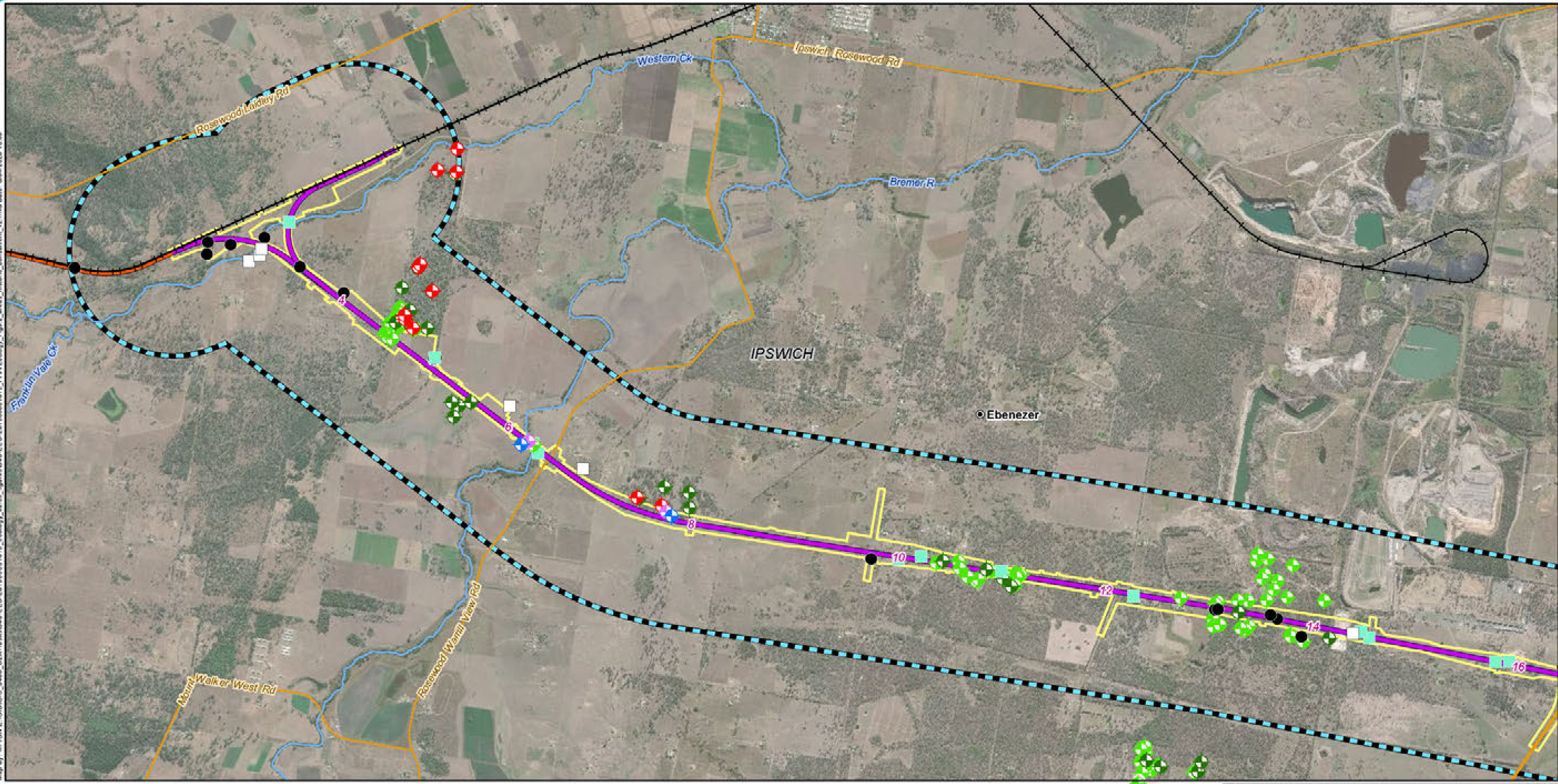
Table 3.3 Timing of field investigations undertaken associated with the Project used to supplement the results of the current study

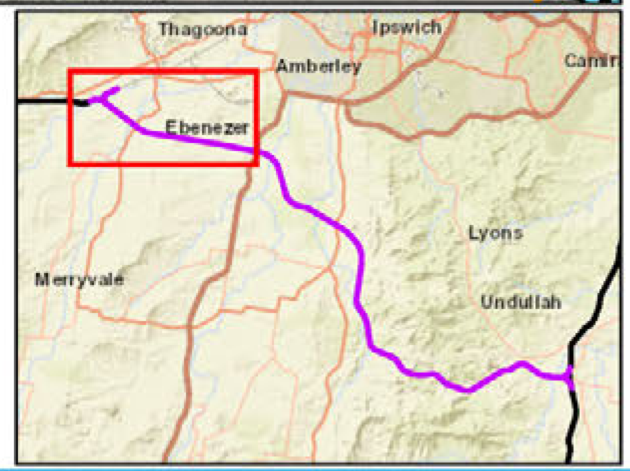
Study/investigation	Consultant/ year	Timing of investigations	Season	Methodologies and notes
Southern Freight Rail Corridor Study (March 2010)	AECOM (2010)	March-April (2008)	Autumn (2008)	▪ Verification of REs ▪ Targeted surveys for threatened flora and fauna species ▪ Incidental aquatic surveys ▪ 26 sites targeted within C2K alignment

Study/investigation	Consultant/ year	Timing of investigations	Season	Methodologies and notes
Calvert to Kagaru Flora and Fauna Technical Report	Jacobs-GHD (2016a)	9-16 May (2016)	Autumn (2016)	▪ Verification of vegetation communities ▪ Targeted surveys for threatened flora and fauna species ▪ Rapid habitat assessments ▪ Nocturnal searches/spotlighting ▪ Electrofishing
Woolooman Tunnel Geotechnical Access – Ecological Assessment Report and Protected Plants Assessment Report	GHD (2017a,b)	13-17 February (2017)	Summer (2017)	▪ Survey of alternative tunnel options in Teviot Range for Project (including areas outside ecology study area) ▪ Protected plant surveys (systematic transect searches and plot-based population surveys) ▪ Searches for fauna breeding places ▪ Threatened fauna habitat surveys ▪ Targeted surveys for threatened fauna species ▪ Nocturnal searches / spotlighting
Protected plant surveys and ecological assessment associated with geotechnical investigations to support EPBC Referral 2018-8263 and inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM (2018b, c)	16 May 2018 and 28 June 2018	Autumn, Winter (2018)	▪ Active searches for threatened species ▪ Protected plant surveys (meander surveys – minimum 30 minutes) at 70 sites throughout C2K alignment ▪ Habitat surveys
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 (2018d, e)	4-14 September 2018 26-28 November 2018	Spring (2018)	▪ Threatened fauna habitat assessments ▪ Searches for fauna breeding places ▪ Vegetation community confirmation ▪ Fauna observations ▪ Carried out at 25 sites throughout C2K alignment
Protected Plant surveys associated with geotechnical investigations – identified as opportunistic surveys throughout this technical report	FFJV (2017-2018)	March 2017 - September 2018	Autumn, Winter, Spring, Summer (2017-2018)	▪ Protected plant surveys (meander surveys – minimum 30 minutes) and habitat surveys carried out at 69 sites throughout alignment ▪ Habitat surveys ▪ Confirmation of vegetation communities

Study/investigation	Consultant/ year	Timing of investigations	Season	Methodologies and notes
Protected plant surveys and pre-clearing surveys associated with geotechnical investigations	ELA (2019a,b	December 2018 – April 2019	Summer 2018/2019	▪ Protected plant surveys (meander surveys – minimum 30 minutes) at 42 sites throughout alignment Habitat surveys ▪ Confirmation of vegetation communities
Pre-clearing surveys associated with geotechnical investigations for C2K alignment	ELA (2019c)	December 2018 – April 2019	Summer/Autumn (2018/2019)	▪ Threatened fauna habitat surveys ▪ Habitat assessment ▪ Searches for fauna breeding places ▪ Fauna observations ▪ Confirmation of vegetation communities ▪ Carried out at 296 sites throughout alignment
Protected plant surveys associated with geotechnical investigations for Gowrie to Kagaru alignment	EMM (2019a, b)	13-24 May 2019 3 June – 16 July 2019	Autumn/Winter (2019)	▪ Threatened fauna habitat assessments ▪ Searches for fauna breeding places ▪ Confirmation of vegetation communities ▪ Fauna observations ▪ Carried out at 15 sites within C2K alignment
Pre-clearing surveys associated with geotechnical investigations for Gowrie to Kagaru alignment	EMM (2019c)	14-29 May 2019	Autumn (2019)	▪ Threatened fauna habitat assessments ▪ Searches for fauna breeding places ▪ Confirmation of vegetation communities ▪ Fauna observations ▪ Carried out at 14 sites within C2K alignment

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
- H2C project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

GHD/Jacobs

- Fauna ecology survey (GHD/Jacobs)
- Supplementary flora survey point (GHD/Jacobs)
- Supplementary habitat survey point (GHD/Jacobs)
- Quaternary flora survey (GHD/Jacobs)
- Aquatic ecology survey (GHD/Jacobs)

- Supplementary fauna survey point (ELA)
- Supplementary habitat survey point (ELA)
- Supplementary flora survey point (EMM)

A3 scale: 1:40,000

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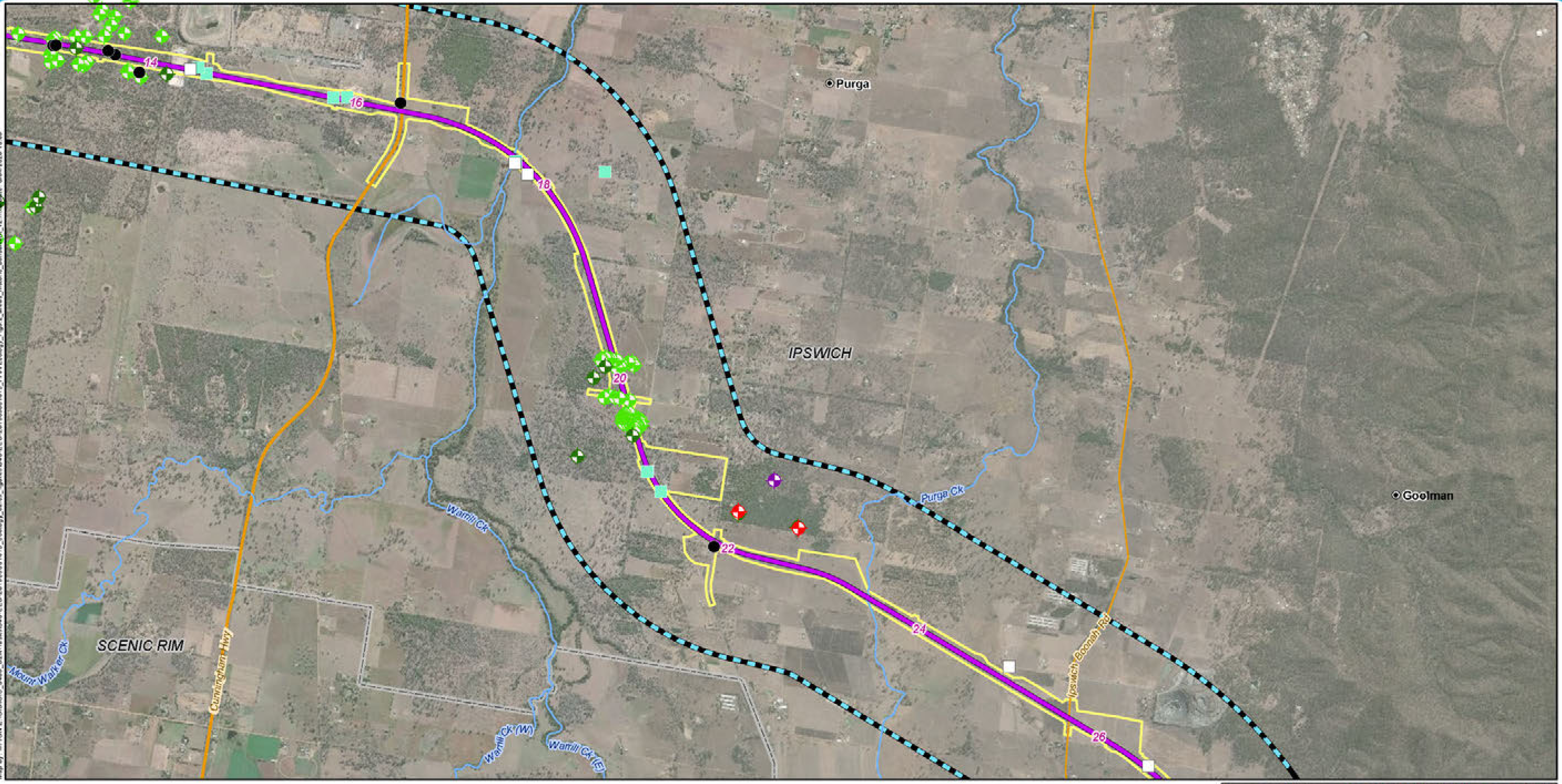
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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



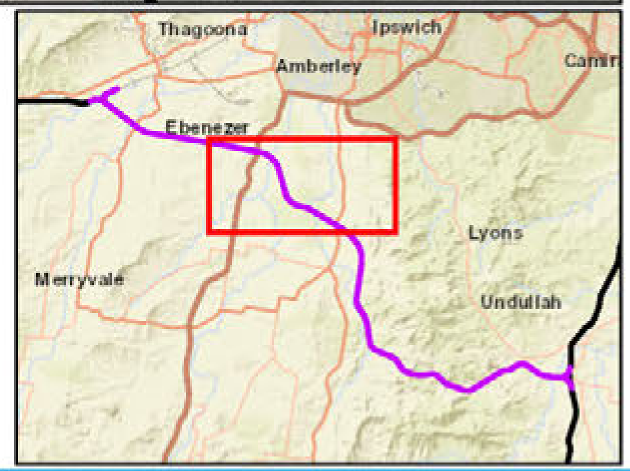
Legend

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

GHD/Jacobs

- Anabat site (GHD/Jacobs)
- Supplementary flora survey point (GHD/Jacobs)
- Quaternary flora survey (GHD/Jacobs)
- Aquatic ecology survey (GHD/Jacobs)

- Supplementary fauna survey point (ELA)
- Supplementary habitat survey point (ELA)
- Supplementary flora survey point (EMM)



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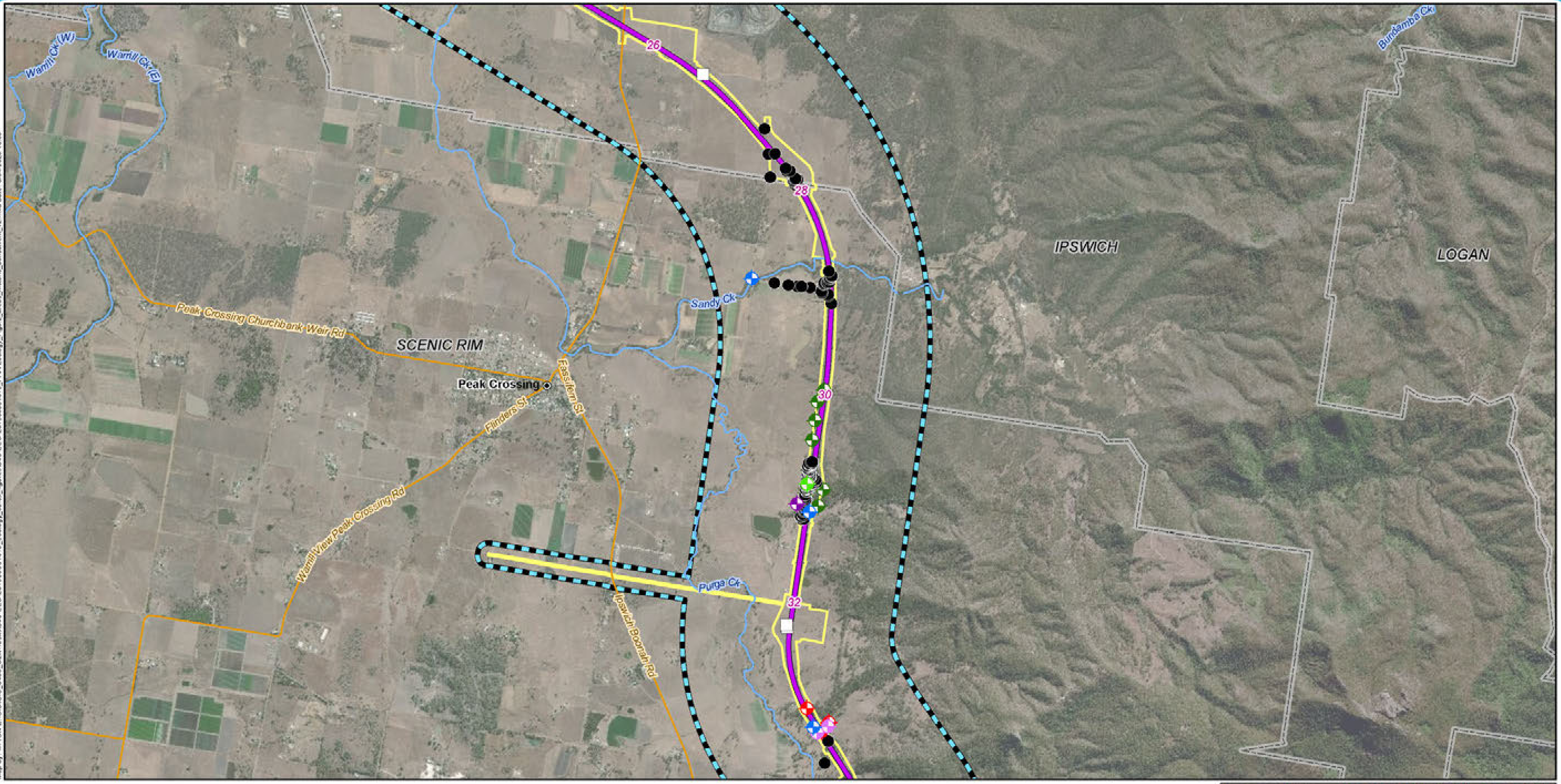
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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



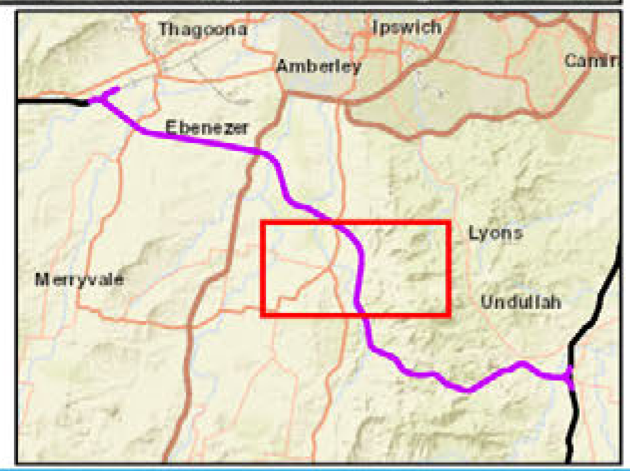
Legend

- 5 Chainage (km)
- Localities
- C2K project alignment
- Watercourses
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

GHD/Jacobs

- Anabat site (GHD/Jacobs)
- Fauna ecology survey (GHD/Jacobs)
- Supplementary flora survey point (GHD/Jacobs)
- Supplementary habitat survey point (GHD/Jacobs)
- Quaternary flora survey (GHD/Jacobs)
- Aquatic ecology survey (GHD/Jacobs)

- Supplementary fauna survey point (ELA)
- Supplementary flora survey point (EMM)



A3 scale: 1:40,000

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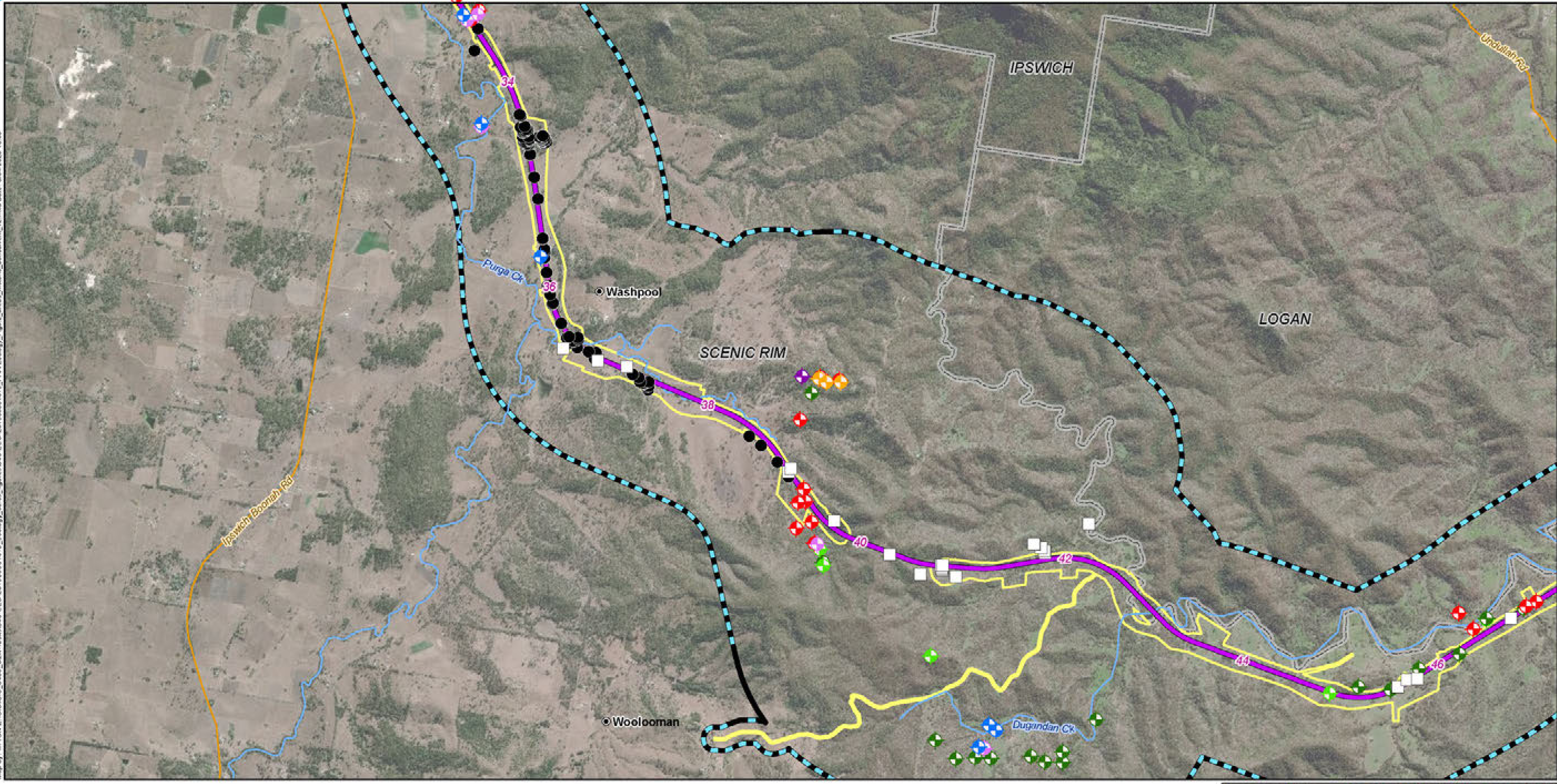
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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

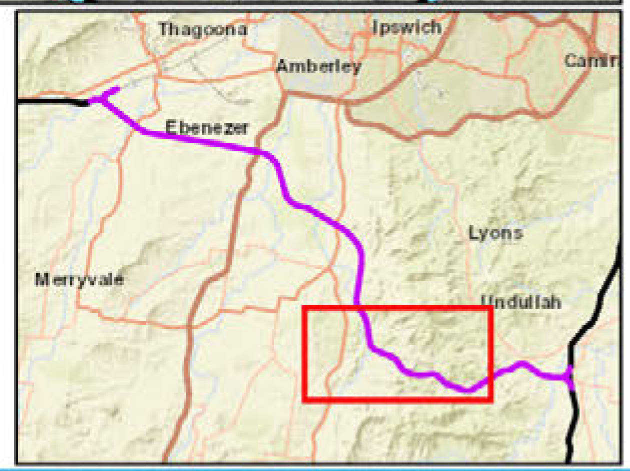
- 5 Chainage (km)
- Localities
- C2K project alignment
- Watercourses
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

GHD/Jacobs

- Anabat site (GHD/Jacobs)
- Fauna ecology survey (GHD/Jacobs)
- Remote cameras (GHD/Jacobs)
- Supplementary flora survey point (GHD/Jacobs)
- Supplementary habitat survey point (GHD/Jacobs)
- Quaternary flora survey (GHD/Jacobs)
- Aquatic ecology survey (GHD/Jacobs)

- Supplementary fauna survey point (ELA)
- Supplementary flora survey point (EMM)

Note that due to topography constraints and the realignment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



A3 scale: 1:40,000

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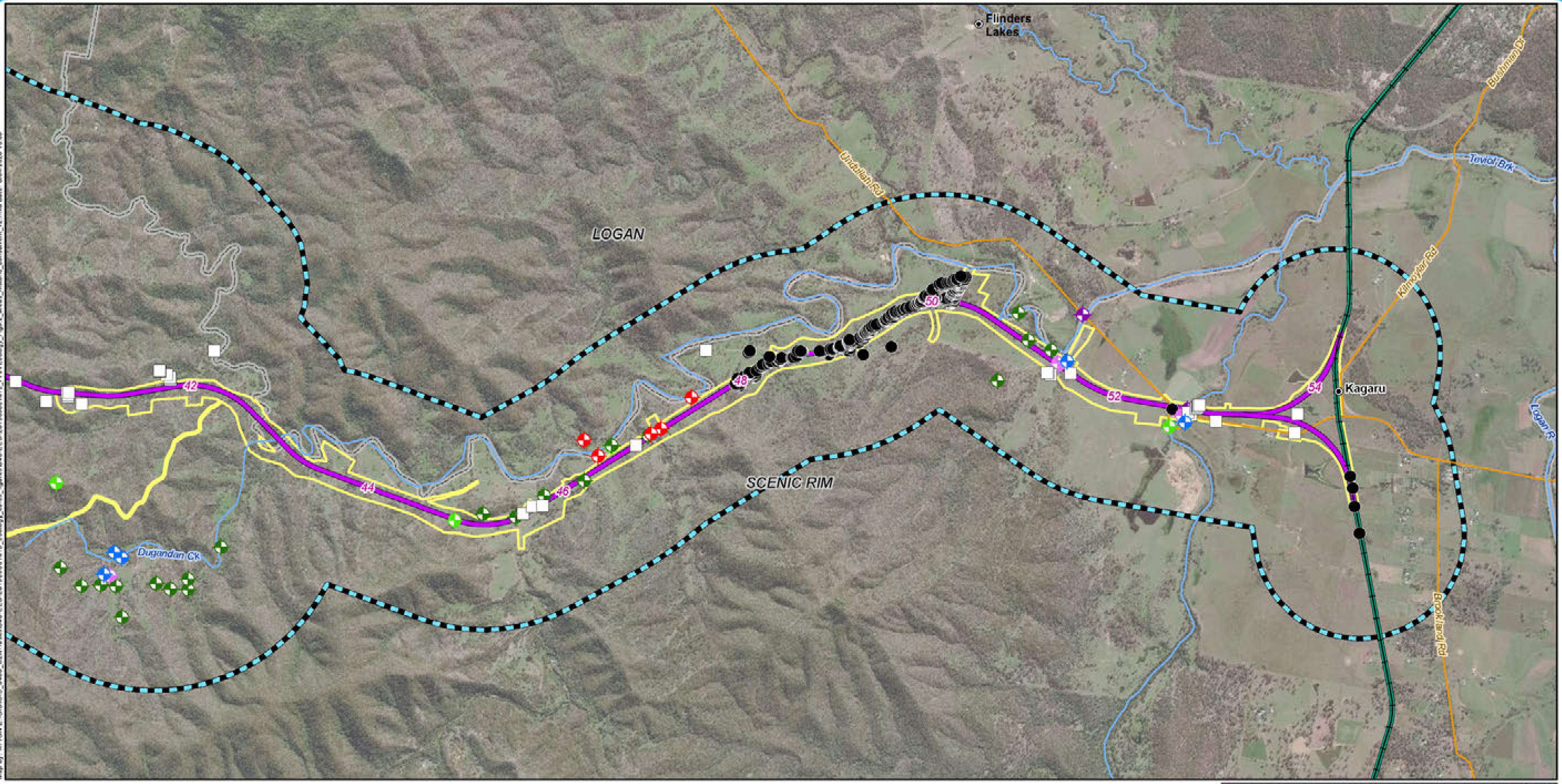
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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

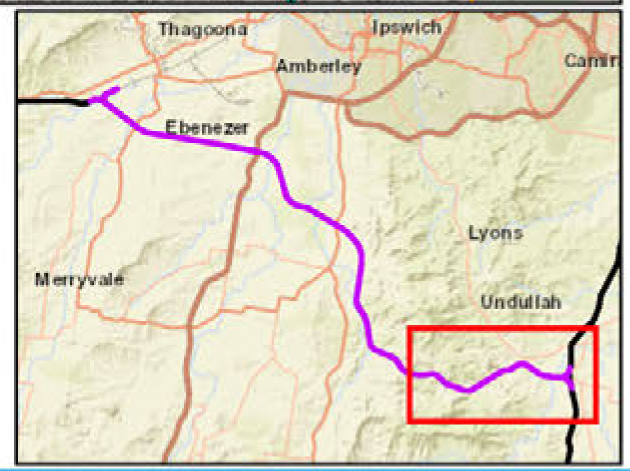
- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- K2ARB project alignment
- Watercourses
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

GHD/Jacobs

- Anabat site (GHD/Jacobs)
- Fauna ecology survey (GHD/Jacobs)
- Supplementary flora survey point (GHD/Jacobs)
- Supplementary habitat survey point (GHD/Jacobs)
- Quaternary flora survey (GHD/Jacobs)
- Aquatic ecology survey (GHD/Jacobs)

- Supplementary fauna survey point (ELA)
- Supplementary flora survey point (EMM)

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



A3 scale: 1:40,000

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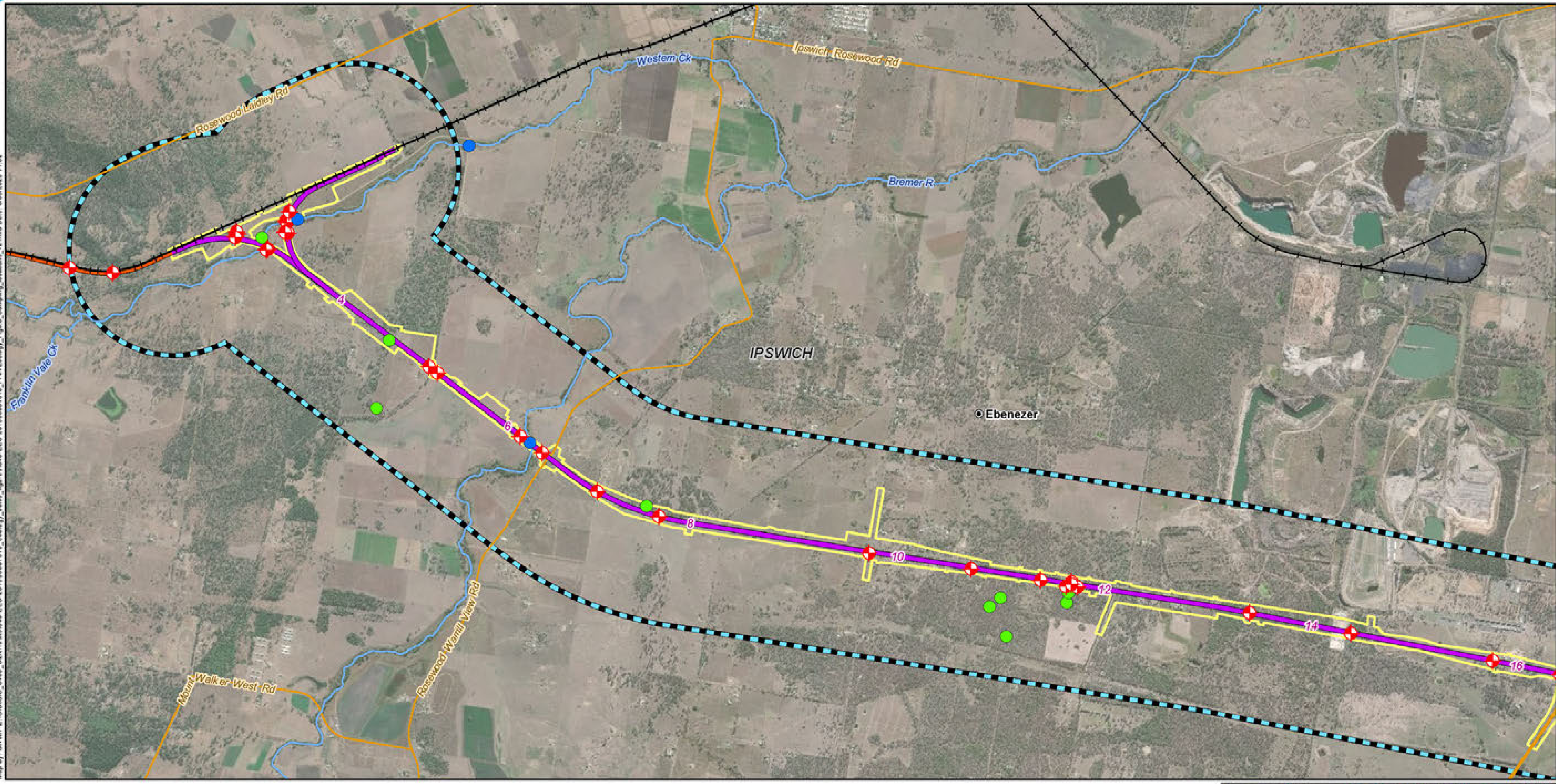
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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



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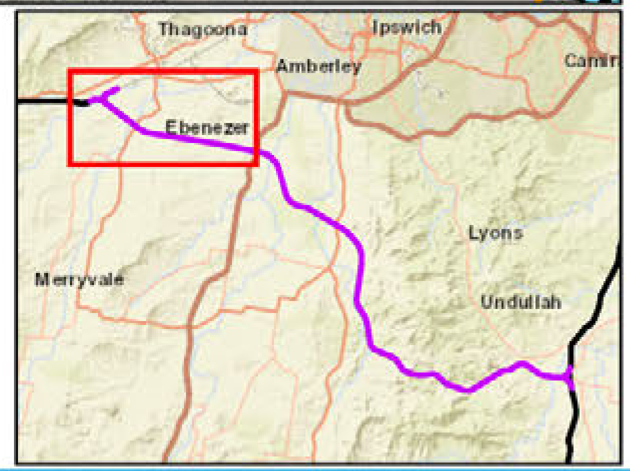
Legend

- 5 Chainage (km)
- Localities
- Anabat/remote camera
- Aquatic sampling sites
- Opportunistic surveys
- Terrestrial sampling sites
- H2C project alignment
- C2K project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

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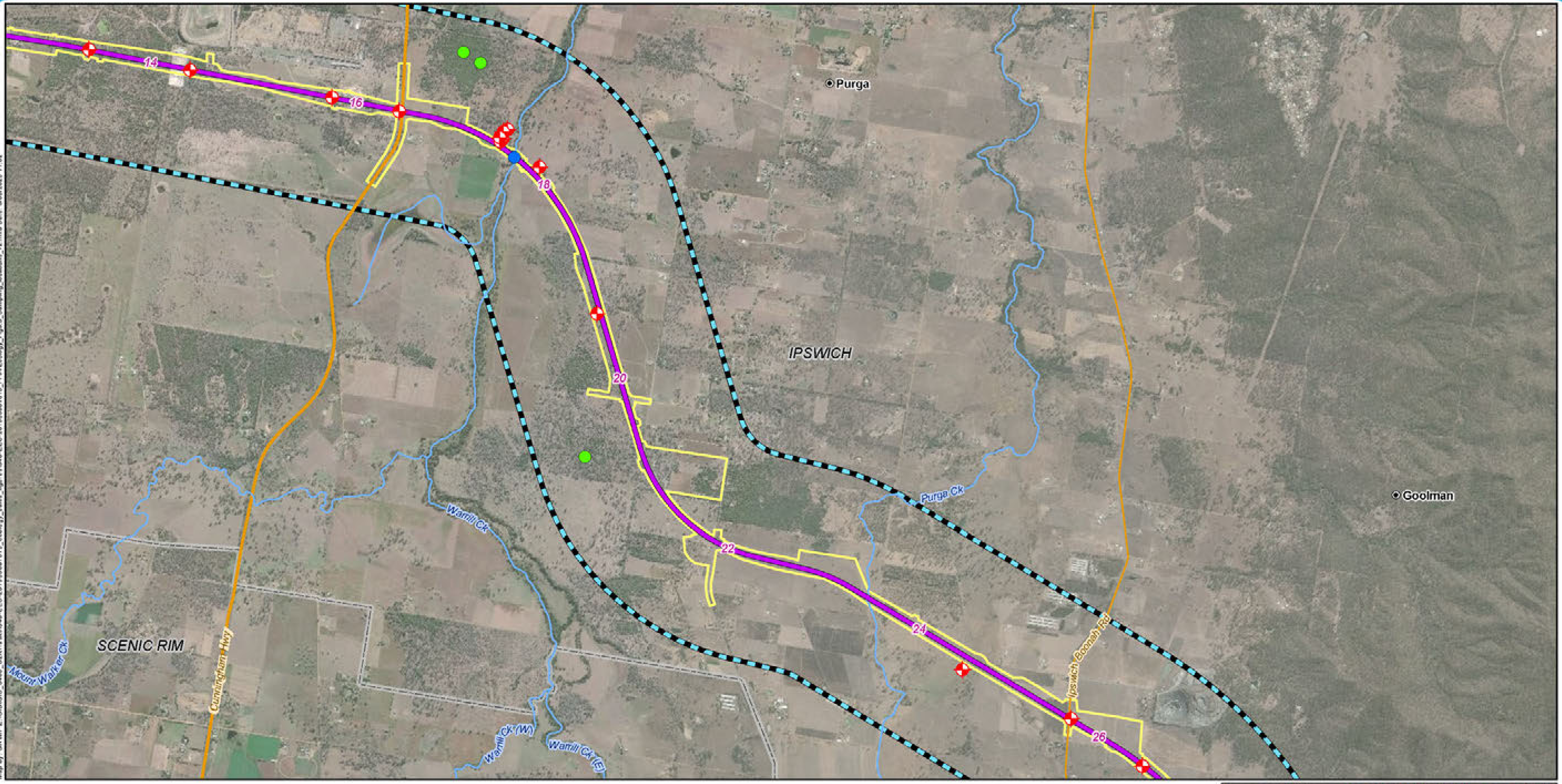
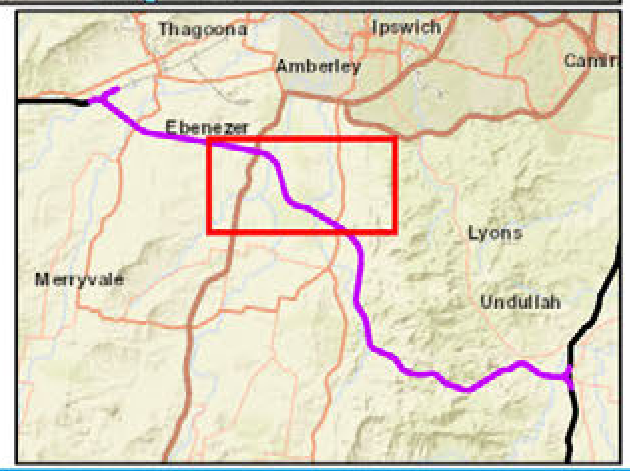
Issue date: 03/09/2020 Version: 0
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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





Legend

- 5 Chainage (km)
- Localities
- Anabat/remote camera
- Aquatic sampling sites
- Opportunistic surveys
- Terrestrial sampling sites
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

A3 scale: 1:40,000

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Future Freight
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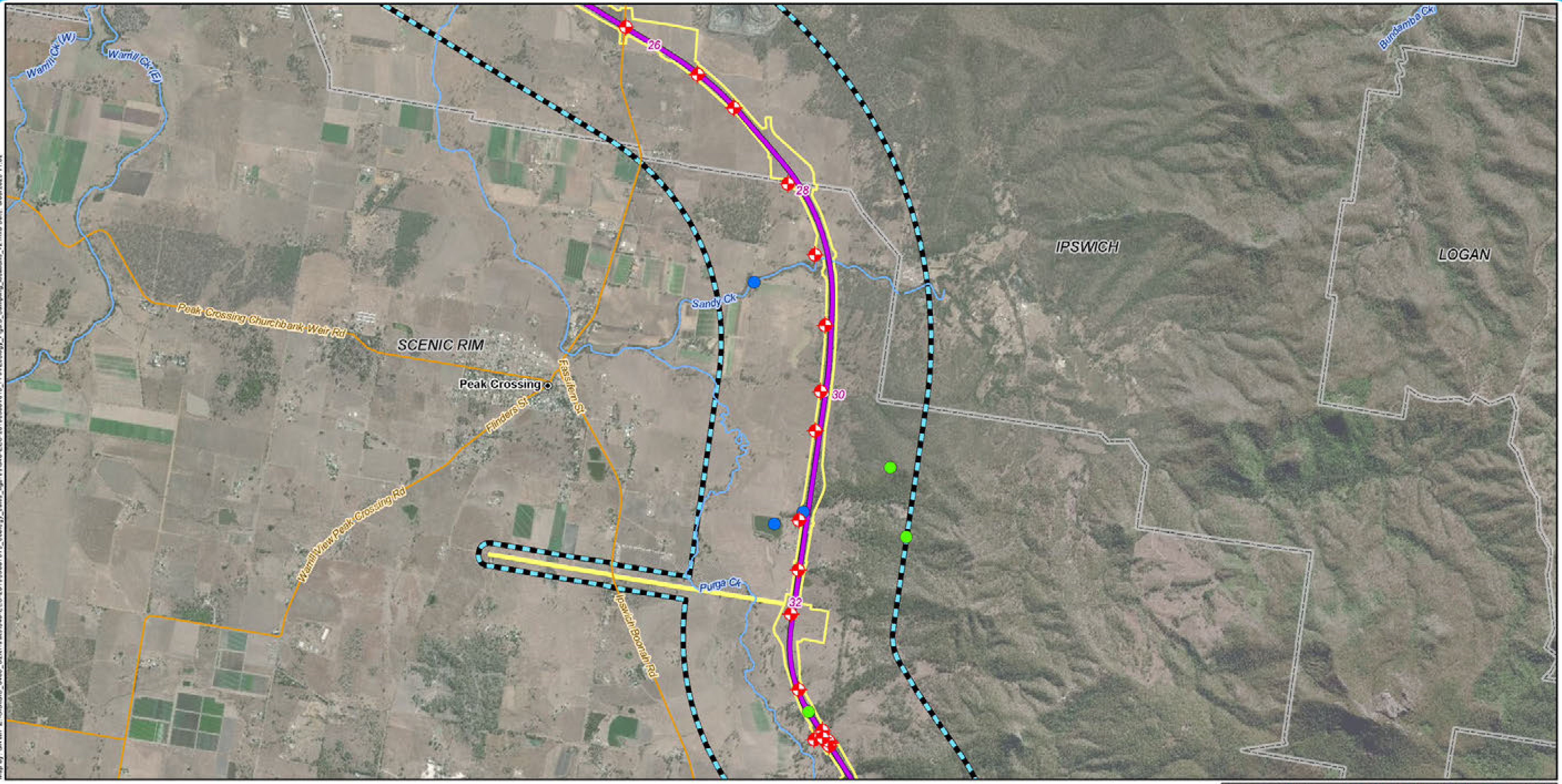
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

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



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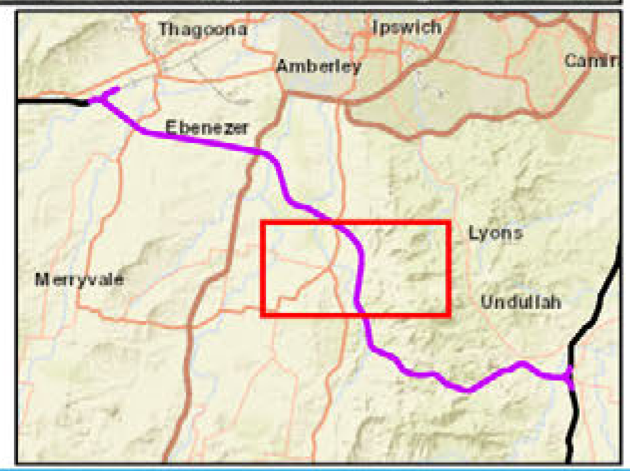
Legend

- 5 Chainage (km)
- Localities
- Anabat/remote camera
- Aquatic sampling sites
- Opportunistic surveys
- Terrestrial sampling sites
- C2K project alignment
- Watercourses
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

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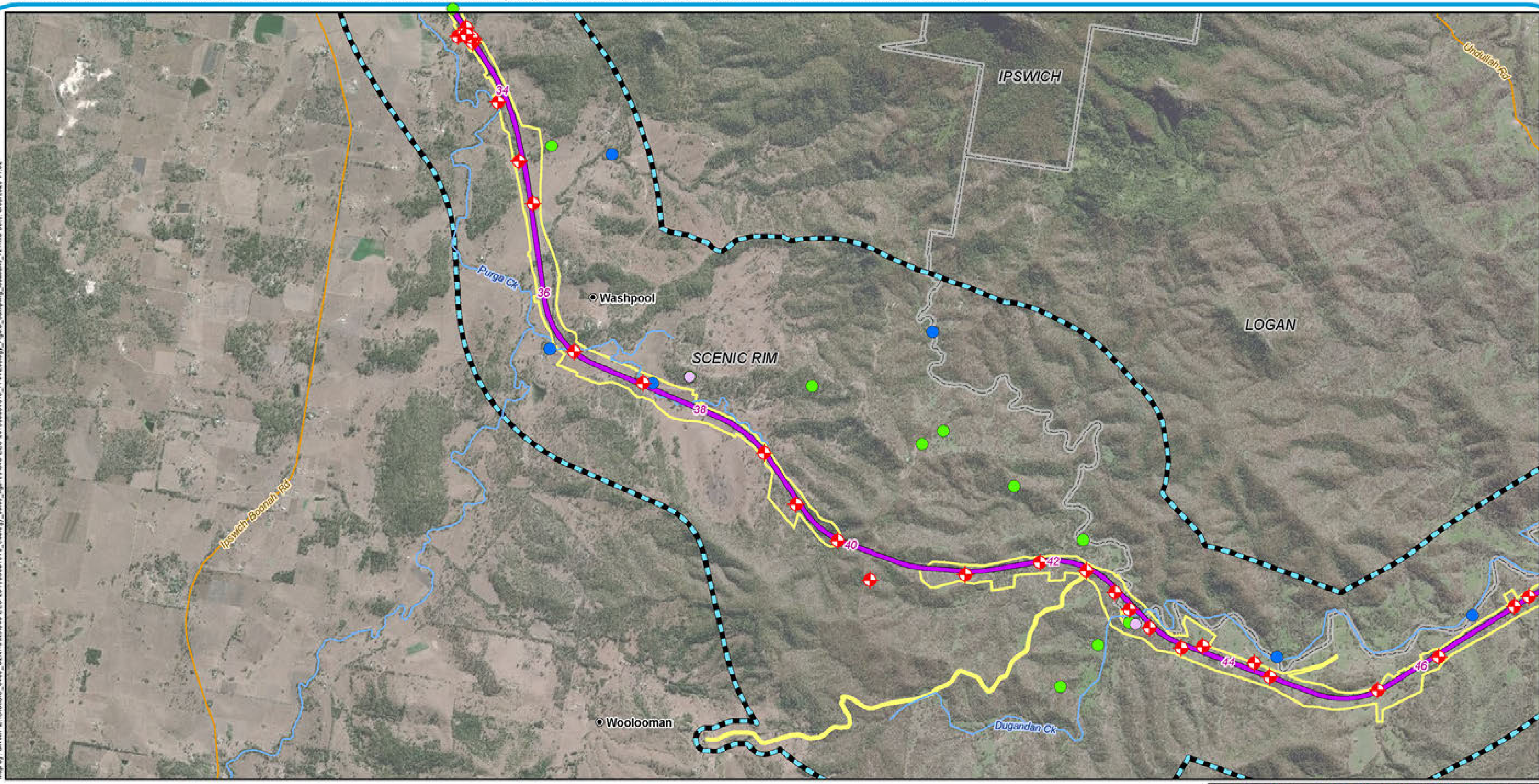
Calvert to Kagaru

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

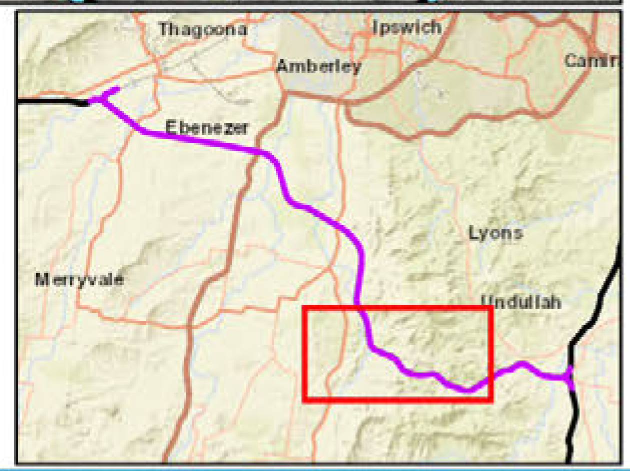


Map by: GN/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_sites_fig\rev1\340-EEC-201905081615_FF\Ecology_Fig3.3_Sampling_locations_v2.mxd Date: 3/09/2020 11:02

Legend

- 5 Chainage (km)
- Localities
- Anabat/remote camera
- Aquatic sampling sites
- Opportunistic surveys
- Terrestrial sampling sites
- C2K project alignment
- Watercourses
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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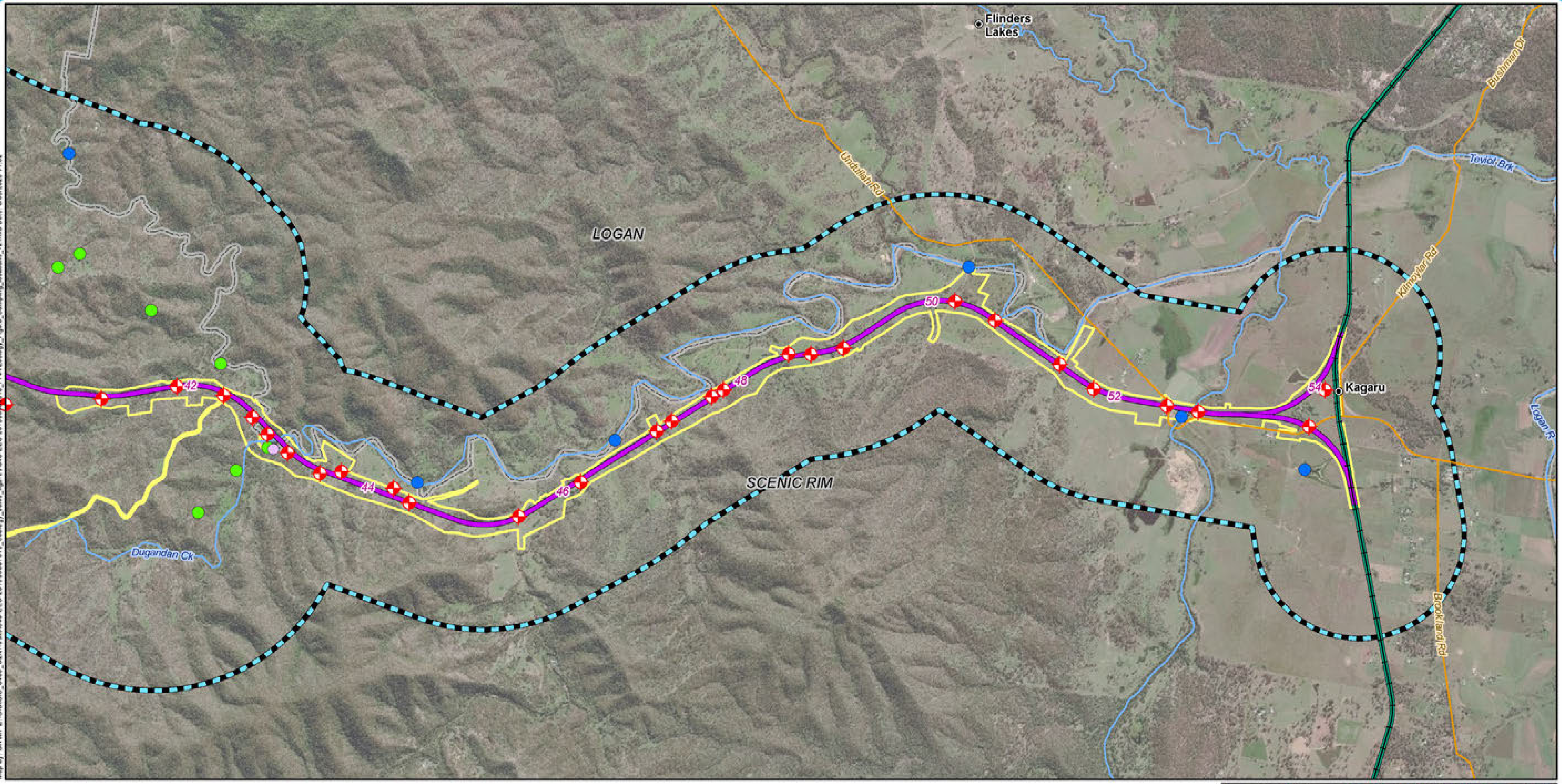
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

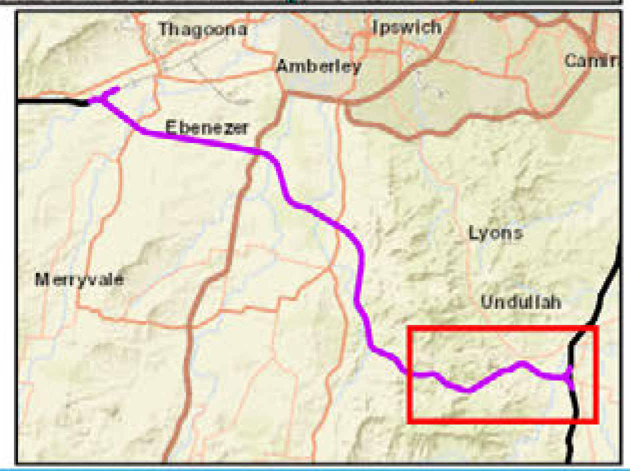
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the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



Legend

5	Chainage (km)
	Localities
	Anabat/remote camera
	Aquatic sampling sites
	Opportunistic surveys
	Terrestrial sampling sites
	C2K project alignment
	K2ARB project alignment
	Existing rail
	Watercourses
	Minor roads
	EIS disturbance footprint (surface disturbance only)
	Ecology study area
	Local Government Areas

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



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

Calvert to Kagaru

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

3.4.1.2 Project ecological studies

Following the initial sampling in 2017, the project alignment throughout the Teviot range was revised, and moved to the north. Additional ecological surveys to support geotechnical investigations (i.e. March 2017 to September 2018) were undertaken along the amended alignment (including the section in the Teviot Range associated with the Tunnel). However, given no surface disturbance is proposed for areas associated with the Tunnel, survey within this section of the alignment has not been as intense as in other areas identified for direct disturbance.

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 16 sites. Specifically, the following features were used to target areas:

- 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)
- Areas containing landscape features that were considered likely to support threatened species when viewed from aerial photography (i.e. Gilgai areas, wetlands and escarpments)
- Areas known or predicted to support threatened species
- Areas 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 carried out in instances where wetland indicators were present (e.g. macrophytes, topography consistent with wetlands or areas mapped as a wetland), the location of the terrestrial and aquatic assessment survey sites survey sites within the ecology study area, and the date of assessment, are presented in Table 3.4 and shown in Figure 3.2.

Table 3.4 Field survey sites and date of assessment (excluding opportunistic survey locations)

Site ID	Site location GDA94					Date of initial assessment	Overlap with historic survey locations
	Zone	Easting	Northing	Latitude (°)	Longitude (°)		
Terrestrial ecology survey sites							
T1	56J	0482332	6917658	-27.661 166	152.549 453	11 September 2017	Does not overlap
T2	56J	0481931	6917458	-27.654 854	152.566 075	11 September 2017	Does not overlap
T3	56J	0481246	6918943	-27.680 447	152.571 835	12 September 2017	Does not overlap
T4	56J	0481831	6918471	-27.704 678	152.682 532	12 September 2017	Overlaps
T5	56J	0481613	6917056	-27.795 896	152.750 496	12 September 2017	Overlaps
T6	56J	480482	6919520	-27.794 863	152.753 320	12 September 2017	Does not overlap
T7	56J	480277	6919395	-27.841 688	152.763 248	12 September 2017	Does not overlap
T8	56J	479217	6919953	-27.868 612	152.834 440	12 September 2017	Overlaps
T9	56J	478035	6920045	-27.840 257	152.800 746	13 September 2017	Does not overlap
T10	56J	476703	6922268	-27.865 005	152.853 613	13 September 2017	Overlaps
T11	56J	475750	6923592	-27.850 105	152.887 912	13 September 2017	Overlaps
T12	56J	462328	6936278	-27.863 030	152.908 488	14 September 2017	Does not overlap
T13	56J	462164	6936560	-27.867 587	152.920 441	14 September 2017	Overlaps
T14	56J	462269	6936647	-27.824 790	152.769 347	14 September 2017	Overlaps
T16	56J	462903	6936597	-27.844 720	152.773 337	14 September 2017	Does not overlap
T17	56J	462918	6936694	-27.775 084	152.748 564	14 September 2017	Does not overlap
T18	56J	469377	6932614	-27.661 166	152.549 453	14 September 2017	Overlaps
T19	56J	455225	6940075	-27.654 854	152.566 075	15 September 2017	Overlaps

Site ID	Site location GDA94					Date of initial assessment	Overlap with historic survey locations
	Zone	Easting	Northing	Latitude (°)	Longitude (°)		
T20	56J	468379	6936376	-27.680 447	152.571 835	15 September 2017	Does not overlap
T21	56J	468218	6936476	-27.704 678	152.682 532	15 September 2017	Does not overlap
T22	56J	456438	6939101	-27.795 896	152.750 496	15 September 2017	Overlaps
T23	56J	456438	6939101	-27.794 863	152.753 320	16 September 2017	Overlaps
T24	56J	456314	6938452	-27.841 688	152.763 248	16 September 2017	Does not overlap
T25	56J	458893	6937518	-27.868 612	152.834 440	16 September 2017	Overlaps
T26	56J	476681	6925260	-27.840 257	152.800 746	16 September 2017	Does not overlap
T27	56J	476530	6925918	-27.865 005	152.853 613	16 September 2017	Does not overlap
Aquatic ecology survey sites							
C2K 1A	56J	455563	6940250	-27.863 030	152.908 488	29 September 2017	Does not overlap
C2K 1A (alt)	56J	457200	6940955	-27.867 587	152.920 441	29 September 2017	Does not overlap
C2K 2A	56J	457778	6938122	-27.824 790	152.769 347	29 September 2017	Overlaps
C2K 3A	56J	468701	6935471	-27.844 720	152.773 337	28 September 2017	Does not overlap
C2K 5A	56J	475422	6925382	-27.775 084	152.748 564	26 September 2017	Overlaps
C2K 5A(alt)	56J	475700	6925497	-27.661 166	152.549 453	26 September 2017	Overlaps
C2K 6A	56J	476688	6920312	-27.654 854	152.566 075	28 September 2017	Does not overlap
C2K 7A	56J	483702	6917341	-27.680 447	152.571 835	27 September 2017	Does not overlap
C2K 7A (alt)	56J	480380	6920477	-27.704 678	152.682 532	27 September 2017	Does not overlap
C2K 8A	56J	485589	6917743	-27.795 896	152.750 496	27 September 2017	Does not overlap
C2K 9A	56J	488964	6919397	-27.794 863	152.753 320	25 September 2017	Does not overlap
C2K 10A	56J	490991	6917967	-27.841 688	152.763 248	25 September 2017	Overlaps
C2K 11A	56J	492168	6917463	-27.868 612°	152.834 440	25 September 2017	Does not overlap
C2K 12A	56J	477285	6922185	-27.840 257°	152.800 746	25 September 2017	Does not overlap
C2K 13A	56J	477682	6919978	-27.865 005°	152.853 613	26 September 2017	Does not overlap
C2K 14A	56J	475227	6927687	-27.850 105°	152.887 912	26 September 2017	Does not overlap

3.4.2 Terrestrial flora field assessment

The location of terrestrial survey sites was dictated by land access agreements with landholders which was provided on a voluntary basis. This reduced the areas that were accessible for environmental investigations. However, adoption of the precautionary principle and the modelling approach suitably accounted for deficiencies in land access.

At each target terrestrial survey site for the FFJV EIS studies, a list of all flora species and vegetation communities encountered were recorded and documented. Any wetlands or other notable features relevant to species of conservation significance were identified and documented. In addition to specific target areas, 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 (refer Appendix C). As per 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 environmental assessment of a representation of distinctly different vegetation communities (including remnant, regrowth and non-remnant communities) and, wetlands or any other features relevant to species of conservation significance, identified during the desktop component was undertaken in the field. 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 (E0), canopy (T1, T2, T3), shrub (S1, S2, S3) and ground (G) strata layers when they were present. Methodologies used were consistent with ‘Tertiary level’ sites as described by Neldner *et al*. (2017). Survey transects approximated 100 m in length and 20 m in width. Where applicable (e.g. wetland or spring features were present) spring and wetland verification was undertaken by assessing the presence of wetland features related to floristic communities, wetland indicators, signs of flooding and topography (refer Appendix I for vegetation assessment sheets).
- 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’ site as described by Neldner *et al* (2017).

A representation of the predictive flora habitat modelling (refer Section 3.3.4) was verified where applicable during field investigations throughout the ecology study area. In addition, where present wetlands and springs were 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).

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 site and each opportunistic site (regardless of their inclusion/exclusion from “High Risk” areas identified in the Queensland 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 (DES 2019)) 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 threatened flora species encountered were submitted with the Queensland Herbarium for incorporation into the HERBRECS database, and all flora survey records were submitted to 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 footprint associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) (EMM 2018b,c; 2019a,b; ELA 2019a,b). As per the guidelines, 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

Terrestrial fauna and habitat assessments were conducted using the following methodologies as described in the survey guidelines identified at the beginning of this Section:

- A general habitat assessment and a record of all fauna encountered (i.e. observed/heard) was undertaken at every vegetation assessment survey site

- 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).

In addition to the techniques identified above, the use of existing datasets, historic records and the formulation of the predictive habitat models provided a comprehensive assessment of the fauna 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.

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 assessments

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 41 sites). Fauna habitat assessments were also undertaken within the ecology study area by GHD (2016) (a total of 34 sites). Fauna habitat features recorded included, but was not limited to:

- Level of disturbance (scale of 0 = "no disturbance" and 3 = "severe disturbance") relating to the following:
  - Fire
  - Grazing
  - Clearing
  - Erosion
- List of conservation significant fauna species that are likely to utilise the area based on available habitat types (based on database search results and predictive habitat mapping)
- Abundance 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
- Abundance of fallen logs (>10 cm diameter)
- Abundance of coarse woody debris (<10 cm diameter)
- Abundance 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 of:
  - Soil banks (e.g. river beds/road cuttings)
  - Boulders
  - Wetlands/drainage features
- Abundance of the following:
  - Flowers
  - Fruit.

All species of fauna observed were identified to the species level where possible (refer Appendix J for habitat assessments sheets).

3.4.3.2 Targeted fauna survey methods

When areas were identified as containing habitat considered likely to support conservation significant species (i.e. both within vegetation assessment areas and at opportunistic locations), specific techniques were employed to increase the likelihood of detecting these species. Remote sensing techniques were used to ensure maximum chances of detecting conservation significant species, without increasing the species risk of harm or placing stress upon the animal (i.e. animals sampled ethically and humanely). Specific techniques adopted as part of the ecological assessments (including survey effort where applicable) and their relevance to target fauna species include the following:

- Anabat devices (Microchiropteran bats) were undertaken by FFJV (EIS studies) at Sites T1 and T9 (overnight) and by GHD (2016) at four other sites along the alignment for a minimum of four nights (refer Figure 3.2 and Figure 3.3 for locations). The total survey effort (18 detector nights) aligns total effort (16 detector nights) required for the Large-eared pied bat (*Chalinolobus dwyeri*) as outlined in the *Survey guidelines for Australia's threatened bats* (DEWHA 2010a).
- Area searches for nests of the Powerful owl (*Ninox strenua*) and Glossy-black cockatoo (*Calyptorhynchus lathami lathami*) and migratory birds such as the Black-faced monarch (*Monarcha melanopsis*), Glossy ibis (*Plegadis falcinellus*), Rufous fantail (*Rhipidura rufifrons*), Satin flycatcher (*Myiagra cyanoleuca*) and Spectacled monarch (*Symposiachrus trivirgatus*)in suitable riparian areas during the EIS studies, and by ELA during targeted pre-clearance surveys (2018 and 2019)
- Standardised surveys for all at all 'terrestrial sampling sites' (refer Figure 3.3 for locations) 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. Bird surveys also carried out by GHD (2016) (refer 'fauna ecology survey site in Figure 3.2 for locations).
- Active searches for arboreal mammals at all 'terrestrial sampling sites' (refer Figure 3.3 for locations), their pellets and scratches were undertaken for the EIS studies and across several Project-associated studies (GHD 2016; ELA 2019) (refer 'fauna ecology survey site' in Figure 3.2 for locations)
- Active search for latrine sites and dens for the Spotted-tailed quoll (*Dasyurus maculatus*) within suitable rocky habitat for the EIS studies, GHD (2016) and ELA (2019)
- Active searches for reptiles at all 'terrestrial sampling sites' (refer Figure 3.3 for locations). This involved 20 minutes of searching by two people over 1 ha within suitable microhabitats, particularly beneath rocks and fallen logs and amongst leaf litter and woody debris. Carried out for the EIS studies, as well as by GHD (2016) and ELA (2019) (refer 'fauna ecology survey site' in Figure 3.2 for locations).
- Spotlighting and night driving for nocturnal amphibians, reptiles, birds and mammals – outside of formalised survey locations. Carried out for the EIS studies and GHD (2016)
- Call playback (nocturnal birds) - outside of formalised survey locations where suitable habitat for target species was identified (GHD 2016). Playback included calls broadcast for two minutes followed by a 5-minute listening period.

Other species encountered during these works were recorded, along with opportunistic observations (all fauna species), refer Appendix I 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 (overnight) at watering points and/or at baited feeding stations (mammals and birds) – Sites T1 and T9 and three in the Teviot Range for the EIS studies. Cameras were also deployed by GHD (2016) (refer Figure 3.2 and 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 generally recommended by DAWE and DES, 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 GHD-Jacobs (2016a)) a large number of 'preclearance surveys' associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) (EMM 2018d, 2018e; 2019c, 2019d; ELA 2019c) have been undertaken during 2018 and 2019. These surveys were carried out to further inform the Project EIS studies and as part of requirements under QLD legislation. Surveys were carried out at 39 locations (EMM) and 296 locations (ELA) 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 (ELA surveys only)
- Incidental fauna observations recorded.

3.4.4 Aquatic field assessments

The aquatic habitat assessments described the environmental values of targeted watercourses (to assess existing environmental condition proximal to, and where the Project alignment intersects watercourses) within the ecology study area. The Australian River Assessment System (AUSRIVAS) Physical Assessment Protocol (Parsons *et al*. 2002) was used in the field assessment of the drainage systems.

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 bank full 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 (identified below) 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).

Assessment parameters used to identify habitat condition are grouped into the following variables:

- Epifaunal substrate/ available cover
- Pool substrate characterisation
- Pool variability
- Sediment deposition
- Channel flow status
- Channel alteration
- Channel sinuosity
- Bank stability
- Vegetation protection, and
- Riparian zone score.

Recordings of incidental fauna and flora 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 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.

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 sweeps were excluded as part of the aquatic ecology field survey methodology due to the highly ephemeral nature of watercourses in the ecology study area, and as it was deemed the overall watercourse ecological values derived from the physical assessments was at an appropriate level required for an EIS.

A single round of aquatic ecology field investigations was conducted at the same locations and at the same time as the first round of the Project's surface water quality monitoring works. At each aquatic ecology field investigation site, the surface water quality information as identified in Section 3.4.4.1 was collected, where possible (i.e. pending the availability of water).

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)
- Clarity (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 were 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 the DES Monitoring and Sampling Manual (DES 2018b) and Australian standards.

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. In instances where preservatives were contained within a sample bottle, these were filled by pouring water from a site specific clean collection 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 (NATA) accredited laboratory (Eurofins) for analysis.

Field and laboratory results were compared against Bremer River Water Quality Objectives (WQO) and Logan Catchment WQOs and trigger values as well as the Australia and New Zealand Environment and Conservation Council (ANZECC)/Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines.

Further information regarding the assessment of surface water quality against water quality objectives is provided in EIS Appendix M: Surface Water Quality Technical Report.

3.4.5 Survey effort

In addition to the targeted EIS study survey locations identified in Table 3.4 (26 sites within the ecology study area) and initial flora studies carried out by GHD-Jacobs in 2016 (60 sites within the ecology study area), 69 opportunistic surveys associated with geotechnical investigations were undertaken by FFJV personnel, specifically targeting areas within the disturbance footprint. The location of opportunistic surveys is shown in Figure 3.3. With regard to survey effort, a total area of approximately 299 ha was assessed (i.e. 82 ha associated with targeted surveys and 217 ha associated with opportunistic investigations). This represents approximately 2.4 per cent of the ecology study area and approximately 30.6 per cent of the disturbance footprint.

Protected plant surveys carried out throughout 2018 and 2019 (refer Table 3.2) by EMM (2018b,c; 2019a,b) and ELA (2019a,b) includes surveys at 196 sites within and adjacent to the Project disturbance footprint. This is estimated to have encompassed approximately 970 ha of lands and 149 km of protected plant meander surveys within the ecology study area. The methods employed are considered to provide an acceptable level of survey effort to sufficiently inform an assessment against the relevant Guidelines for MSES flora species.

The surveys targeted a range of habitats including cleared agricultural land, remnant and regrowth vegetation.

3.4.6 Permits to conduct works

The ecological field surveys (undertaken by FFJV) reported in this document were conducted 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). These permits were issued by the Queensland Government.

3.4.7 Quality assurance/quality control

Quality assurance/quality control 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 2016) was present within each survey team
- A portion of any threatened flora species (as listed under the NC Act) encountered, or species that could not be confidently identified during field recognisance, 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.
- Scats/pellets that were collected in the field were taken to the Queensland Museum for species confirmation
- Any conservation significant fauna species had to be sighted/confirmed by both members of the field team to produce a confirmed record. Where applicable/possible, proof (e.g. photograph, scat or other evidence) was collected.
- At least one suitably qualified person with AUSRIVAS accreditation was present within each survey team for the aquatic ecology habitat surveys

- 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. The botanical names comply with the rules of the current International Code of Botanical Nomenclature (McNeill et al. 2006) and the International Code of Nomenclature for Cultivated Plants (Bricknell *et al*. 2016). 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
- Duncan et al's Action Plan for Australian Bats (1999) for microbats
- 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 sensitive environmental receptors where they may be subject to significant impacts (refer Section 5.3.2). Where impacts were identified as potentially significant, these were subject to assessment against the MNES significant impact assessment guidelines 1.1 for non-threatened migratory species (refer Section 5.3.3) and the MSES significant impact guidelines for MSES (refer Section 5.3.4).

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 environmental receptors. A sensitive environmental receptor is defined as a feature, area or structure (man-made or natural) that may be affected by direct or indirect changes to the environment. 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 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 years (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	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 even where there may be overlap of more than one feature in the same location. In the case where there are conflicting classes, the "worst-case" is taken.

Table 3.7 Sensitivity criteria for sensitive 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 an impacted sensitive environmental receptor's sensitivity 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 notes:

Significance categories as identified in Table 3.8 are defined in 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 Guidelines (for migratory species) or MSES Guidelines 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 matters of national environmental significance (migratory species) and matters of state environmental significance significant impact guidelines

Following the initial assessment of significance (refer Section 5.3.2)), an assessment of the significance of impacts was undertaken for MNES (non-threatened migratory species) or MSES that returned a mitigated initial significance rating of Major, High, Moderate or Low. 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* (DoE 2013) (MNES Guidelines)
- Queensland Environmental Offsets Policy Significant Residual Impact Guideline (*Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004*) (DSDIP 2014) (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 Guidelines respectively.

3.6 Cumulative impact assessment methodology

When numerous projects occur in a region, they result may 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 size and timing overlap.

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

3.6.1 Project selection

Projects for inclusion in the cumulative impact assessment are all those within a 50 km radius of the Project (referred to as the ‘cumulative impact area’) including the projects that:

- 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, Manufacturing, Infrastructure and Planning (DSDMIP) 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 3.9 include infrastructure development projects located in proximity to the Project. It is noted that the Remondis Waste to Energy Facility located in the Swanbank Industrial Estate has not been included as part of the cumulative impact assessment as the project is located in a highly disturbed environment. 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

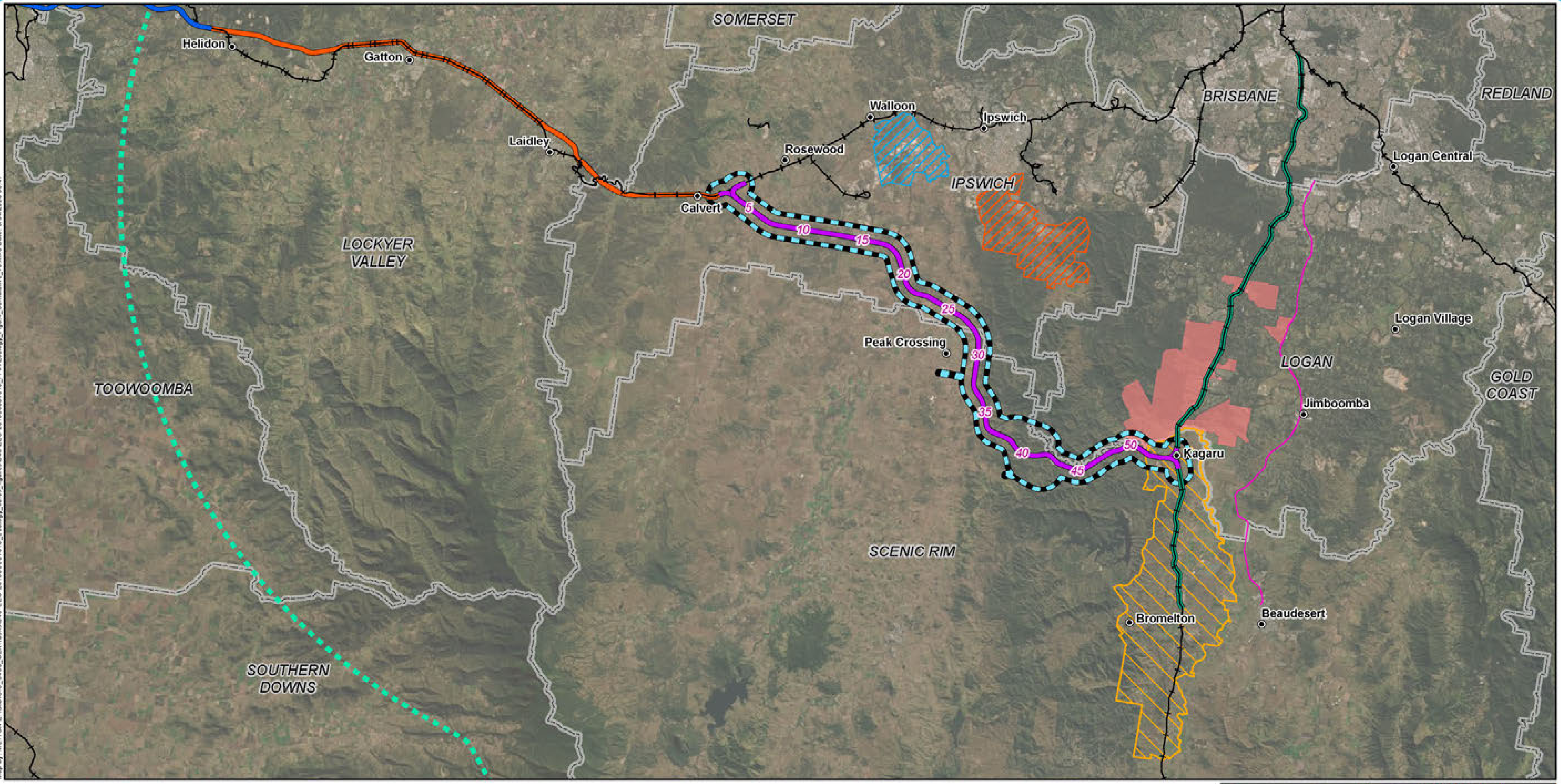
Project and proponent	Location	Description	Source	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria[1]	Relationship to the Project
Kagaru to Acacia Ridge and Bromelton (K2ARB) (ARTC)	Rail corridor from Kagaru to Acacia Ridge and Bromelton	Enhancing and connecting the existing rail corridor (approximately 49 km) from northeast of Kagaru to Acacia Ridge and from south of Kagaru to Bromelton	Application for coordinated project status currently under consideration by the Coordinator-General	Proponent awaiting coordinated project decision by the Coordinator-General	2023 to 2025 Jobs TBA	> 50 years Jobs TBA	c)	Potential overlap of construction for the Project and commencement for K2ARB
Helidon to Calvert (H2C) (ARTC)	Rail alignment from Helidon to Calvert	The H2C project will include the following: - 47 km single-track dual-gauge freight rail line to accommodate double stack freight trains up to 1,800 m long - Tunnel through the Little Liverpool Range - Construction of rail infrastructure, culverts, bridges, viaducts and crossing loops - Connection to the existing West Moreton Railway Line - Ancillary works including road and public utility crossings and realignments	http://eisdocs.dsdip.qld.gov.au/Inland%20Rail%20Helidon%20to%20Calvert/IAS/h2c-initial-advice-statement.pdf	Proponent currently preparing EIS	2021 to 2026 Average 193 full-time construction jobs	> 50 years Jobs 20 full time equivalent	b) and c)	Potential overlap of construction for H2C and commencement for the Project
Greater Flagstone Priority Development Area (PDA) (Queensland Government)	Located within Logan City, west of Jimboomba and the Mount Lindesay Highway, along the Brisbane-Sydney rail line	When fully developed, it is anticipated that the Greater Flagstone PDA will provide approximately 50,000 dwellings to house a population of up to 120,000 people	https://dsdmip.qld.gov.au/edq/greater-flagstone.html	PDA declared by the Queensland Government on 8 October 2011	2011 to 2041 Jobs TBA	TBA	c) and d)	Potential overlap of construction times, demand for resources and traffic volumes in the Kagaru area and vegetation clearing

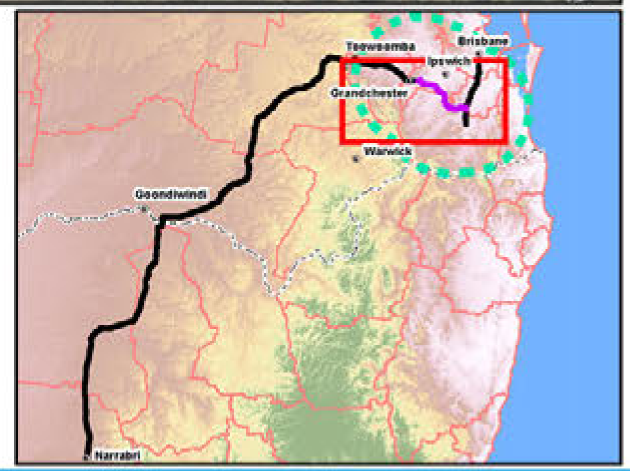
Project and proponent	Location	Description	Source	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria[1]	Relationship to the Project
Bromelton State Development Area (SDA) (Queensland Government)	South of Kagaru in Bromelton	Delivery of critical infrastructure within 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.	https://www.statedevelopment.qld.gov.au/resources/project/bromelton/bromelton-sda-development-scheme-dec-2017.pdf	The current version of the Bromelton SDA Development Scheme was approved by Governor in Council, December 2017 The Development Scheme is managed by the Coordinator-General	2016 to 2031 Jobs TBA	TBA	c) and d)	Ongoing development north of Kagaru in the Bromelton SDA could result in a conflict for construction resources and see an increase of traffic volumes in the Kagaru area and vegetation clearing.
Ripley Valley PDA (Queensland Government)	Approximately 5 km south-west of the Ipswich central business district and south of the Cunningham Highway	The Ripley Valley PDA covers a total area of 4,680 ha and is an opportunity to provide approximately 50,000 dwellings to house a population of approximately 120,000 people. It is located in one of the largest industry growth areas in Australia and offers opportunities for further residential growth to meet the region's affordable housing needs.	https://dsdmip.qld.gov.au/edq/ripley-valley.html	PDA declared by State Government on 8 October 2011	2009 to 2031 Jobs TBA	TBA	c) and d)	Development could result in potential conflict for construction resources and see an increase in vehicle traffic
South West Pipeline: Bulk Water Connection to Beaudesert (Seqwater)	East of Kagaru, running north from Beaudesert	The proposal is investigating a bulk water pipeline connection from the Southern Regional Water Pipeline to Beaudesert, connecting Beaudesert to the South-east Queensland Water Grid. The pipeline will pass through the site of the future Wyaralong Water Treatment Plant.	http://buildingqueensland.qld.gov.au/projects/south-west-pipeline-bulk-water-connection-to-beaudesert/	Currently completing Detailed Business Case	2021 Jobs TBA	TBA	c)	Potential conflict with demand for construction resources

Table notes:

a Currently being assessed under Part 1 of Chapter 3 of the *Environmental Protection Act 1994* (Qld) and, as a minimum, have an initial advice statement available on the DES website.
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 Project.
d Could potentially compound residual impacts that the Project may have on environmental aspects.

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
- Cumulative impact study area
- MNES study area
- Local Government Areas

Projects

- Ripley Valley Priority Development Area
- RAAF Base Amberley
- State Development Area Boundary - Bromelton
- Priority Development Area Boundary - Greater Flagstone
- South West Pipeline
- Inland Rail H2C
- Inland Rail K2ARB

A3 scale: 1:350,000

0 5 10 15 20 25km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 08/04/2020 Version: 3
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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 Project 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 (refer Table 3.10) has been collated with timelines to demonstrate the temporal relationship between projects. This has included:
  - Identification of projects outside of the Inland Rail Program
  - Only 'State significant' or 'strategic' projects that are in the public domain as being planned, constructed or operated at the time of the Project EIS ToR have been considered
  - Where additional projects worthy of consideration have arisen after the finalisation of the Project 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 H2C and K2ARB 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 should be 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 Project impact on an ecological value such as changed flood regimes 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 Overview

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

4.2 Regional and local context

Moving from west to east, the landscapes within the Calvert area (western study area) are characterised by very high levels of anthropogenic disturbance and present 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, drainage features typically retain some degree of floristic structural complexity and have to potential to act as local fauna movement conduits and refuge habitats for a diversity for species.

Areas around Ebenezer (east of Calvert) are typically characterised by a highly fragmented and anthropogenically impacted (i.e. subject to land clearing for agricultural purposes) landscape. However, areas of woody regrowth vegetation (i.e. Category C regulated vegetation) are more abundant when compared to the western portion of the alignment, particularly those areas to the south of the Project. As in the west, non-native pasture improvement species (e.g. grasses) dominate much of the landscape. Areas containing remnant vegetation (i.e. Category B regulated vegetation) are present within this area, however these vegetation communities largely exist as isolated islands within a fragmented landscape. Despite this fragmented landscape, the areas associated with Ebenezer have been identified as an ecological corridor of regional significance under the BPA. This area has also been modelled by DES as containing core habitat for the endangered Swamp tea-tree (*Melaleuca irbyana*).

The areas south of Purga towards Peak Crossing and Washpool are largely rural landscapes dominated by pasture species. However, within these areas woody regrowth and remnant vegetation in the form of intact ecosystems are increasingly common to the east of the ecology study area, particularly around Peak Crossing and Washpool. These areas coincide with the Project's parallel alignment with the Teviot Range. Most of this remnant vegetation is located outside of the disturbance footprint and situated in areas of sloping topography which are generally not conducive to agricultural activities.

Throughout the Woolooman area (in the east of the ecology study area) and the Teviot Range, the terrain is rugged and there is minimal development although historic land clearing practices have resulted in large areas of woody regrowth vegetation that has not yet reached remnant status (in relation to canopy height and cover). Whilst there is some remnant vegetation contained within the ecology study area, most remnant communities are located to the north and south of the ecology study area. The existing nature of the topography and vegetation within the Teviot Range, enhances its' ability to function as a fauna movement conduit, facilitating wildlife movement in a north-south direction. The Teviot Range has been identified as a terrestrial ecological corridor of State significance under the BPA. In addition, this area functions as flora and fauna refuge habitat and is known to support conservation significant species such as Lloyd's olive (*Notelaea lloydii*), Koala (*Phascolarctos cinereus*) (refer EIS Appendix K: Matters of National Environmental Significance Technical Report for further information related to MNES) and the Glossy-black cockatoo (*Calyptorhynchus lathami*) and the Powerful owl (*Ninox strenua*).

The area of Teviot Range to the north and east of the Project alignment and the ecology study area (i.e. Flinders Peak) is centred on a cluster of intrusive volcanic plugs of Tertiary age (Mounts Blaine, Catherine, Goolman, Perry, Welcome, Flinders Peak and Ivorys Rock) and is recognised by DES as an area of special biodiversity (DEHP 2016). This is due to the presence of several SEQ endemic taxa and wildlife refugia.

The geology west of the Teviot Range is underlain by interbedded sandstone, mudstone and siltstone of the Walloon Coal Measures. The central portion of the ecology study area is dominated by medium to coarse grained sandstone of the Gatton Sandstone that forms the topographic high of the Teviot Range. The eastern portion of the alignment is underlain by the interbedded siltstone, claystone and sandstone of the Koukandowie Formation and Walloon Coal Measures.

Relatively thin deposits of alluvial sediments overlay the sedimentary rocks in places and are associated with the primary surface water features within the groundwater study area. The alluvial sediments are limited in extent, both laterally and vertically, away from the watercourses. The key groundwater units are the unconfined alluvial sediment aquifers associated with the key watercourses, and the low permeability aquifers of the Walloon Coal Measures, Koukandowie Formation and Gatton Sandstone.

The water table is typically a subdued version of topography, with the depth to groundwater increasing beneath topographic highs (for example the Teviot Range), and shallower groundwater in lower lying reaches (such as close to surface water drainage lines). Depths to groundwater in the alluvial sediments are anticipated to be between 5 m and 15 m but have been measured at less than 5 m in several locations across the groundwater study area. In the main outcrop areas of Walloon Coal Measures, the water table is expected to be at least 5 m, and greater than 10 m beneath higher relief. Within the Gatton Sandstone of the Teviot Range the water table will be in the order of 60 m or more below ground surface at its deepest.

Potential aquatic and terrestrial groundwater dependent ecosystems were identified as being present within the groundwater study area. Numerous watercourses traversing the groundwater study area are designated as moderate potential aquatic GDEs from regional studies (as defined in the GDE Atlas (BoM2020)) including Western Creek, Bremer River, Warrill Creek, Purga Creek and Teviot Brook. The potential GDEs are described as wetlands ‘supplied by alluvial aquifers with near-permanent flow’.

Low and moderate potential terrestrial GDEs (from regional studies) have been identified within the Teviot Range portion of the groundwater study area. These are generally described as wetland vegetation supplied by low porosity sedimentary rock with intermittent flow. Wetland supplied by alluvial aquifers with near permanent flow (eastern flank) and riparian vegetation supplied by sedimentary rocks with saline flow (western flank) are also indicated.

Groundwater quality is variable across the key groundwater units. The groundwater study area is located within the Clarence–Moreton bioregion assessment area where strong evidence of interaction between groundwater and surface water has been reported (Raiber et al. 2016). This supposition is based on several lines of evidence inclusive of assessment of groundwater and surface water quality, streamflow time-series data, groundwater hydrographs and streambed elevation.

It is anticipated that there will be interaction between watercourses and shallow groundwater in the associated alluvial sediments at some locations, particularly where drainage channels are more deeply incised and groundwater levels are shallow. The degree of interconnection will vary laterally due to local variations in alluvial sediment lithology, underlying bedrock geology and drainage channel morphology, as well as seasonally due to changes in groundwater elevations due to rainfall/drought events. At times watercourses may change from gaining systems (receiving baseflow from shallow groundwater) to losing systems (with surface water locally recharging the alluvial sediments).

An assessment of surface water–groundwater interaction in the Bremer River Basin found that hydraulic connection between the aquifer and river was relatively poor and of limited lateral extent (Raiber et al. 2016). This was thought to be linked to the broad valley of the Bremer River and limited depth of incision into the underlying alluvial sediments, with upper sections typically fine-grained clay rich floodplain sediments.

The eastern portion of the alignment (areas around Kagaru), is characterised by largely non-remnant vegetation communities and agricultural land. The landscape is highly fragmented with remnant vegetation communities restricted to steep topography or drainage features.

In relation to MNES that are not identified as controlling provisions for the Project under the EPBC Act, 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 ecology study area. The Project is located 30 km to 40 km upstream of Moreton Bay, a wetland of international importance (Ramsar) and is considered sufficiently displaced such that potential downstream impacts will be negligible. Therefore, these MNES are not discussed further in this document.

4.3 Catchment area overview

The Project alignment travels through two catchments, the Bremer River and the Logan River. The Bremer River catchment covers the area between Calvert and east of Woolooman as the alignment reaches the peak of the Scenic Rim mountain range, and the Logan River catchment area, as the alignment descends the mountain range towards Kagaru (SEQ Catchments 2006, 2017).

The Project is located in the lower reaches of the Bremer catchment intersecting the Western Creek, the Bremer River, Warrill Creek and Purga Creek and their associated floodplains west of the Teviot Range. The Bremer River catchment is situated west of Brisbane within the local government boundaries of Ipswich City Council and the Scenic Rim Regional Council and expands to an area of approximately 2,030 square km (km^2) with the main Bremer River channel surrounded by smaller sub-catchments. The Project alignment predominantly traverses through the sub-catchments of Mid Bremer River, Lower Bremer River, Lower Warrill Creek, Western Creek and Purga Creek. Rainfall in the catchment is considered high along its steeper sections which are situated to the south and east whilst the remainder of the catchment experiences average rainfall of under 1,000 mm/yr (SEQC 2006). Dominant land uses within the Bremer catchment include grazing, native bush, intensive agriculture and urban. The lower catchment is mostly urbanised, where the rest of the catchment is rural with the majority of the catchment cleared for cattle grazing. The upper catchment contains areas of natural bushland ((SEQ Catchments 2006, 2017).

Lake Moogerah, along with a number of weirs, are located upstream of the Project on Warrill Creek, which are likely to impact environmental flows. The catchment health is considered to be in poor condition (Healthy Land and Water 2019a), with freshwater health continuing to decline due to a decrease across most indicators, particularly water quality and fish community health (Healthy Land and Water 2019b). There are also a number of palustrine wetlands associated with this catchment within close proximity to the Project, including Ten Mile Swamp.

The Project is also located in the mid-reaches of the Logan River catchment intersecting Woollaman Creek through the Teviot Range and Teviot Brook at its eastern extent. The Logan River catchment is situated to the south of Brisbane with its headwater in the McPherson and Main Ranges. The majority of the catchment features in the local government areas of the Scenic Rim Regional Council and Logan City Council but also includes small sections of other local government areas. The Project alignment intercepts the sub-catchment of Lower Teviot Brook. Rainfall in the catchment is very high especially in the eastern headwaters which combined with good recharge of groundwater associated with basalt geology lead to permanent flow (SEQC 2017). Wyaralong Dam is located upstream of the Project on Teviot Brook and influences environmental flows within the catchment. The catchment health is considered to be in slightly improved condition, although freshwater health has declined and remains in poor condition predominantly due to a decrease in fish community health across the investigated sites.

The dominant land uses within the Logan catchment include grazing, native bush, rural residential and intensive agriculture. The upper catchment has been cleared for agriculture, grazing and dairying while the mid and lower catchment flows through rural, residential and urban areas (DES 2015).

4.4 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 D. 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.

4.4.1 Flora

4.4.1.1 Conservation significant flora species

In total, 20 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, 17 are also listed as MNES (i.e. identified as threatened species under the EPBC Act). For further information related to these 17 MNES species, refer to EIS Appendix K: 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 (refer Table 4.1). All of these species have been identified from specimen backed sources (i.e. Atlas of living Australia or WildNet) and are considered likely to occur within the ecology study area. 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 status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Poaceae	*Arthraxon hispidus**	Hairy-joint grass	V			□	Possible*
Euphorbiaceae	*Bertya ernestiana**	A shrub	V			□	Possible*
Orchidaceae	*Bulbophyllum globuliforme*#,*	Miniature moss-orchid	NT				Possible*
Cupressaceae	*Callitris baileyi*	Bailey's cypress	NT		□		Likely
Cycadaceae	*Cycas ophiolitica**	-	E			□	Unlikely, the ecology study area is outside of the species natural range (i.e. Rockhampton region of Queensland)
Sapindaceae	*Cupaniopsis tomentella**	Boonah tuckeroo	V	□		□	Possible*
Characeae	*Lychnothamnus barbatus*^,*	A green algae	V			□	Possible*
Proteceae	*Macadamia integrifolia**	Macadamia nut	V			□	Possible*
Proteceae	*Macadamia tetraphylla**	Rough-shelled bush nut	V			□	Unlikely, there are no occurrences of this species within 40 km of the ecology study area. Outside of the known range.*
Apocynaceae	*Marsdenia coronata*	Slender milkvine	V	□	□		Likely

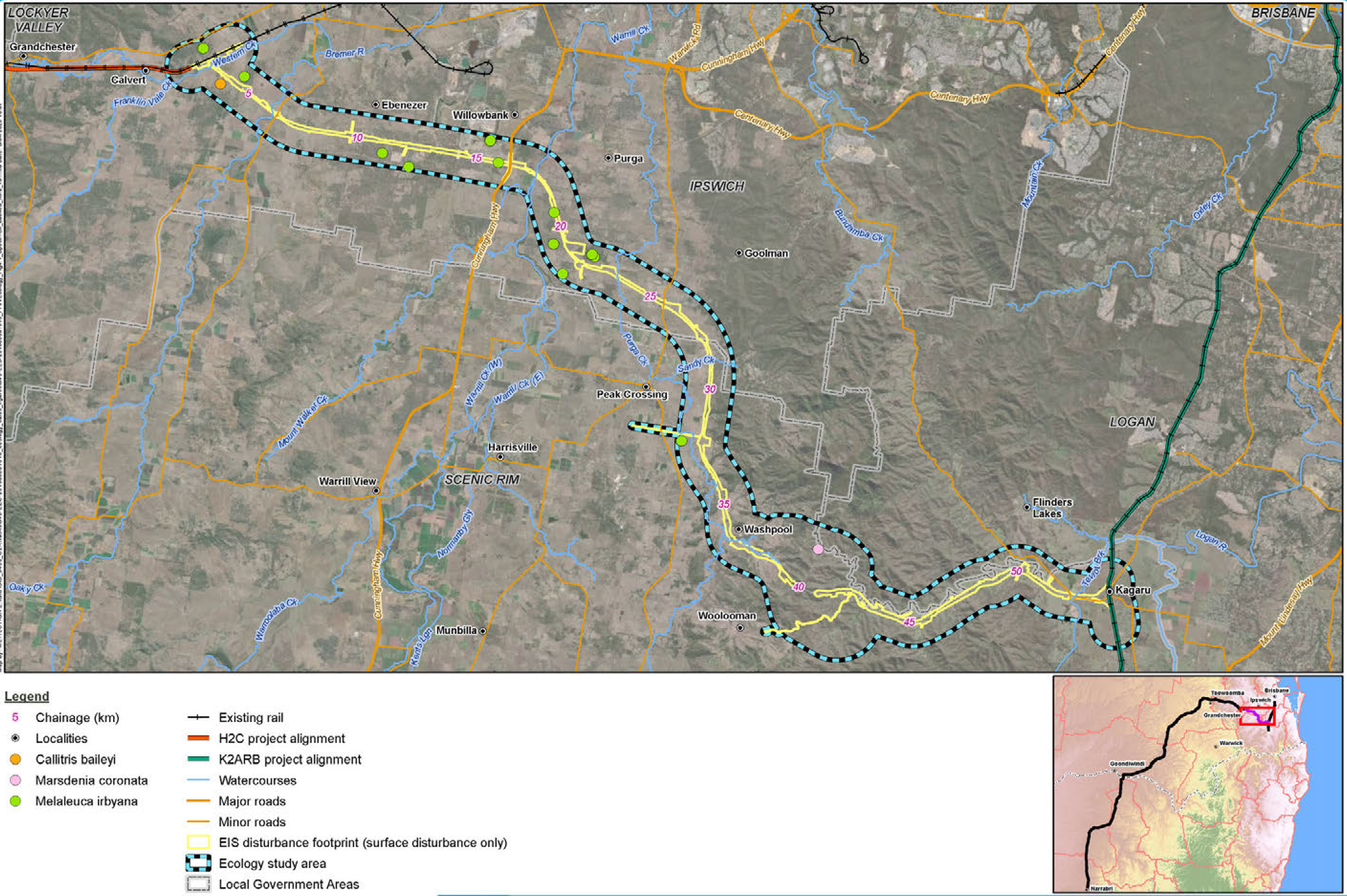
Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Myrtaceae	*Melaleuca irbyana*	Swamp tea-tree	E	□	□		Likely
Oleaceae	*Notelaea ipsviciensis**	Cooneana olive	CE			□	Unlikely, this species is very localised occurring in the Ipswich area. The ecology study area is outside of the known range.*
Oleaceae	*Notelaea lloydii**	Lloyd's olive	V	□		□	Likely*
Orchidaceae	*Phaius australis**	Lesser swamp-orchid	E			□	Possible*
Rutaceae	*Phebalium distans**	Mt Berryman phebalium	E			□	Possible*
Sapotaceae	*Planchonella eerwah**	Shiny-leaved condoo	E	□	□	□	Likely*
Asteraceae	*Rhaponticum australe**	Austral cornflower	V			□	Unlikely, the ecology study area is outside of the species natural range
Simaroubaceae	*Samadera bidwillii**	Quassia	V			□	Likely*
Fabaceae	*Sophora fraseri**	Brush sophora	V			□	Likely*
Santalaceae	*Thesium australe**	Austral toadflax	V			□	Likely*

Table notes:

E = Endangered V = Vulnerable NT = Near threatened
* = MNES species. These species are discussed further in EIS Appendix K: 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 from Warrill Creek that is in proximity to the ecology study area.

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



A3 scale: 1:150,000

0 1 2 3 4 5km

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Integrating Community, Environment and Engineering

Issue date: 08/04/2020 Version: 3
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

4.4.1.2 Priority Back on Track flora species

There are 32 non-MNES Back on Track priority flora species listed for the SEQ NRM region (ERM 2010) (refer Table 4.2). This includes two species (i.e. Bailey's cypress (*Callitris baileyi*) and Swamp tea-tree (*Melaleuca irbyana*)) identified from databases searches summarised in 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 4.1. These species are assessed within EIS Appendix K: Matters of National Environmental Significance Technical Report.

Of the 32 non-MNES Back on Track priority flora taxa identified as part of the database review and Project EIS field assessments, six flora species have the potential to occur within the ecology study area (refer Table 4.2).

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 EPBC Act they have been identified as a sensitive environmental receptor potentially impacted by the Project (refer Section 4.6.2) and are assessed as such within the impact assessment section (refer Section 5.2.3).

Table 4.2 Back on Track priority flora species for the Southeast Queensland natural resource management region and likelihood of occurrence within the ecology study area (excluding matters of national environmental significance)

Species name		Back on Track status (SEQ NRM)	NC Act Status	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, preferred habitat is poorly represented within ecology study area
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, preferred habitat is poorly represented within ecology study area
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 within 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 (RBGFV 2015).	Possible
Blandfordia grandiflora	Christmas bells	H	E	It is usually found in wet coastal heaths on sandy soils (ANPS n.d.).	Unlikely, preferred habitat is poorly represented within ecology study area
Boronia safrolifera	-	H	LC	Occurs in swamps or badly draining, wet, sandy areas in heath (wallum) (Wetland Info 2009).	Unlikely, preferred habitat is poorly represented within study area. Outside of known distribution

Species name		Back on Track status (SEQ NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
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
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.	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, preferred habitat is poorly represented within ecology study area
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, occurs along coastlines.
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 (TSSC 2008a).	Unlikely, preferred habitat is poorly represented within ecology study area
Cupaniopsis newmanii	Long-leaved tuckeroo	H	NT	Grows on the margins of, and within warmer rainforest (PlantNet 2018).	Unlikely, preferred habitat is poorly represented within ecology study area
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, preferred habitat is poorly represented within ecology study area
Durringtonia paludosa	-	Cr	NT	Grows in closed sedgeland communities in coastal swamps (PlantNET 2018).	Unlikely, no suitable habitat present.
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, no suitable habitat present.
Glycyrrhiza acanthocarpa	Native liquorice	H	LC	Grows in various habitats, especially on heavy soils prone to flooding (PlantNET 2018).	Unlikely, Project outside of species distribution.

Species name		Back on Track status (SEQ NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Gossia gonoclada	Angle-stemmed myrtle	H	E	Found in lowland riparian rainforest and notophyll vine forest, below the peak flood level, along permanent watercourses subject to tidal influence (DotEE 2018).	Unlikely, preferred habitat is poorly represented within 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
Lepidosperma quadrangulatum	-	Cr	LC	Grows in coastal wet heath or swampy forest dominated by eucalypt or melaleuca species with a shrubby understorey (Wetland Info 2009).	Unlikely, preferred habitat is poorly represented within ecology study area
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, coastal species. Project outside of species distribution.
Macarthuria complanata	-	H	NT	Information deficient.	Unlikely, preferred habitat is poorly represented. Outside of known 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 ecology study area and outside of natural distribution
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, preferred habitat is poorly represented within ecology study area

Species name		Back on Track status (SEQ NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Picris conyzoides	-	H	V	Information deficient.	Unlikely, outside of known distribution
Platysace sp. (Mt Ninderry P.R.Sharpe+ 2092)	-	Cr	LC	A mountain top specialist, probably inhabiting heathland (Wetland Info 2009).	Unlikely, preferred habitat is poorly represented within ecology study area
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, preferred habitat is poorly represented within ecology study area. Outside of known distribution
Swainsona fraseri	Brush sophora	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.	Unlikely, occurs in small area located at least 44 km west of the Project
Thismia rodwayi	-	H	NT	Restricted to damp humus and leaf-litter in deeply shaded tall forests and fern gullies (RBGFV 2015).	Unlikely, preferred habitat is poorly represented within ecology study area
Zieria exsul	-	H	E	Occurs in wallum heath and woodland featuring *Corymbia trachyphloia*, *Eucalyptus racemose*, *E. siderophloia* and *Allocasuarina littoralis.* Known from two localities on the Sunshine Coast (Duretto and Forster 2007).	Unlikely, no habitat present. Outside of known 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, preferred habitat is poorly represented within ecology study area. Outside of known distribution

Table notes:

- = No common name or conservation listing CE = Critically endangered Cr = Critical priority E = Endangered
H = High priority LC = Least Concern Me = Medium priority NT = Near Threatened V = Vulnerable

4.4.2 Fauna

4.4.2.1 NC Act conservation significant and EPBC Act migratory fauna species

In total, 29 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 K: Matters of National Environmental Significance Technical Report as they are not discussed further within this document.

The remaining four conservation significant fauna species listed under the provisions of the NC Act (excluding all species listed under the EPBC Act) have been identified from databases 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

Table 4.3 Conservation significant fauna species identified from database searches and previous assessment (excluding matters of national environmental significance)

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Birds							
Accipitridae	*Erythrotriorchis radiatus**	Red goshawk	E			□	Possible*
Ardeidae	*Botaurus poiciloptilus**	Australasian bittern	E			□	Possible*
Cacatuidae	*Calyptorhynchus lathami^*	Glossy-black cockatoo	V				Likely
Columbidae	*Geophaps scripta scripta**	Squatter pigeon	V			□	Unlikely. The species is typically associated with the western slopes of the Great Dividing Range. While there are some records of this species within the broader project context, there are no recent records within 20 km of the ecology study area (AoLA 2020)*
Dasyornithidae	*Dasyornis brachypterus**	Eastern bristlebird	E			□	Unlikely, species occurs in montane areas in eucalypt forests with a dense tussock grass layer (DAWE 2020b). Habitat does not occur and the species has never occurred in or near the MNES study area.*
Estrildidae	*Poephila cincta cincta**	Southern Black-throated Finch	E			□	Unlikely. Expert advice indicated that this species is locally extinct within SEQ (DAWE 2020)*

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Meliphagidae	*Anthochaera phrygia**	Regent honeyeater	CE			✓	Possible*
Meliphagidae	*Grantiella picta**	Painted honeyeater	V			✓	Possible*
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.*
Psittacidae	*Lathamus discolor**	Swift parrot	E			✓	Known. Recorded within MNES study area during protected plant surveys (EMM 2018)*
Rostratulidae	*Rostratula australis**	Australian painted snipe	E			✓	Possible*
Scolopacidae	*Calidris ferruginea**	Curlew sandpiper	CE			✓	Possible*
Scolopacidae	*Numenius madagascariensis**	Eastern curlew	E			✓	Possible*
Strigidae	*Ninox strenua*	Powerful owl	V		✓		Likely
Turnicidae	*Turnix melanogaster**	Black-breasted button-quail	V			✓	Possible*
Apodidae	*Hirundapus caudacutus**	White-throated needletail	V			✓	Likely*
Mammals							
Macropodidae	*Petrogale penicillata**	Brush-tailed rock-wallaby	V			✓	Possible*
Muridae	*Pseudomys novaehollandiae**	New Holland mouse	V			✓	Possible*
Petauridae	*Petauroides volans volans**	Southern greater glider	V	✓	✓	✓	Likely*
Phascolarctidae	*Phascolarctos cinereus**	Koala	V	✓		✓	Known. Recorded during surveys by Jacobs-GHD (2016a)*
Potoroidae	*Potorous tridactylus tridactylus**	Long-nosed potoroo	V			✓	Possible*
Pteropodidae	*Pteropus poliocephalus**	Grey-headed flying-fox	V			✓	Likely*

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	SL	□	□		Possible
Vespertilionidae	*Chalinolobus dwyeri**	Large-eared pied bat	V			□	Possible*
Reptiles							
Elapidae	*Furina dunmalli**	Dunmall's snake	V			□	Unlikely. No database records of this species ever occurring to the east of the Great Dividing Range (AoLA 2020).*
Pygopodidae	*Delma torquata**	Collared delma	V			□	Possible*
Scincidae	*Anomalopus mackayi**	Five-clawed worm-skink	E			□	Possible*
Amphibians							
Limnodynastidae	*Adelotus brevis*^	Tusked frog	V				Likely
Invertebrates							
Nymphalidae	*Argynnis hyperbius inconstans**	Australian fritillary	E			□	Unlikely, no suitable habitat likely present and no evidence the species may occur. Additionally, there are no known records of the larval host plant *V. betonicifolia* within the MNES study area, with the nearest record from 1987 located 16 km from the disturbance footprint*

Table notes:

- = Species not listed E = Endangered V = Vulnerable SL = Special least concern (cultural)

□ = 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

* MNES species. These species are discussed further in EIS Appendix K: 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, 11 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 (i.e. a threatened species) 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/intertidal environments within the ecology study area.

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

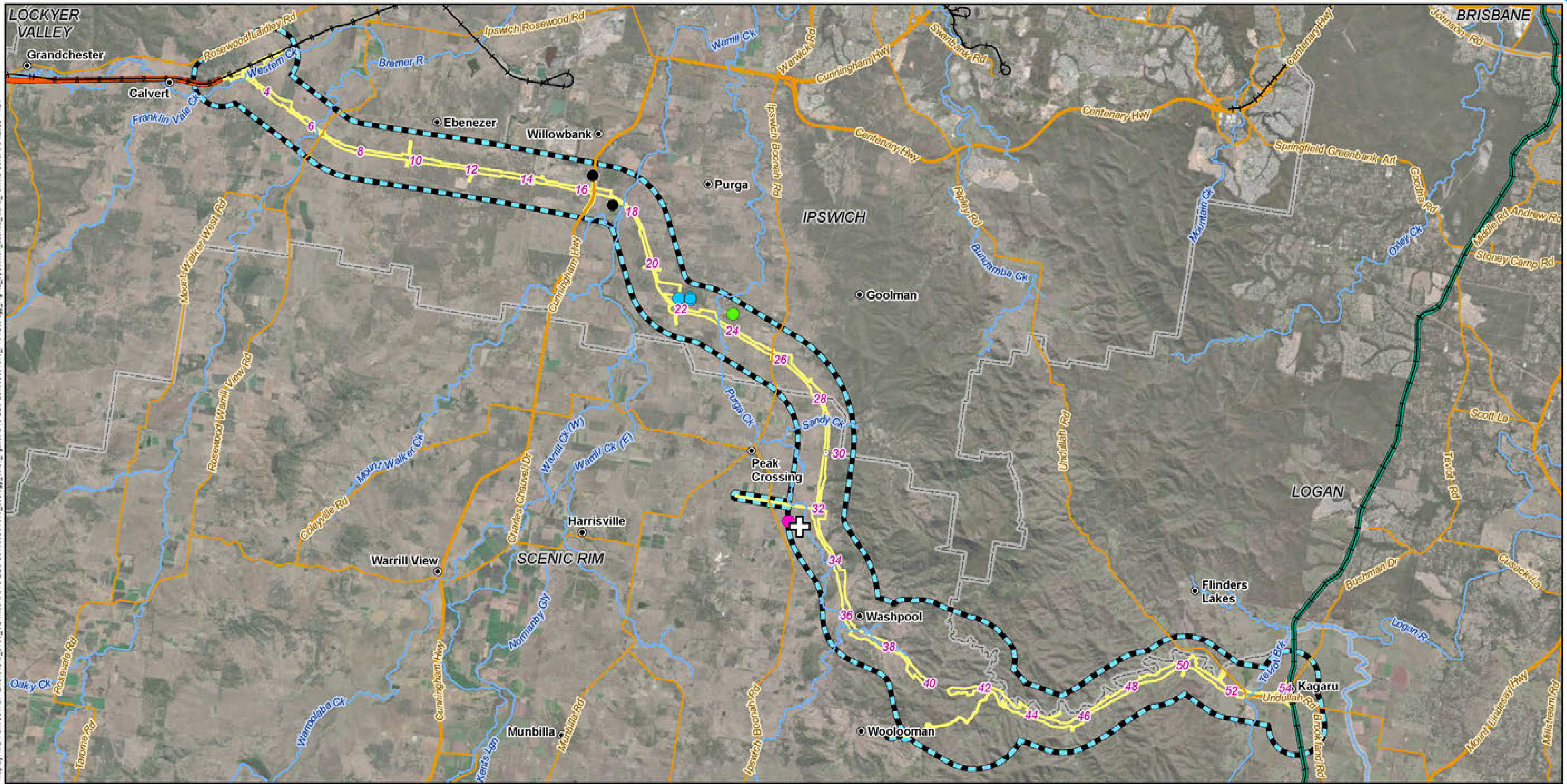
Table 4.4 Migratory fauna species identified from database searches (matters of national environmental significance that are not a controlling provision of the Project)

Family	Scientific name	Common name	Conservation status	
			EPBC Act	NC Act
Accipitridae	*Pandion haliaetus*	Osprey	M	SLC
Cuculidae	*Cuculus optatus*	Oriental cuckoo	M	SLC
Dicruridae	*Myiagra cyanoleuca*	Satin flycatcher	M	SLC
Dicruridae	*Rhipidura rufifrons*	Rufous fantail	M	SLC
Dicruridae	*Monarcha melanopsis*	Black-faced monarch	M	SLC
Dicruridae	*Symposiachrus trivirgatus*	Spectacled monarch	M	SLC
Motacillidae	*Motacilla flava*	Yellow wagtail	M	SLC
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	M	SLC
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	M	SLC
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	M	SLC
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	M	SLC

Table notes:

M = Migratory SLC = Special Least Concern

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



Legend

- 5 Chainage (km)
- Localities
- Tachyglossus aculeatus
- Monarcha melanopsis
- Plegadis falcinellus
- Rhipidura rufifrons
- Ninox strenua
- H2C project alignment
- K2ARB project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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Calvert to Kagaru

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

4.4.2.2 Priority Back on Track fauna species

There are 16 non-MNES Back on Track priority fauna species for the SEQ NRM (ERM 2010) (refer Table 4.5).

Six 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. The remining 10 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 Non-matters of national environmental significance Back on Track priority fauna species for the Southeast Queensland 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
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 Queensland 2019).	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 2019).	Unlikely, habitat of suitable quality is not contained within the ecology study area. Outside of the species known range.

Species name		Back on Track status (SEQ NRM)	NC Act	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
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 2018c).	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.
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 2018c).	Unlikely, habitat of suitable quality is not contained within the ecology study area
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 2019).	Possible
Hoplocephalus stephensii	Stephens' banded snake	C	LC	Lives in rainforests, moist forests, heaths and vine thickets (QLD Museum 2019).	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 (DotEE 2018).	Unlikely, habitat of suitable quality is not contained 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**				
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 (DotEE 2018).	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 2019).	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).	Possible
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).	Possible

Table notes:

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

4.4.3 Matters of state environmental significance wildlife habitat and essential habitat

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 Convention).

Mapped MSES wildlife habitat (incorporating essential habitat) occurring within the disturbance footprint is identified in Figure 4.3. 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 K: Matters of National Environmental Significance Technical Report.

Table 4.6 Matters of state environmental significance wildlife habitat and essential habitat present within the ecology study area

Identified wildlife habitat	Extent (ha)	
	Ecology study area	Disturbance footprint
MSES Wildlife habitat	1,381.79	88.97
Essential habitat	1,259.38	25.89

4.4.4 Invasive species biosecurity areas

The ecology study area is contained within fire ant biosecurity zones 1 and 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*).

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

Given that portions 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.

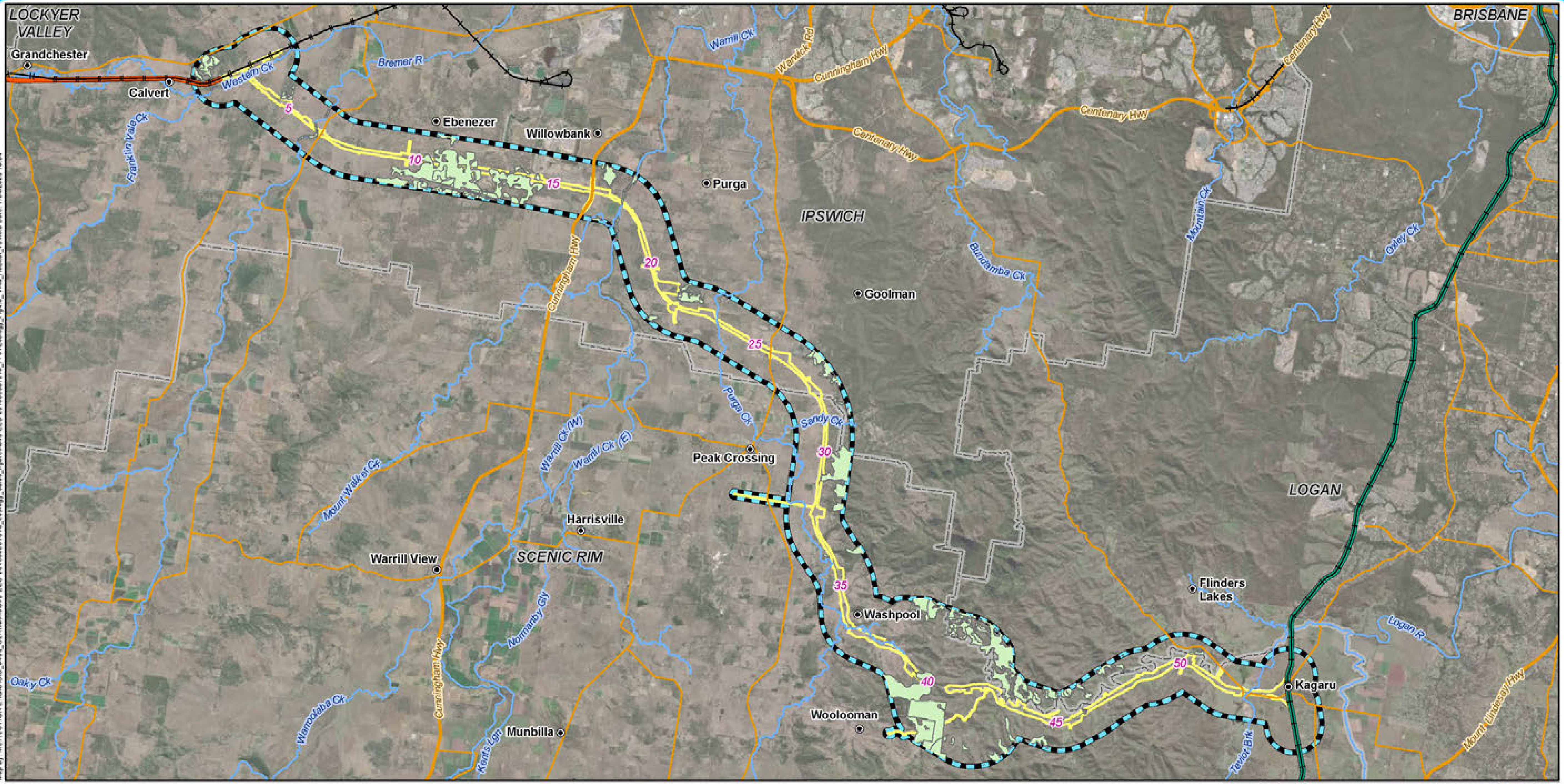
4.4.5 Defined watercourses

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 and Mines 2014).

A number of defined watercourses (refer Figure 4.5) and unmapped waterways and waterbodies occur within the water quality study area. Defined watercourses crossed by the Project alignment include:

- Western Creek – at chainage locations Ch 1.20 km and Ch 3.10 km
- Bremer River – at chainage location Ch 6.30 km
- Warrill Creek – at chainage location Ch 17.60 km
- Purga Creek – at chainage locations Ch 23.40 km
- Sandy Creek – at chainage location Ch 28.70 km
- Unnamed tributary of Purga Creek – at chainage locations Ch 36.60 km, Ch 37.50 km and Ch 37.90 km
- Teviot Brook – at chainage location Ch 52.80 km.

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



Map by: MEF/LCT/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_calcs_figures\340-EEC-201905081615_FF\Ecology_Fig4.3_Wild_Habitat_v3.mxd Date: 7/04/2020 13:34

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- MSES wildlife habitat

A3 scale: 1:150,000

0 1 2 3 4 5km

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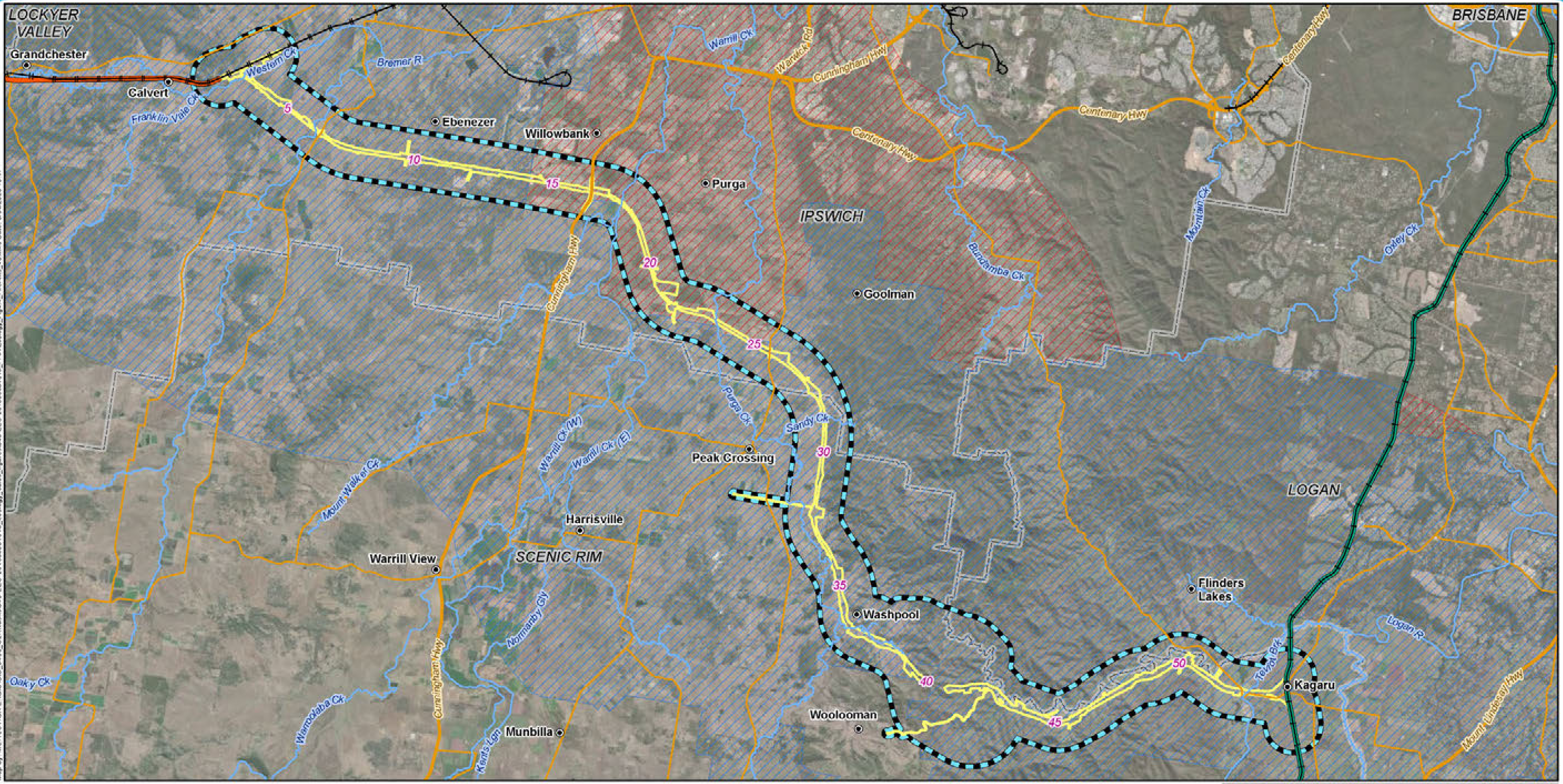
Figure 4.3: Matters of state environmental significance (MSES) wildlife habitat

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



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Fire ant biosecurity zone 1
- Fire ant biosecurity zone 2

A3 scale: 1:150,000

0 1 2 3 4 5km

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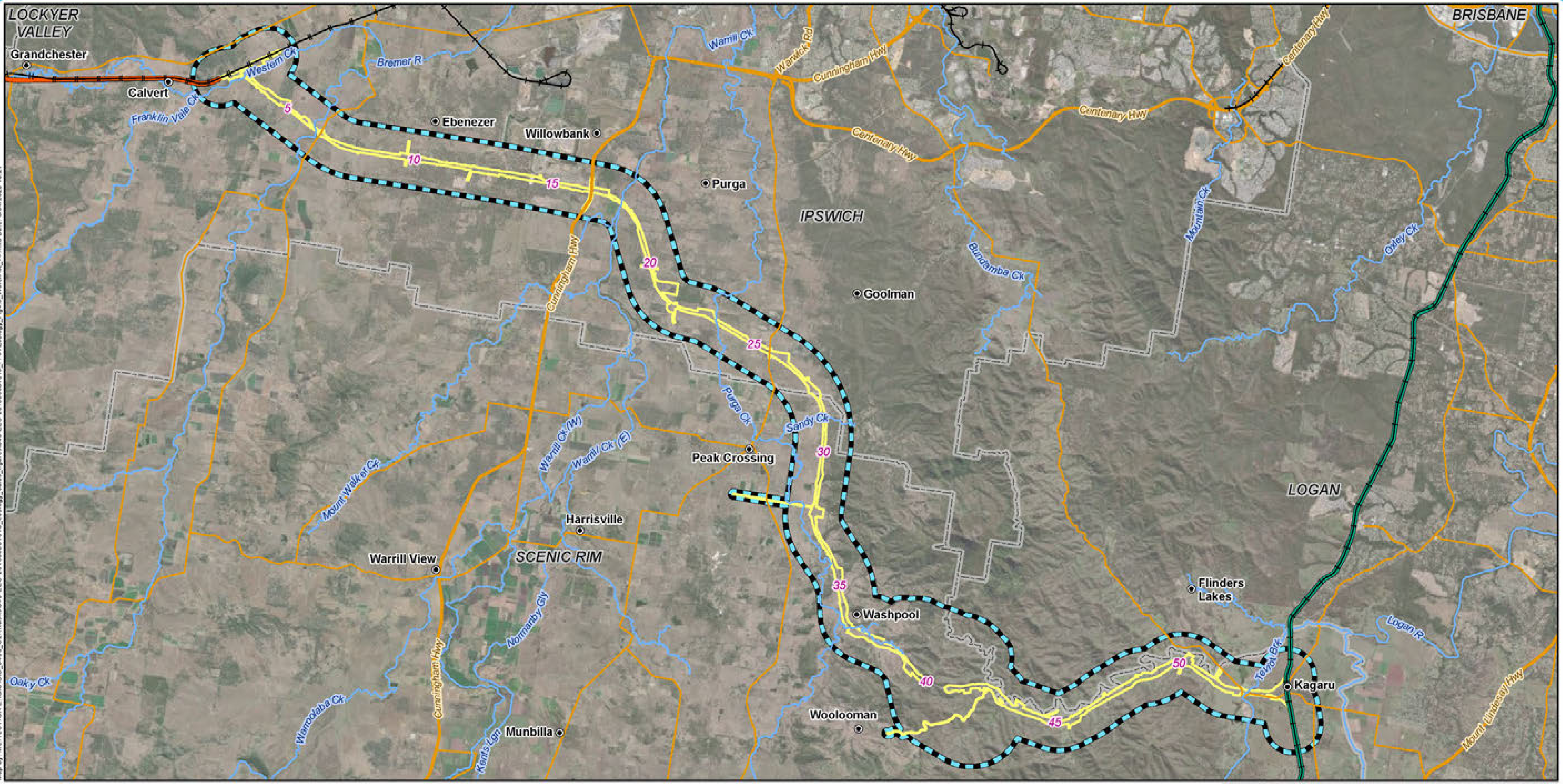
Figure 4.4: Fire ant biosecurity zones

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
- H2C project alignment
- K2ARB project alignment
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- 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

Calvert to Kagaru

Figure 4.5: Water Act 2000 watercourses

4.4.6 Stream order mapping

Queensland uses the stream ordering system adopted from Strahler (1952) in which waterways are given an 'order' according to the number of additional upstream tributaries associated with each waterway. This system is used to provide an indication on waterway complexity and therefore the potential aquatic habitat present. In addition to providing for an indication of habitat complexity, stream order mapping identifies waterways that may be currently unmapped under the Water Act.

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 population.

The stream orders for watercourses intersected by the Project alignment are outlined in Table 4.7. Stream order of one were not recorded as they are unlikely to contain valuable fish habitat and as such the number of streams recoded in Table 4.7 may not directly match up with the mapped waterways identified in the Queensland Waterways for Waterway Barrier Works in Table 4.8.

Table 4.7 Stream orders present within the ecology study area

Stream order (DNRME)	Waterway (approximate chainage (km))
6	Warrill Creek (Ch 17.60) Purga Creek (Ch 23.40)
5	Western Creek (Ch 1.30, Ch 3.10) Bremer River (Ch 6.20) Un-named tributary of Teviot Brook (Ch 28.70, Ch 43.10) Teviot Brook (Ch 52.80)
4	Un-named tributary of Purga Creek (Ch 35.80, Ch 36.60) Un-named tributary of Teviot Brook (Ch 42.80, Ch 46.20, Ch 51.40)
3	Un-named Tributary of Bremer River (Ch 7.70) Ebenezer Creek (Ch 13.40) Un-named tributary of Purga Creek (Ch 33.30, Ch 37.60, Ch 37.90) Un-named tributary of Teviot Brook (Ch 41.70, Ch 47.00, Ch 48.30, Ch 53.20) Woollaman Creek (Ch 51.50)
2	Un-named tributary of Ebenezer Creek (Ch 14.40) Un-named tributary Purga Creek (Ch 27.80, Ch 29.90, Ch 31.20, Ch 32.00, Ch 33.90, Ch 38.90, Ch 39.30, Ch 39.60) Un-named tributary of Teviot Brook (Ch 43.40, Ch 44.20)
1	n/a

4.4.7 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, watercourse or inlet of the sea. Waterways for waterway barrier works are regulated under the Fisheries Act and 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 34 individual waterways for waterway barrier works which cross the Project alignment. Of the 34 waterways, seven waterways are intercepted multiple times (refer Table 4.8). The 34 waterways are classified (derived from DAF mapped waterways) as follows:

- Low risk of impact (category 1) – 11 waterways mapped as 'Low' intersect the alignment

- Moderate risk of impact (category 2) – 11 waterways mapped as 'Moderate' intersect the alignment
- High risk of impact (category 3) – 4 waterways mapped as 'High' intersect the alignment
- Major risk of impact (category 4) – 8 waterways mapped as 'Major' intersect 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.

The location of the DAF Queensland Waterways for Waterway Barrier Works waterway mapping within the ecology study area is illustrated in Figure 4.6.

Table 4.8 Department of Agriculture and Fisheries waterways for waterway barrier works which intersect the proposed Project alignment

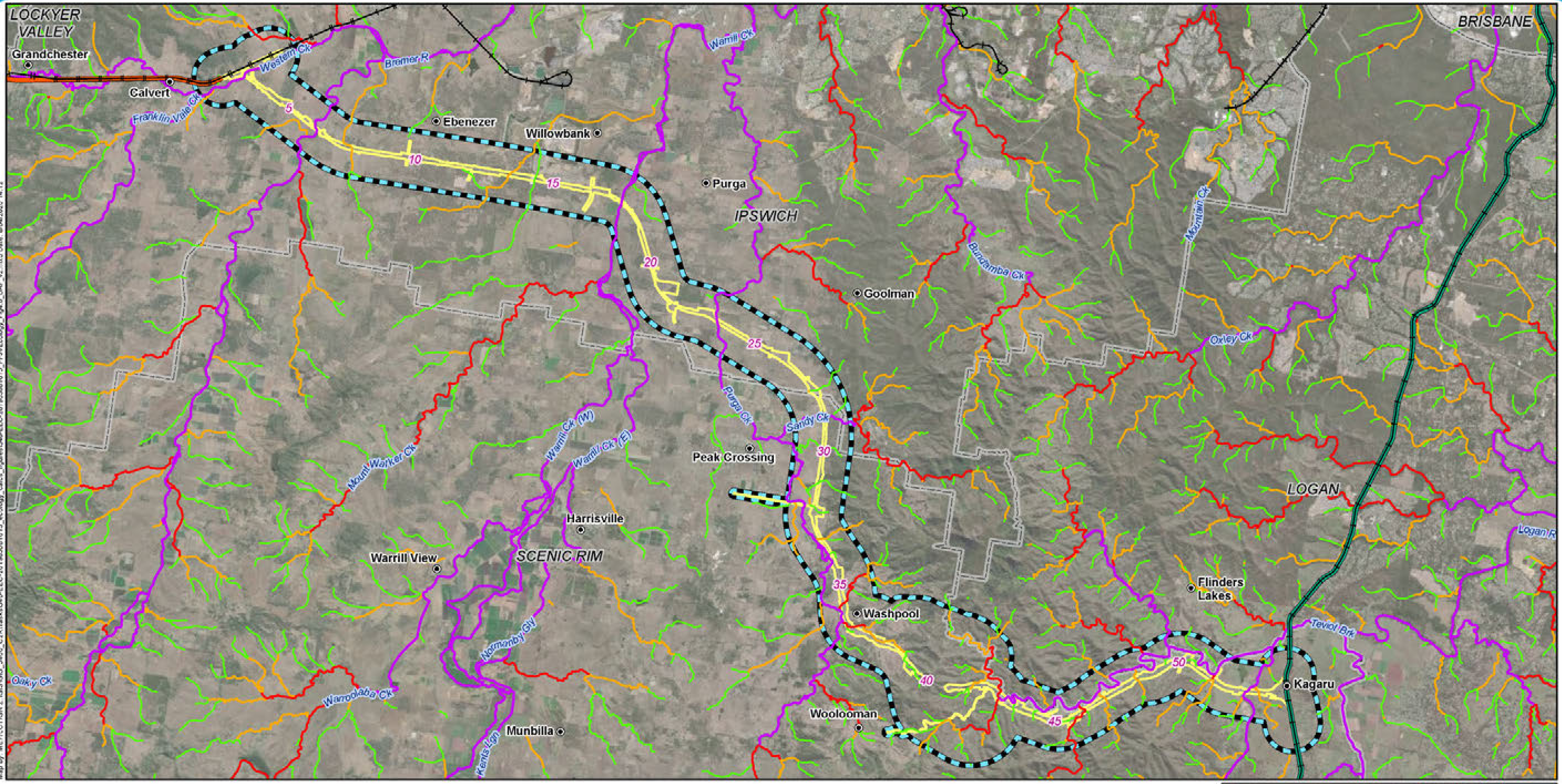
Waterway impact risk (DAF)	Waterway (approximate chainage (km))
Major (Category 4)	Western Creek (Ch 1.30, Ch 3.10) Bremer River (Ch 6.20) Warrill Creek (Ch 17.60) Purga Creek (Ch 23.40) Un-named tributary of Purga Creek (Ch 28.70) Dugandan Creek (Ch 43.10) Teviot Brook (Ch 52.80)
High (Category 3)	Un-named tributary of Purga Creek (Ch 35.80, Ch 36.60) Un-named tributary of Teviot Brook (Ch 42.80, Ch 46.20)
Moderate (Category 2)	Un-named tributary of Bremer River (Ch 7.70) Ebenezer Creek (Ch 13.40) Un-named tributary of Purga Creek (Ch 33.30, Ch 37.60, Ch 37.90) Un-named tributary of Teviot Brook (Ch 41.70, Ch 47.00, Ch 48.30, Ch 53.20) Woollaman Creek (Ch 51.40, Ch 51.50)
Low (Category 1)	Un-named tributary of Ebenezer Creek (Ch 14.40) Un-named tributary of Purga Creek (Ch 27.80, Ch 29.90, Ch 31.20, Ch 32.00, Ch 33.90, Ch 38.90, Ch 39.30, Ch 39.60) Un-named tributary of Teviot Brook (Ch 43.50, Ch 44.20)

4.4.8 Wetlands

There are no Wetlands of International Importance (Ramsar wetlands) or wetlands of national significance located in, or within 10 km of the ecology study area. Six wetlands of high ecological significance (HES) (under EP Reg), are present within the ecology study area, but outside the disturbance footprint. The six HES wetland areas are located at the following watercourse and chainage (km):

- Two HES wetlands proximal to Western Creek (Ch 2.40)
- HES wetland at tributary of the Bremer River (Ch 5.20 to Ch 5.60)
- HES wetland at tributary of Warrill Creek (Ch 17.00 to Ch 17.60)
- HES wetland at Purga Creek (Ch 36.00)
- HES wetland at Teviot Brook (Ch 52.40 to Ch 52.80).

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
- H2C project alignment
- K2ARB project alignment
- EIS disturbance footprint (surface disturbance only)
- 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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Calvert to Kagaru

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

These wetlands constitute a MSES under the EP Reg. The location of referable wetlands is provided in Figure 4.7 and the extent contained within the ecology study area is presented in Table 4.9. An analysis of the conservation and ecological values of the wetland systems within the ecology study area is provided in Section 4.4.9.

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

Feature	Extent (ha)	
	Ecology study area	Disturbance footprint
HES Wetlands	66.00	0.00

4.4.9 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/ecosystems, special features, connectivity and representativeness (DEHP 2015).

The assessment below has been provided for the catchments relevant to the ecology study area (Bremer and Logan River catchments).

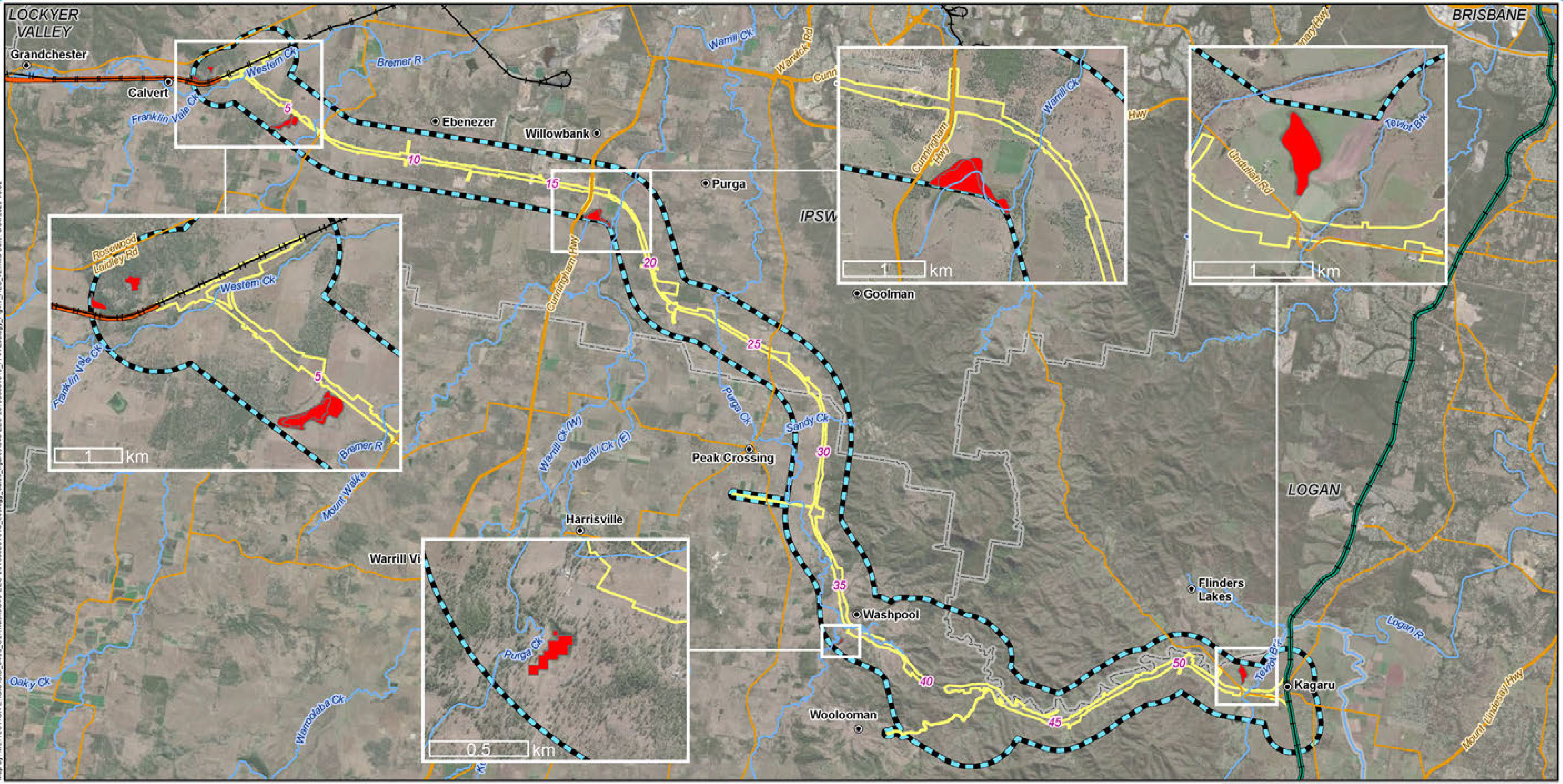
Table 4.10 provides the assessment for the catchments relevant to the ecology study area. The catchment aquatic conservation assessment indicates a skew towards higher value wetlands (against the criteria indicated above) throughout both catchments, indicating the presence of wetland sensitive environmental receptors. Noting this, monitoring sites within the ecology study area were all classed as very low, low or medium (indicating wetland sensitive environmental receptors of limited sensitivity) (refer Table 4.11).

Table 4.10 Aquascore for Bremer River and Logan River catchments

Catchment	Aquascore (%)				
	Very low	Low	Medium	High	Very high
Riverine wetlands					
Bremer River catchment	3% of the catchment had an Aquascore of very low	3% of the catchment had had an Aquascore of low	64% of the catchment area had an Aquascore of medium	12% of the catchment had an Aquascore of high	18% of the catchment had an Aquascore of very high
Logan River catchment	0% of the catchment had an Aquascore of very low	6% of the catchment had had an Aquascore of low	43% of the catchment area had an Aquascore of medium	27% of the catchment had an Aquascore of high	24% of the catchment had an Aquascore of very high
Non-riverine wetlands					
Bremer River catchment	5% of the catchment had an Aquascore of very low	1% of the catchment had had an Aquascore of low	64% of the catchment area had an Aquascore of medium	0% of the catchment had an Aquascore of high	30% of the catchment had an Aquascore of very high
Logan River catchment	8% of the catchment had an Aquascore of very low	1% of the catchment had an Aquascore of low	32% of the catchment area had an Aquascore of medium	29% of the catchment had an Aquascore of high	29% of the catchment had an Aquascore of very high

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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- High Ecological Significance wetlands

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 4.7: High ecological significance (HES) wetlands

The results of the Aquascore riverine assessment relevant to each monitoring site is presented in Table 4.11.The majority of monitoring sites had Aquascores of medium, with an even spread of low and very low Aquascores for other monitoring sites.

Table 4.11 Specific Riverine AquaBAMM score for water quality monitoring sites

Aquascore	Monitoring site	Associated watercourse
Very Low	5A, 5A (alt), 12A	Purga Creek
Low	7A (alt), 7A, 8A, 9A	Dugandan Creek and Woollaman Creek
Medium	1A, 1A (alt), 2A, 3A, 14A, 6A, 13A, 10A, 11A	Western Creek, Bremer River, Warrill Creek, Purga Creek and Teviot Brook
High	-	-
Very High	-	-

4.4.10 Springs and groundwater dependent ecosystems

There are no springs known to occur within the ecology study area based on government data sources and ground truthing. However, terrestrial GDEs and surface areas GDEs are present within the ecology study area. The location of terrestrial GDEs and aquatic areas GDEs are provided in Figure 4.8, and quantified in Table 4.12.

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

Feature	Extent (ha)	
	Ecology study area	Disturbance footprint
Springs	0.00	0.00
Terrestrial GDEs[1]	329.69	18.31
Aquatic GDEs[2]	109.06	1.17
Total	**438.75**	**19.48**

Table notes:

1 Terrestrial ecosystems that rely on the subsurface presence of groundwater–this includes all vegetation ecosystems

2 Aquatic ecosystems that rely on the surface expression of groundwater–this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs. Marine and estuarine ecosystems can also be groundwater dependent,

4.4.11 Declared fish habitat areas

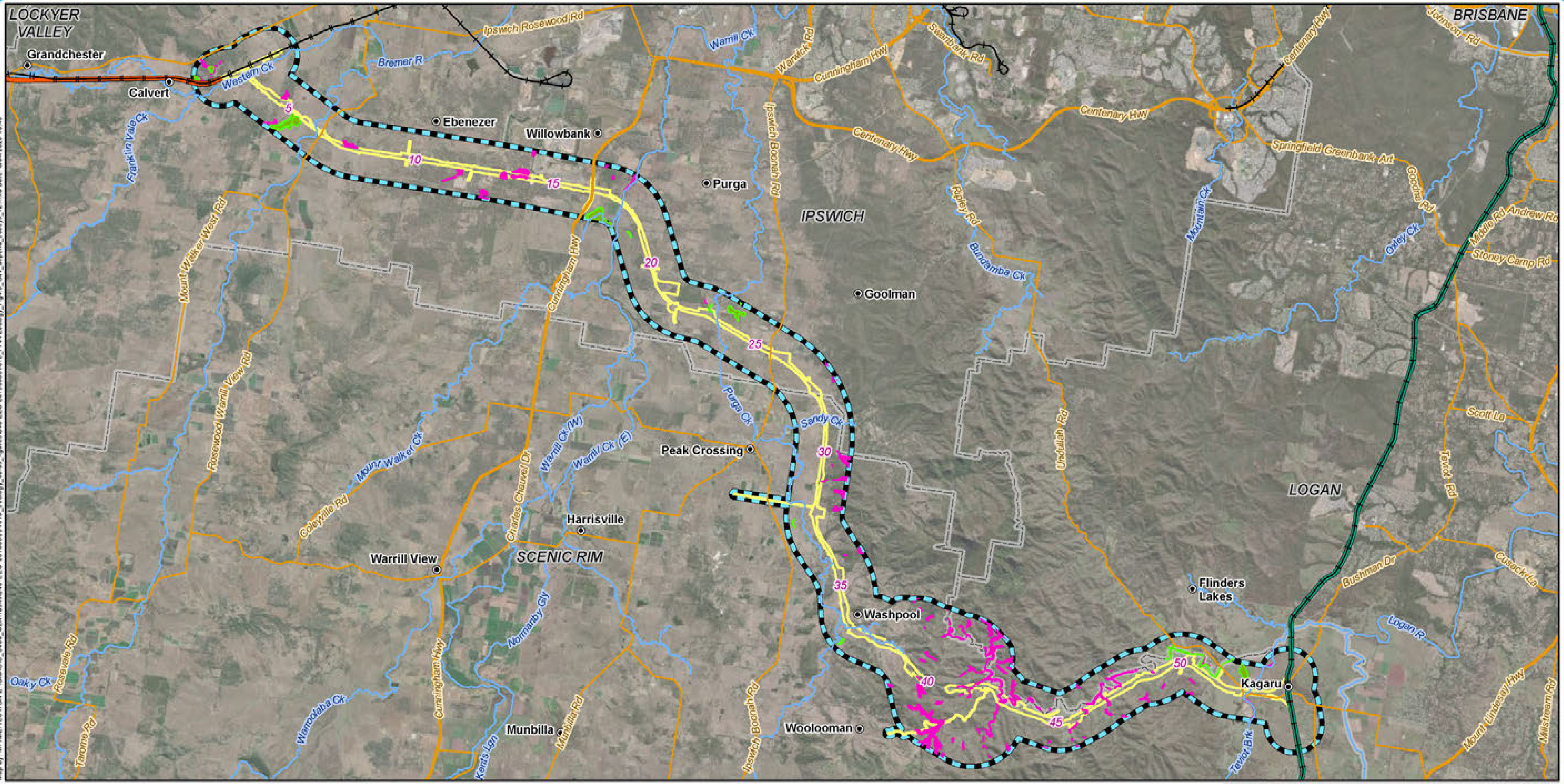
A declared FHA is an area protected against physical disturbance from coastal development, while still allowing legal fishing. There are no declared FHAs mapped within the ecology study area.

4.4.12 Local fisheries and fishing clubs

The Fisheries Act provides provisions for ecological 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 or within a 5 km radius of the ecology study area. However, there is the potential that smaller unofficial clubs exist in the area. Stocking of fish into impoundments and dams may have been undertaken by local landholders or the DAF within and adjacent to the ecology study area. Stocking of species outside of their natural range/drainage system (e.g. Mary River Cod in Wyaralong Dam) may have historically occurred and may account for any records of such species within the local 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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Surface areas - Groundwater Dependant Ecosystems
- Terrestrial Groundwater Dependant Ecosystems

A3 scale: 1:150,000

0 1 2 3 4 5km

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Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

4.4.13 Protected areas

A total of three areas protected under the Nature Conservation (Protected Areas) Regulation 1994 (i.e. Koala Crossing Nature Refuge, Purga Nature Reserve (Ipswich Council Management), and Gum Tips Nature Refuge) are contained within the ecology study area but outside the disturbance footprint. Areas protected under the *Forestry Act 1959* (i.e. Protected Forestry Areas) and voluntary declarations protected under the VM Act are not contained within the ecology study area. Nearby nature refuges (however not located within the ecology study area) include Sticky Gully Nature Refuge and Angel Place Nature Refuge, both located to the south of the ecology study area.

The location of protected areas is provided in Figure 4.9 and the extent contained within the ecology study area is provided in Table 4.13.

Table 4.13 Extent of protected areas contained within the Ecology study area

Area name	Extent (ha)	
	Ecology study area	Disturbance footprint
Purga Nature Reserve	83.02	0.36
Koala Crossing Nature Reserve	8.37	0.00
Gum Tips Nature Refuge	7.47	0.00
Total	98.86	0.36

4.4.14 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).

As defined by the Nature Conservation (Koala) Conservation Plan 2017, which categorises areas into four distinct categories: Koala Priority Areas, Koala Habitat Areas, Koala Habitat Restoration Areas, Locally Refined Koala Habitat Areas.

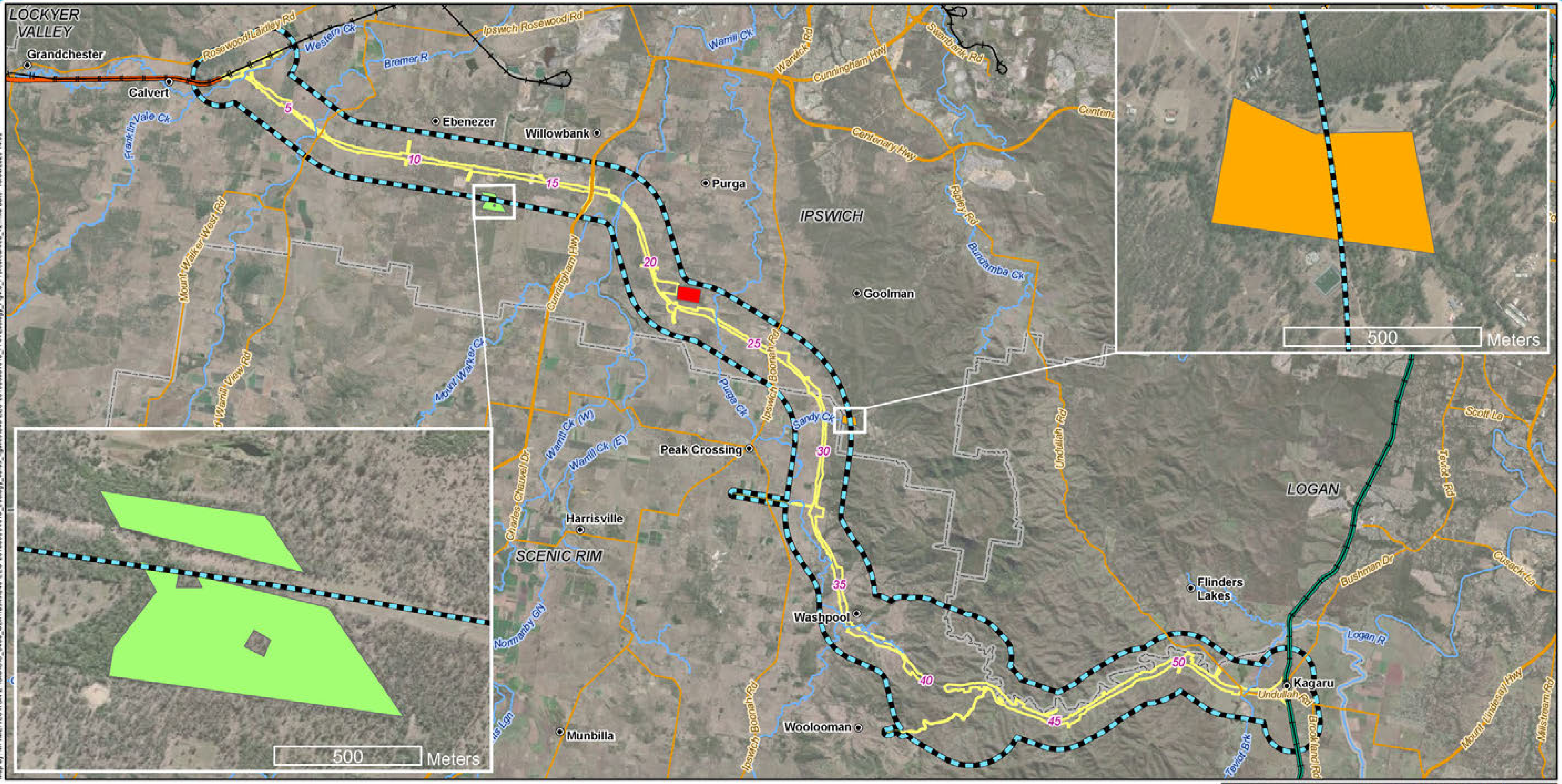
Koala Priority Areas are large, connected areas where a focus will be on habitat protection, habitat restoration and threat mitigation to safeguard Koala populations in South East Queensland. Koala Priority Areas constitute the second largest habitat category within the Ecology study area and the second largest category in 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. This mapping also generally aligns with the essential habitat mapping for Koalas.

Koala Habitat Restoration Areas is land that could be restored and established as Koala habitat. These areas feature low threats or constraints, and high conservation opportunities. The category constitutes the second largest are within the ecology study area, and constitute the largest habitat category within the Project disturbance footprint

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. A relatively small proportion of the Study area and Project disturbance footprint is mapped as Locally refined Koala Habitat Areas.

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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Gum Tips Nature Refuge
- Koala Crossing Nature Reserve
- Purga Nature Reserve

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

The extent of these areas is shown in Figure 4.10 and defined in Table 4.15.

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

Koala mapping category	Extent (ha)	
	Ecology study area	Disturbance footprint
Koala Priority Areas	3,770.56	258.48
Koala Habitat Areas	3,006.09	145.57
Koala Habitat Restoration Areas	3,636.14	295.13
Locally Refined Koala Habitat Areas	327.42	27.92

4.4.15 Biodiversity Planning Assessment

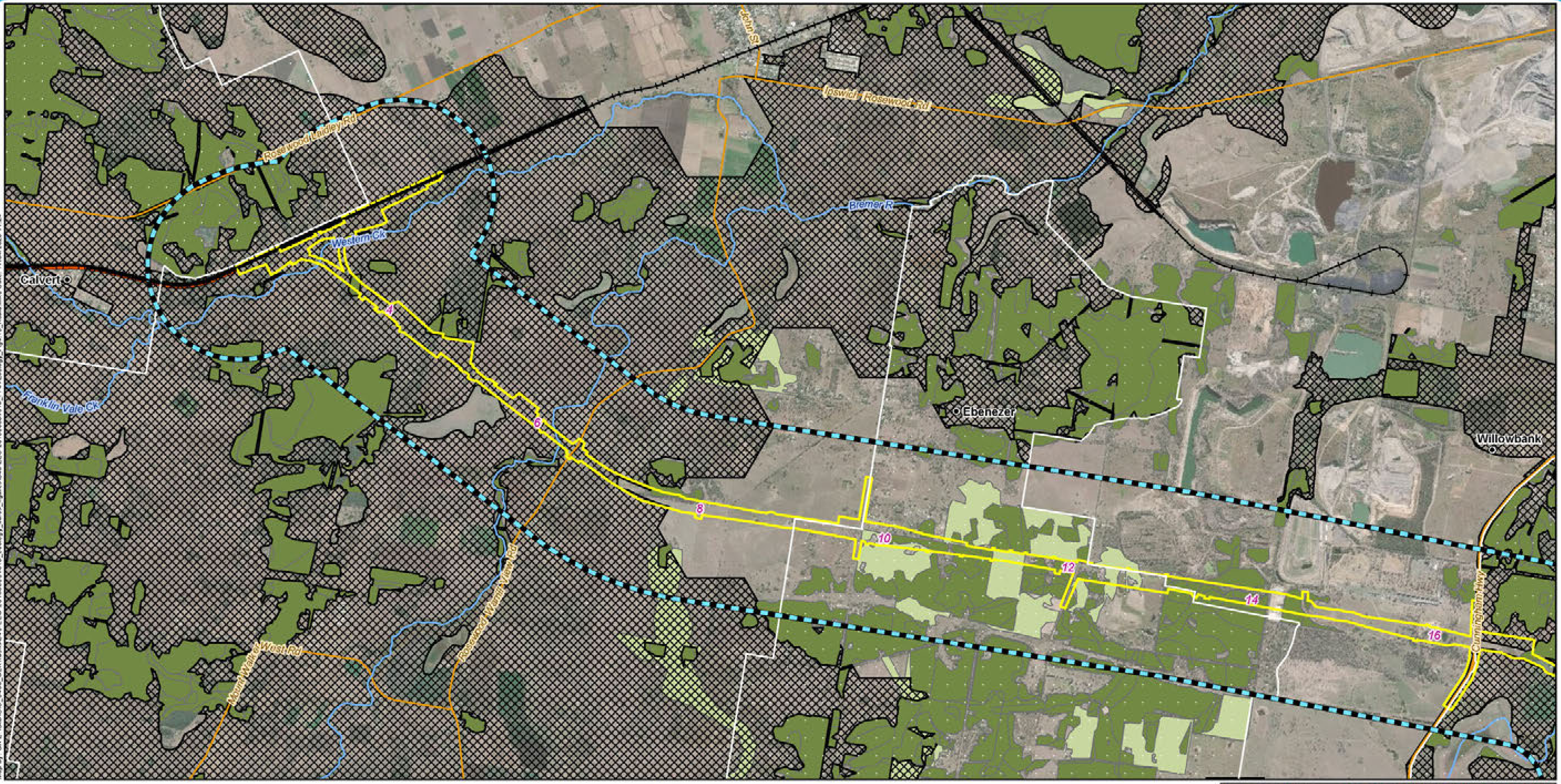
DES attributes biodiversity significance on a bioregional scale through a BPA. A BPA involves the integration of ecological criteria using the BAMM.

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.

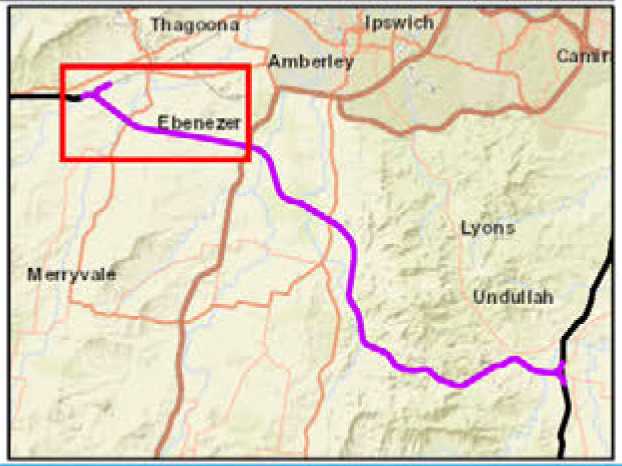
The results of the BPA assessment for habitat values and corridors are provided in Sections 4.4.15.1 and 4.4.15.3 respectively.

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
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas
- Locally refined koala habitat areas



A3 scale: 1:45,000

0 0.5 1 1.5 2 2.5km

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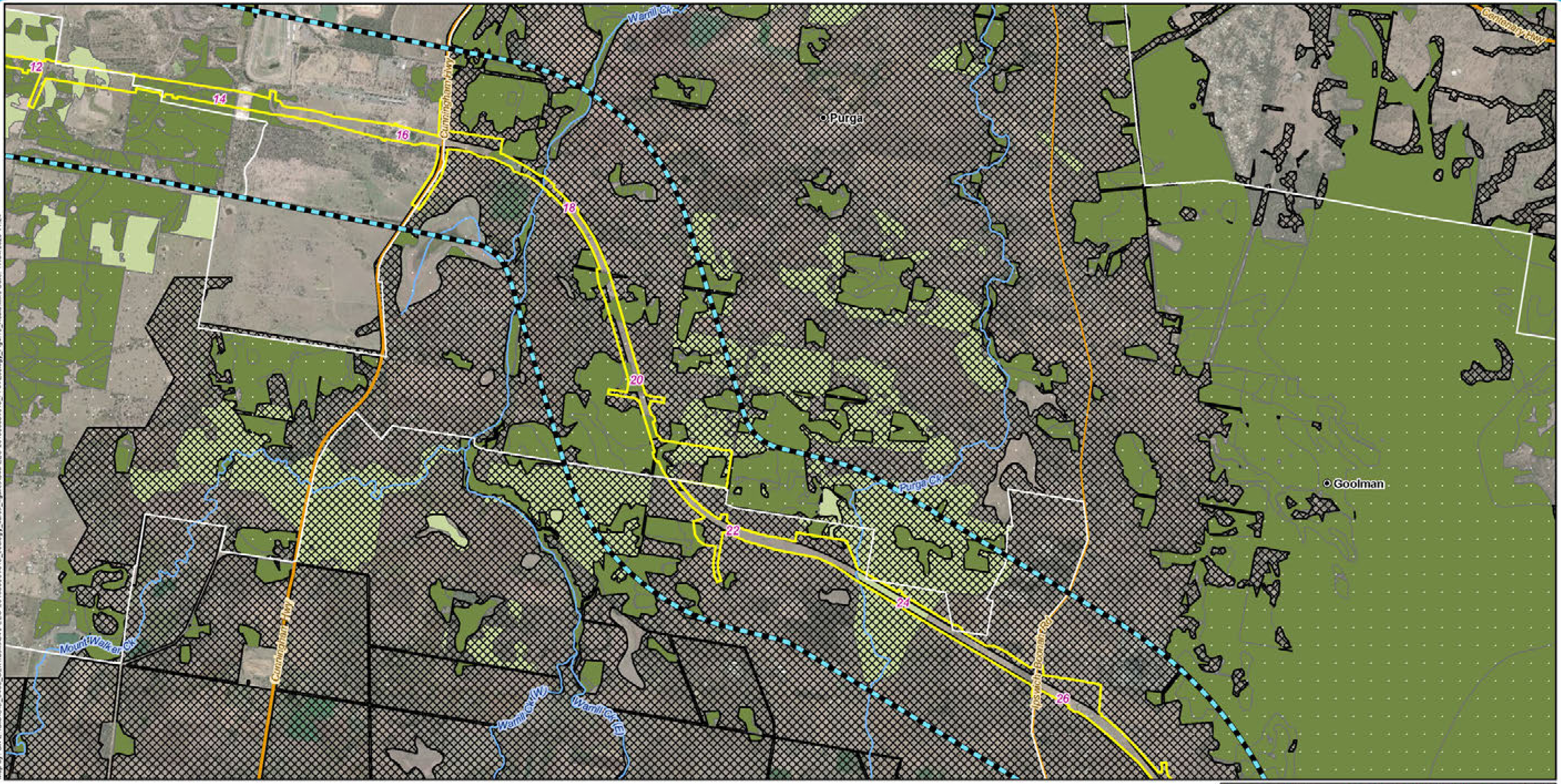
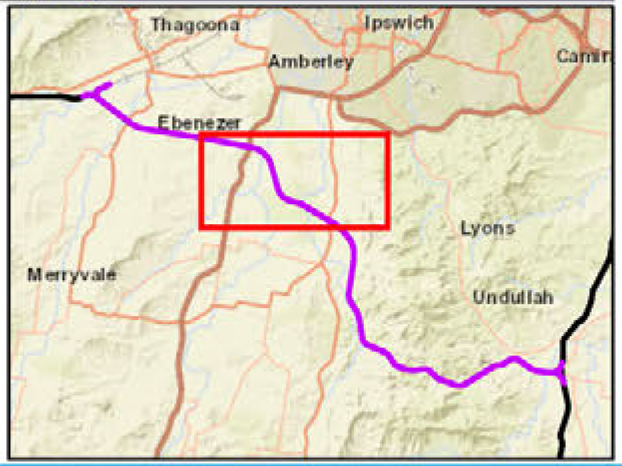
Figure 4.10a: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017





Legend

- 5 Chainage (km)
- Localities
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas
- Locally refined koala habitat areas

A3 scale: 1:45,000

0 0.5 1 1.5 2 2.5km

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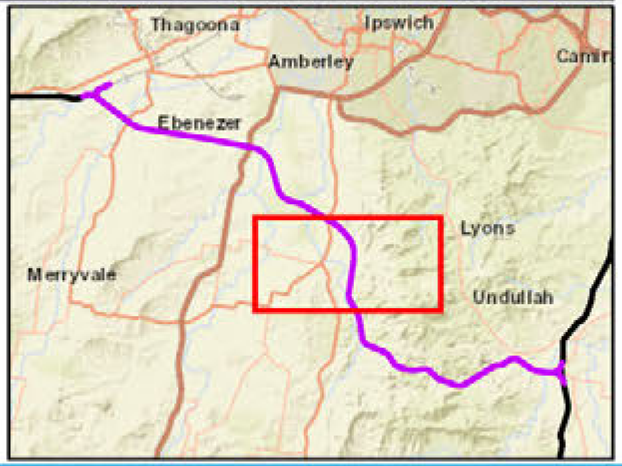
Figure 4.10b: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

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
- Watercourses
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas
- Locally refined koala habitat areas



A3 scale: 1:45,000

0 0.5 1 1.5 2 2.5km

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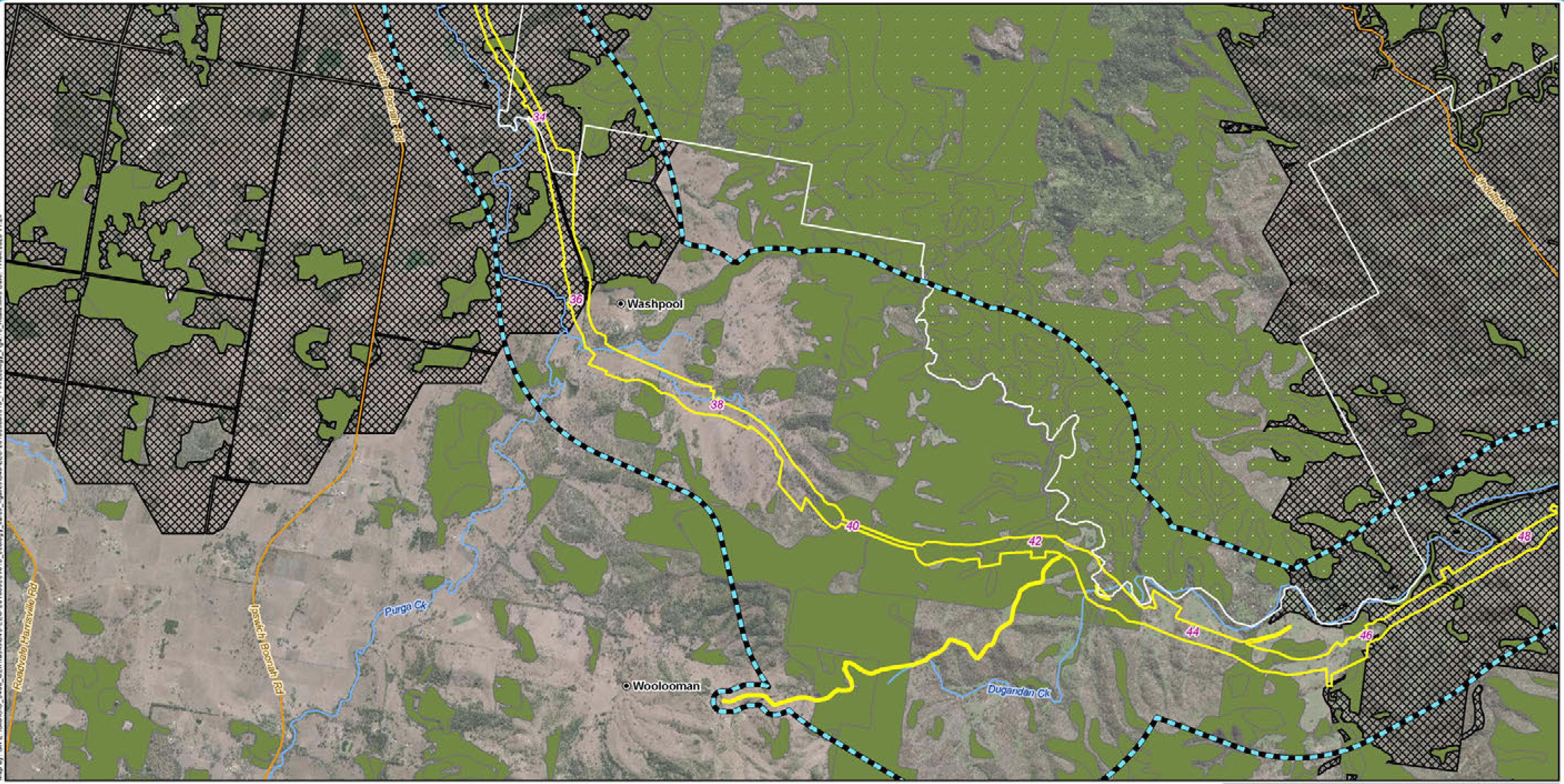
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

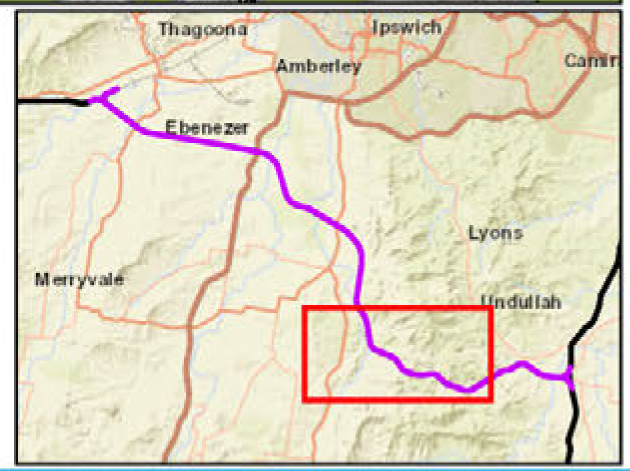
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,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



Legend

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

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



A3 scale: 1:45,000

0 0.5 1 1.5 2 2.5 km

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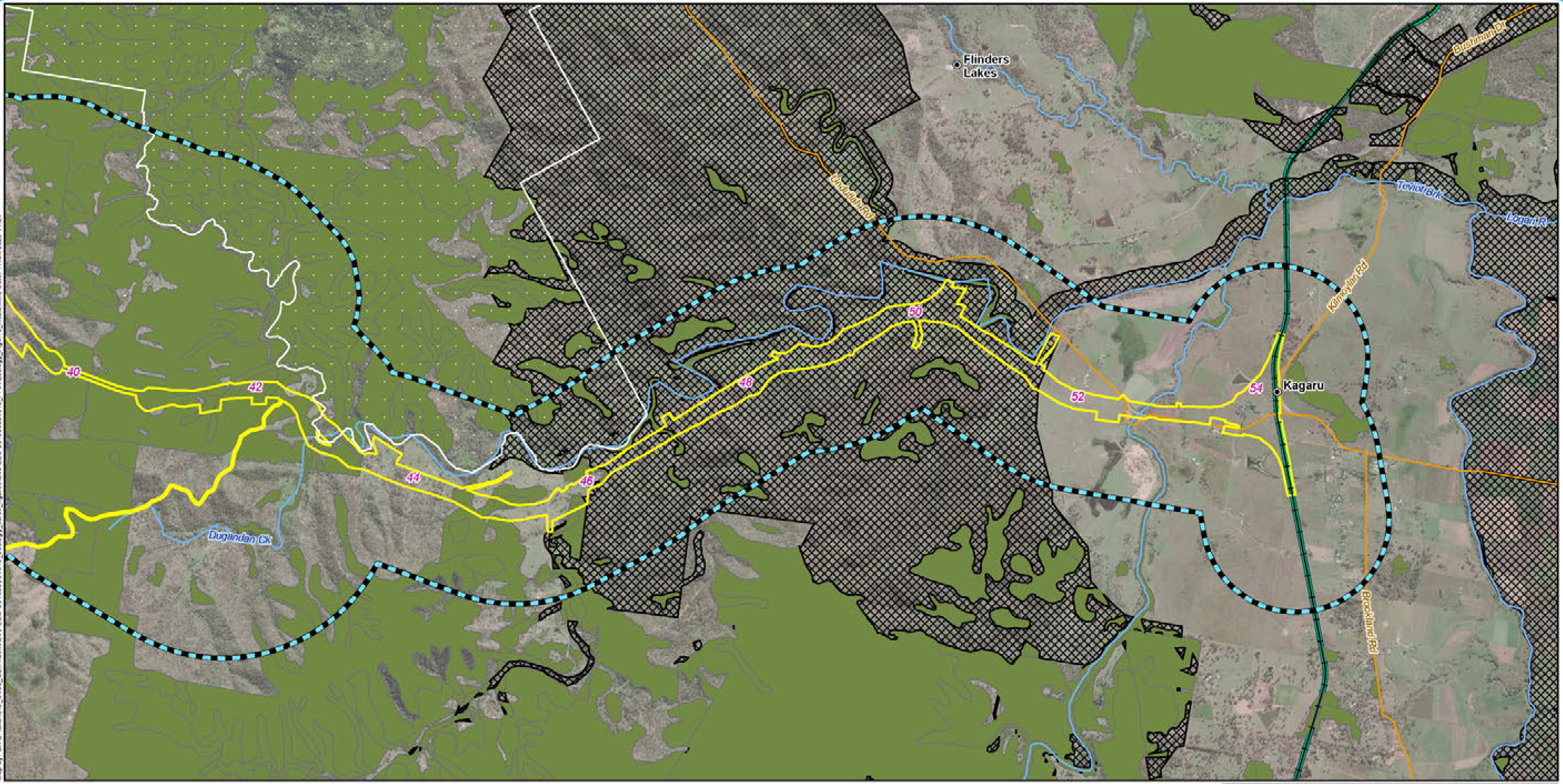
Issue date: 17/04/2020 Version: 0
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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

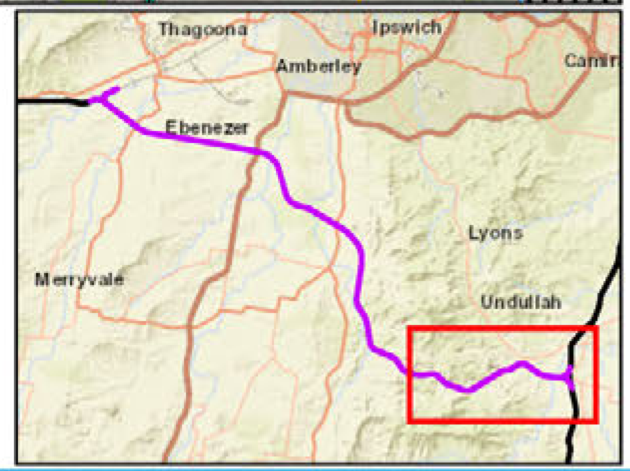
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,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



Legend

- 5 Chainage (km)
- Localities
- K2ARB project alignment
- Existing rail
- Watercourses
- Minor roads
- EIS disturbance footprint
- Ecology study area
- Koala priority areas
- Koala habitat restoration areas
- Koala habitat areas

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.



A3 scale: 1:45,000

0 0.5 1 1.5 2 2.5 km

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Issue date: 17/04/2020 Version: 0
Coordinate System: GDA 1994 MGA Zone 56

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

4.4.15.1 Special area decisions

The BPA Expert panel has determined that the **Teviot Range** is of **Regional significance**, due to the following attributes:

- Teviot Range - Flinders Peak centred on a cluster of intrusive volcanic plugs of Tertiary age (Mts Blaine, Catherine, Goolman, Perry, Welcome, Flinders Peak and Ivorys Rock)
- Contains SEQ endemic taxa including:
  - Mountain reed grass (*Arundinella montana*),
  - Boonah tuckeroo (*Cupaniopsis tomentella*)
  - Grey gum (*Eucalyptus major*),
  - Slender Milk-vine (*Marsdenia coronata*),
  - Lloyd’s olive (*Notelaea lloydii*),
  - Shiny-leaved Condoo (*Planchonella eerwah*),
  - Rib-fruited mallet-wood (*Rhodamnia dumicola*),
  - *Tephrosia* sp. (The Grampians L.H.Bird AQ565381),
  - *Zieria scopulus.*
- Wildlife refugia: area to west is changing from rural to urban as part of implementation of SEQ Regional Plan.
- Taxa at limits of geographic range. Species include:
  - Stiff-leaf wattle (*Acacia obtusifolia*),
  - Cliff bottlebrush (*Melaleuca comboynensis*).

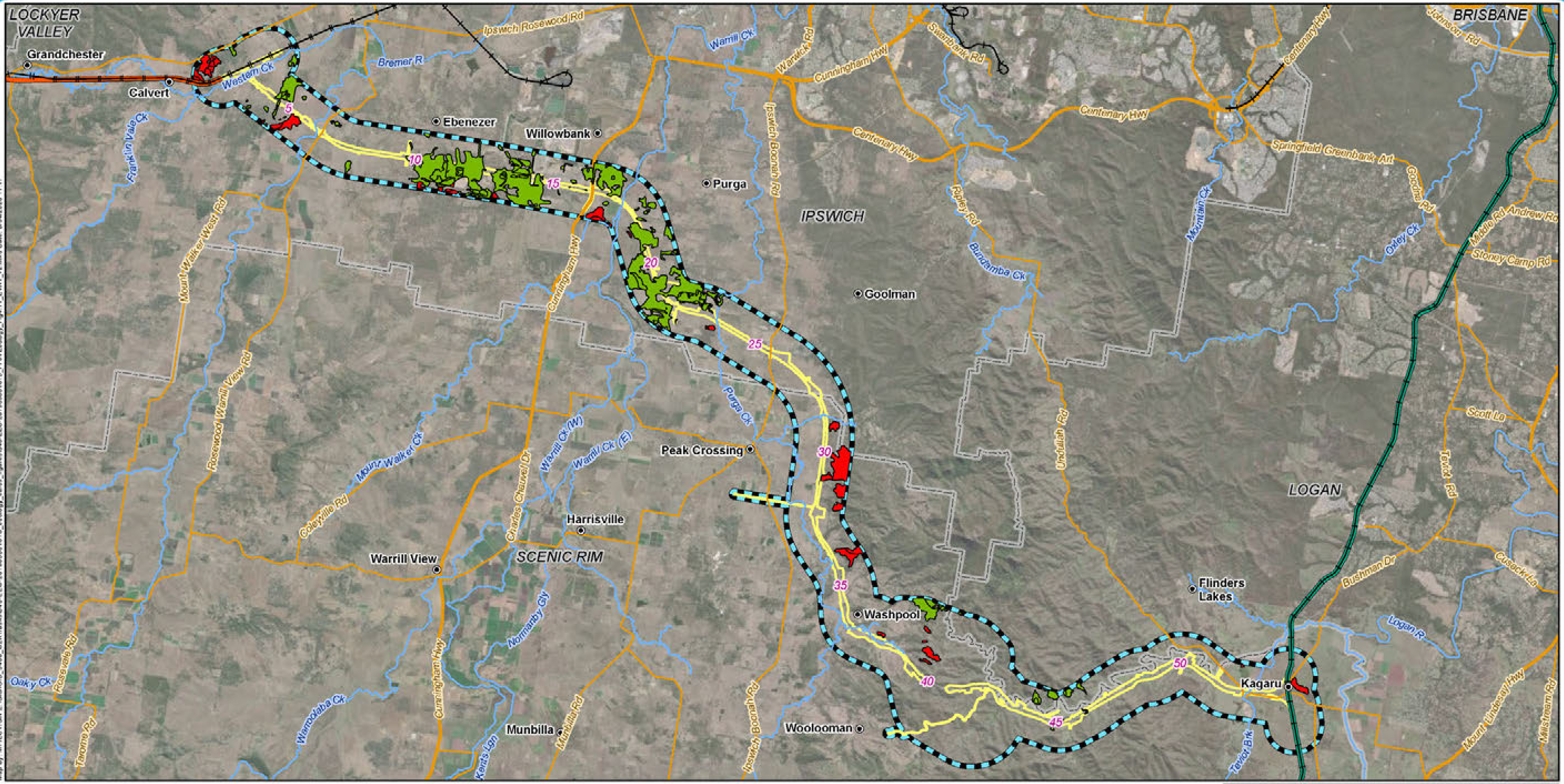
4.4.15.2 State and regional habitat values

The ecology study area includes areas of State and regional habitat values for EVNT taxa. The extent of this habitat within the ecology study area is provided in Table 4.15 and shown in Figure 4.11. These areas overlap substantially with those mapped as essential habitat and MSES Wildlife habitat (refer Section 4.4.3).

Table 4.15 The extent of Biodiversity Planning Assessment habitat values within the ecology study area

Habitat for EVNT taxa	Extent (ha)	
	Ecology study area	Disturbance footprint
State	1,110.92	116.92
Regional	293.23	1.35

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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

EVNT taxa habitats

- Regional Habitat
- State Habitat

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 4.11: State and regional EVNT taxa and habitats

4.4.15.3 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 terrestrial and riparian ecological corridors. 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	Disturbance footprint
Regional Terrestrial	1,005.86	87.86
State Riparian	510.72	40.86
State Terrestrial	1,809.17	119.80

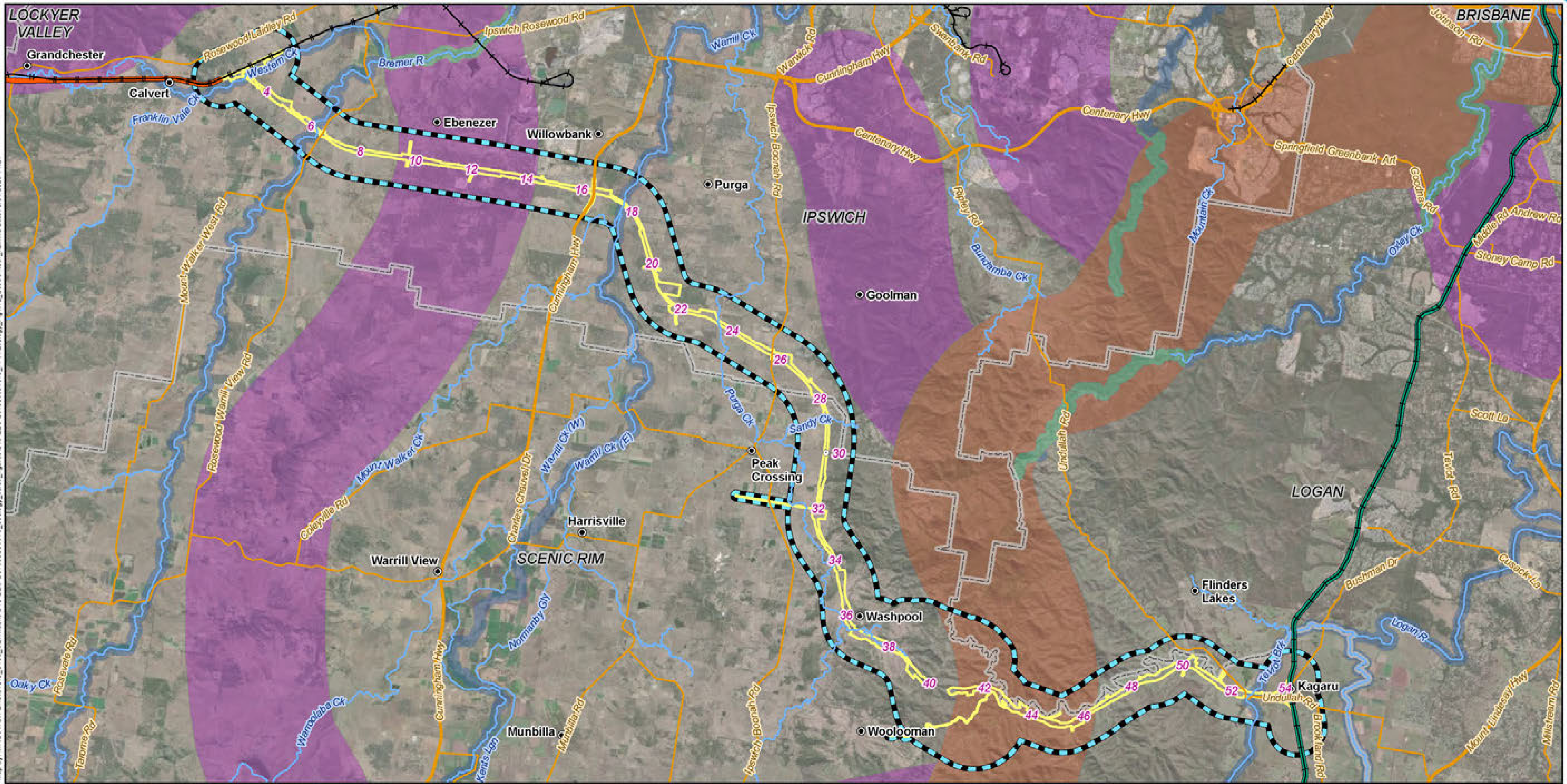
4.4.16 Register of critical habitats

No critical habitats as protected under the provisions of the NC Act (i.e. identified as an MSES), occur within the ecology study area.

4.4.17 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.

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



Map by: MFA/CT/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_calcs_figures\340-EEC-201905081615_FFJV\Ecology_Fig4.12_EcoCorridor_v2.mxd Date: 8/04/2020 14:21

Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- K2ARB project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

Ecological corridors (BPA mapping)

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

A3 scale: 1:150,000

0 1 2 3 4 5km

Issue date: 08/04/2020 Version: 2

Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 4.12: Terrestrial and riparian ecological corridors

4.4.18 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 (DNRME 2019), 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 4.13).

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:

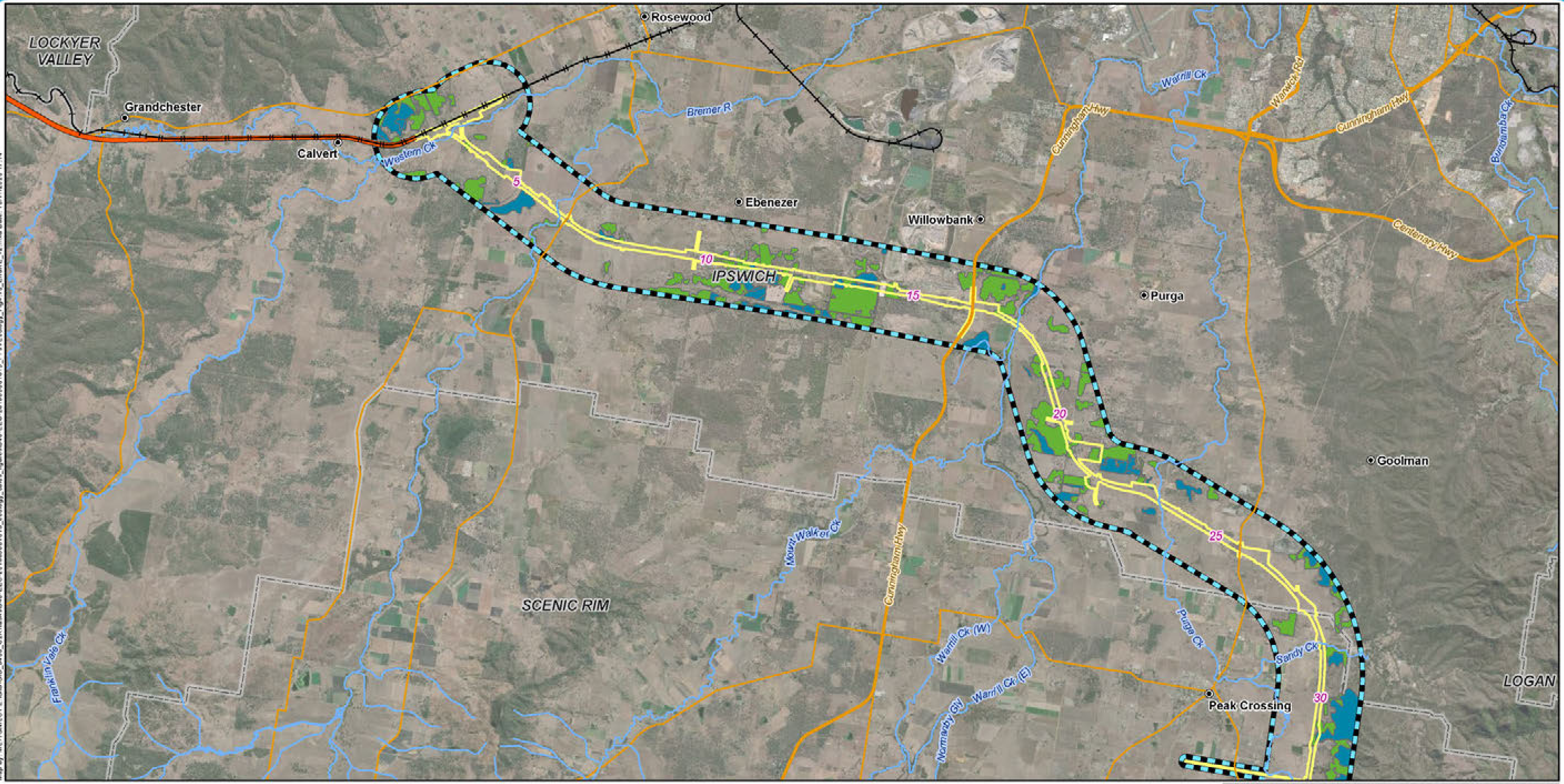
- Category A, B, C and R areas that are located within a defined distance from the defining banks of a relevant watercourse identified on the vegetation management watercourse and drainage feature map
- Category A, B, C and R areas that are located within 100 m from the defining bank of a wetland identified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

Table 4.17 summarises the extent of Category B and C areas of regulated vegetation that are Endangered or Of concern REs within the ecology study area.

Table 4.17 Extent of Category B and C 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	Disturbance footprint
Category B - Remnant vegetation	1,755.32	33.55
Category C - High value regrowth	1,779.10	118.00

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



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

Regulated vegetation

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

A3 scale: 1:100,000

0 0.75 1.5 2.25 3 3.75km

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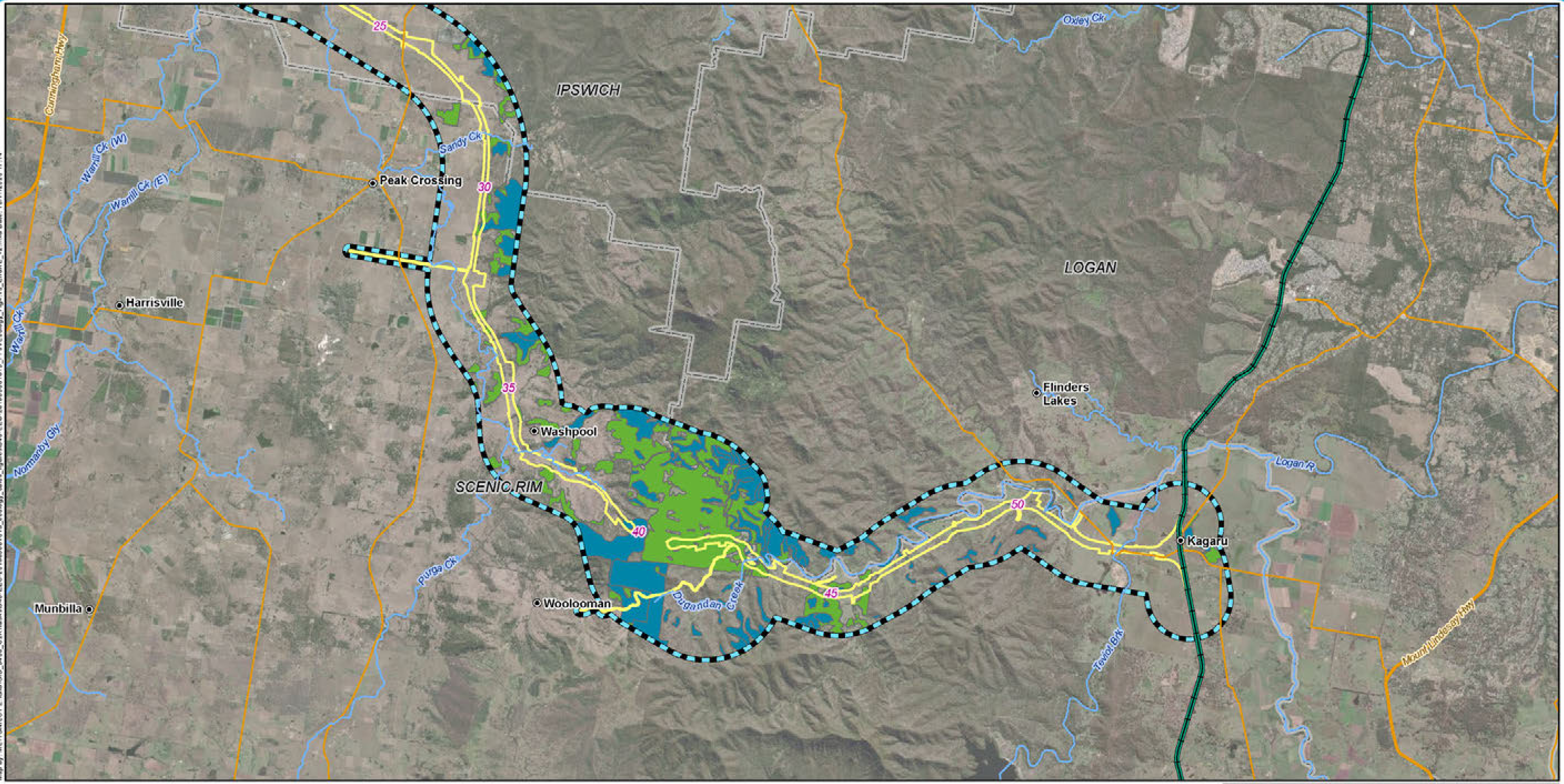
Figure 4.13a: Regulated vegetation management mapping

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



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

Regulated vegetation

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

Note that due to topography constraints and the realigment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.

A3 scale: 1:100,000

0 0.75 1.5 2.25 3 3.75km

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Figure 4.13b:Regulated vegetation management mapping

Category B and C regulated vegetation intersecting a watercourse/wetland occur within the ecology study area. Category R regulated vegetation intersecting a watercourse/wetland does not occur. Approximately 16.09 ha of Category B regulated vegetation (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature is present within the disturbance footprint. The extent of regulated vegetation intersecting watercourses and wetlands is summarised in Table 4.18 and shown in Figure 4.14.

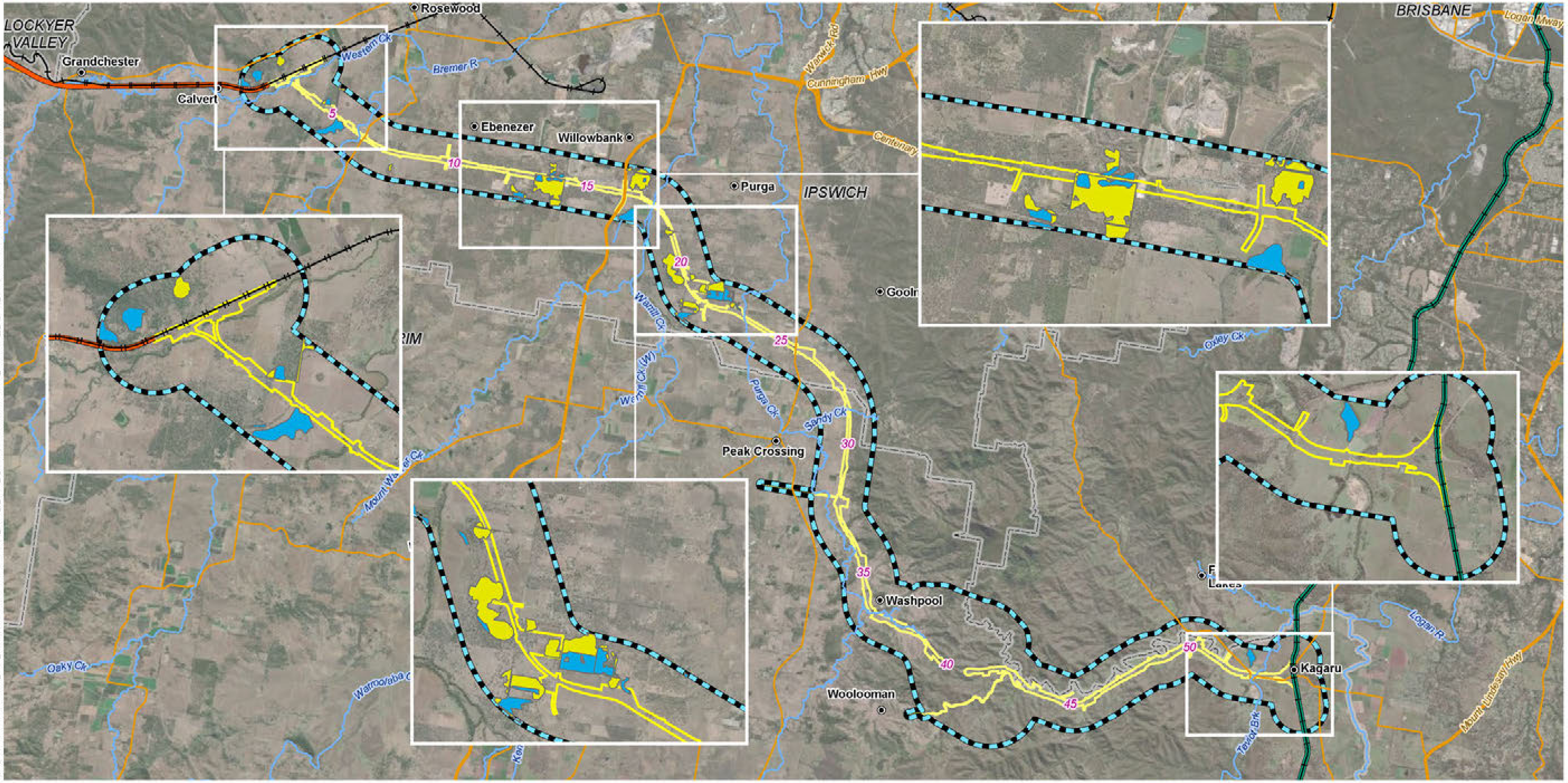
Table 4.18 The extent of regulated vegetation intersecting watercourses and wetlands within the ecology study area

Regulated vegetation category	Extent (ha)	
	Ecology study area	Disturbance footprint
A	36.80	0.00
B	290.53	13.40
C	378.16	30.29
X	796.18	58.98

Table 4.19 provides a breakdown of the remnant vegetation (i.e. REs) that constitute Category B regulated vegetation.

Figure 4.15 shows the distribution of these REs within the ecology study area and Table 4.20 provides a summary of the total areas of Endangered, Of concern and Least concern Category B regulated vegetation contained within the ecology study area. The extent (area) of Endangered, Of concern and Least concern Category C regulated vegetation contained within the ecology study area is provided in Table 4.21.

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
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- Ecology study area
- EIS disturbance footprint (surface disturbance only)
- Local Government Areas

Areas within 100 m of wetlands

- Category B - Remnant
- Category C - Regrowth

A3 scale: 1:156,879

0 1 2 3 4 5km

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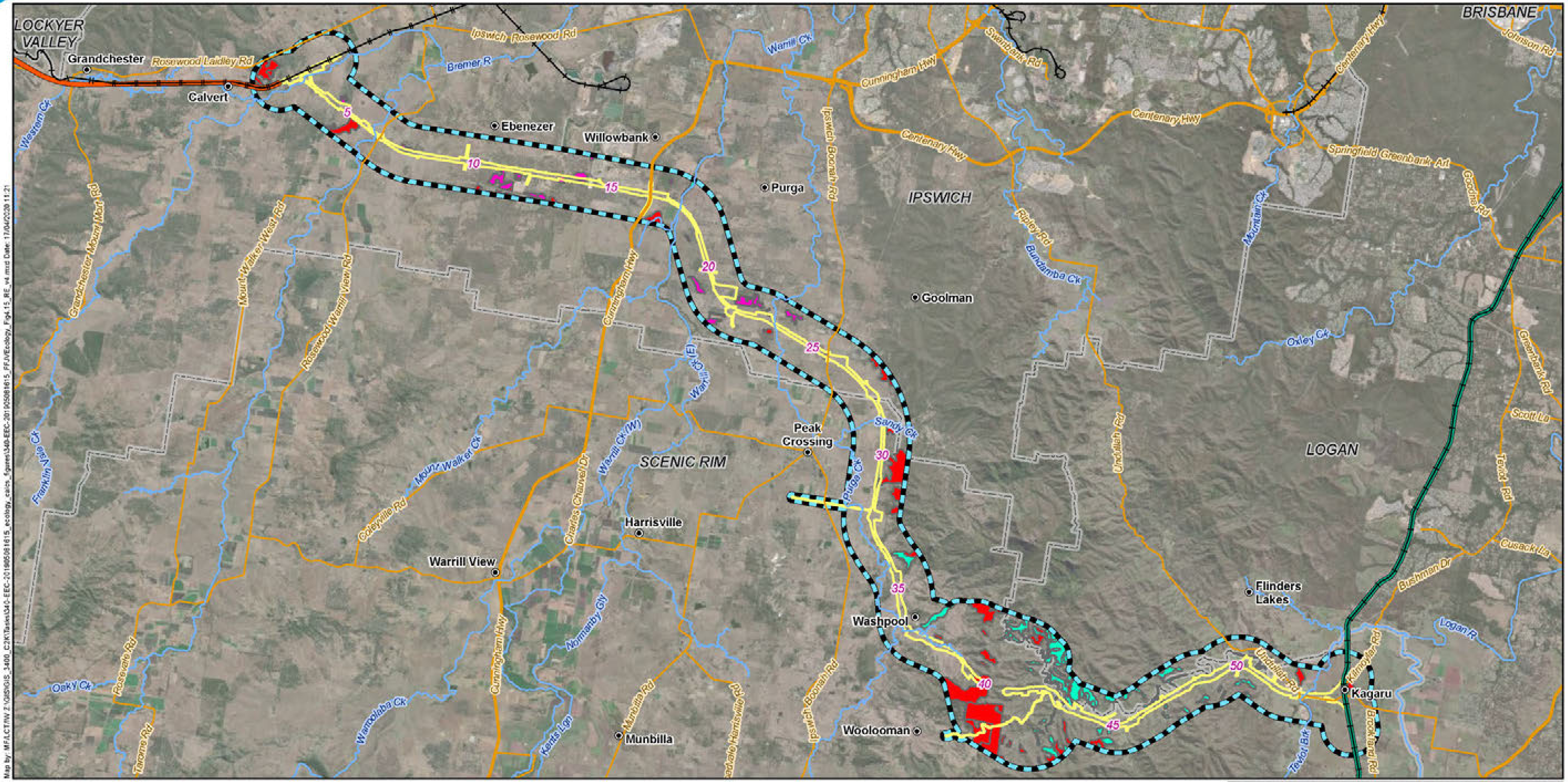
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

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



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- Ecology study area
- EIS disturbance footprint (surface disturbance only)
- 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: 1:150,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 17/04/2020 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

4.15: Distribution of Regional Ecosystems

Table 4.19 Descriptions of Regional ecosystems (category B and C regulated vegetation) within the ecology study area

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11)	Extent (ha)	
	VM Act	BD		Within ecology study area	Disturbance footprint
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.	83.86	2.74
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).	29.00	1.97
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.	113.54	14.72
12.3.7c	LC	OC	*Melaleuca bracteata* open forest +/- emergent *Eucalypts tereticor*nis. Occurs in drainage depressions on Quaternary alluvial plains. Riverine wetland or fringing riverine wetland.	0.37	0.00
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.	73.98	0.75
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. This is analogous to the EPBC Act listed Swamp Tea-tree (*Melaleuca irbyana*) Forest of SEQ Threatened ecological community	111.27	7.54
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.	82.95	10.67

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11)	Extent (ha)	
	VM Act	BD		Within ecology study area	Disturbance footprint
12.8.24	E	E	*Corymbia citriodora* subsp. *variegata*, *Eucalyptus crebra* +/- *E. moluccana* open forest. Occurs on Cainozoic igneous rocks especially lower slopes of rhyolite and trachyte hills (e.g. Moogerah Peaks)	0.54	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.	1,289.05	37.37
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.	47.13	0.05
12.9-10.7	OC	OC	*Eucalyptus crebra* +/- *E. tereticornis, Corymbia tessellaris, Angophora leiocarpa, E. melanophloia* woodland. Occurs on Cainozoic and Mesozoic sediments.	558.51	17.20
12.9-10.11	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 Mesozoic sediments where drainage of soils is impeded.	151.29	11.30
12.9-10.16	OC	OC	Microphyll to notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Araucaria cunninghamii, Agathis robusta, Backhousia myrtifolia, Cupaniopsis parvifolia, Dendrocnide photinophylla, Rhodosphaera rhodanthema, Flindersia australis, F. xanthoxyla, Drypetes deplanchei, Olea paniculata, Diospyros geminata, Gossia bidwillii, Excoecaria dallachyana* and *Vitex lignum-vitae. Archontophoenix cunninghamiana* often present in gully floors. Occurs on Cainozoic and Mesozoic sediments.	71.64	4.58
12.9-10.17	LC	NC	Open forest to woodland complex generally with a variety of stringybarks, grey gums, ironbarks and in some areas spotted gum. Canopy trees include *Eucalyptus siderophloia, E. propinqua or E. major, E. acmenoides or E. portuensis, E. carnea* and/or *E. microcorys* and/or *Corymbia citriodora* subsp. *variegata*. Other species that may be present locally include *Corymbia intermedia, C. trachyphloia, Eucalyptus tereticornis, E. biturbinata, E. moluccana, E. longirostrata, E. fibrosa* subsp. *fibrosa* and *Angophora leiocarpa. Lophostemon confertus* or Whipstick *Lophostemon confertus* often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses, shrubs and ferns. Hills and ranges of Cainozoic and Mesozoic sediments.	10.78	0.00

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11)	Extent (ha)	
	VM Act	BD		Within ecology study area	Disturbance footprint
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.	196.76	4.89
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.	297.26	30.12
Non-remnant/ HVR	-	-	Not applicable	9,324.31	828.59

Table notes:

LC = Least concern NC = No concern at present OC = Of concern E = Endangered BD = Biodiversity

Table 4.20 Extent of remnant (category B) Endangered, Of concern and Least concern Regional ecosystems contained within the ecology study area

RE VM Act category	Extent (ha)	
	Ecology study area	Disturbance footprint
Endangered: ▪ 12.3.3 ▪ 12.3.3d ▪ 12.3.18 ▪ 12.3.19 ▪ 12.8.24 ▪ 12.9-10.11 ▪ 12.9-10.27.	154.94	10.56
Of concern: ▪ 12.3.8 ▪ 12.9-10.3 ▪ 12.9-10.7 ▪ 12.9-10.16.	725.78	9.02
Least concern: ▪ 12.3.7 ▪ 12.3.7c ▪ 12.9-10.2 ▪ 12.9-10.17 ▪ 12.9-10.17a.	874.60	13.97

Table 4.21 Extent of regrowth (category C) communities contained within the ecology study area

RE VM Act category	Extent (ha)	
	Ecology study area	Disturbance footprint
High value regrowth vegetation (HVR) (Category C)	1,779.10	118.00

4.4.19 Offset areas

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

4.4.20 Protected plants flora survey trigger map

The flora survey trigger map identifies high-risk areas where endangered, vulnerable or near threatened native plants are present or are likely to be present. High risk areas are located within the ecology study area. The extent of distribution of high risk areas is summarised in Table 4.22 and shown in Figure 4.16.

Table 4.22 Extent of high risk areas contained within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Disturbance footprint
High risk area	2,537.43	118.80

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

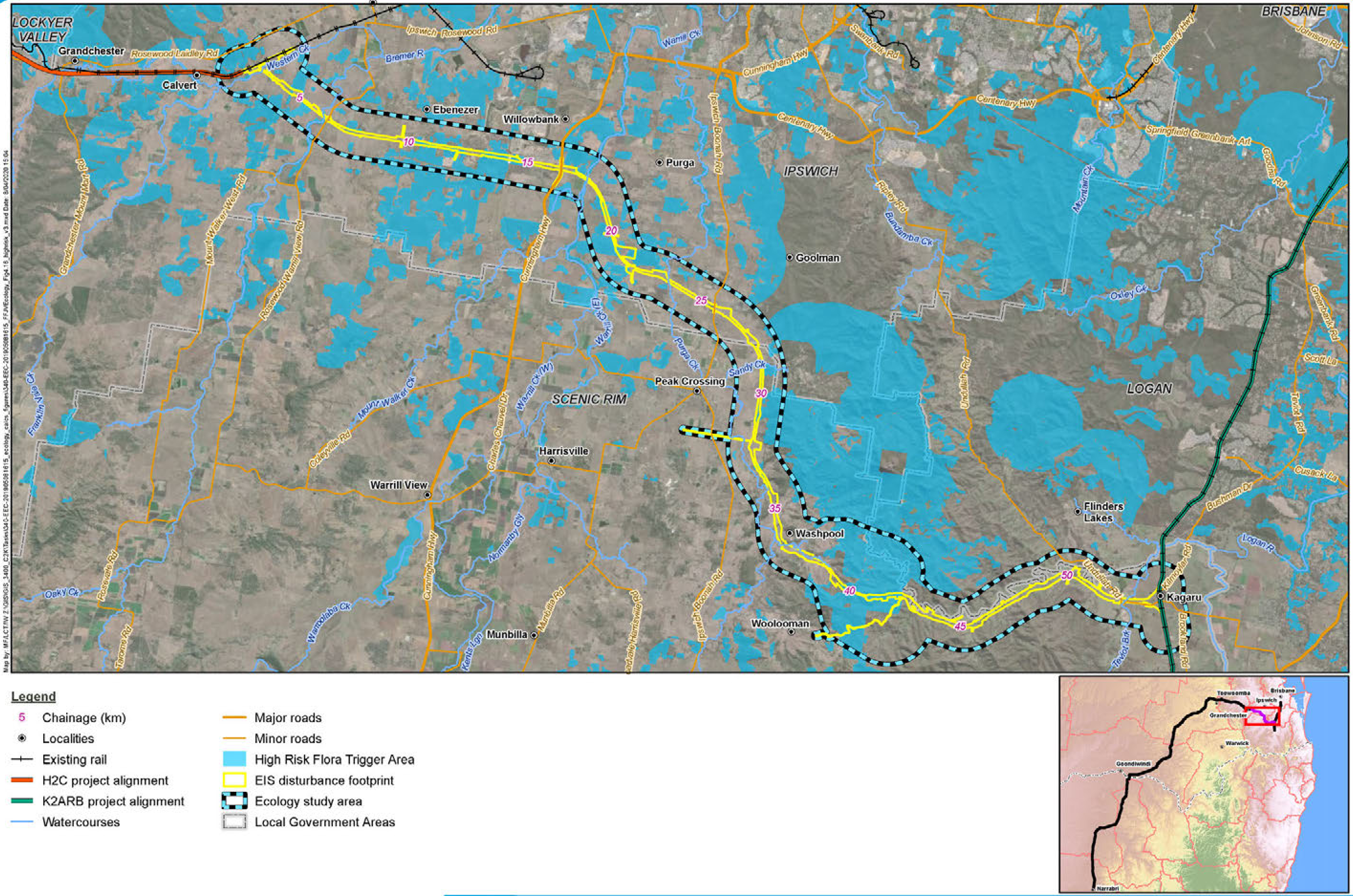


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Figure 4.16: High risk flora areas

4.5 Results of field assessments

This section 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.

4.5.1 Flora

4.5.1.1 Species richness

A total of 252 plant species were identified within the ecology study area during Project EIS field assessments. This included a total of 183 (72.5 per cent) native species, and 69 (27.5 per cent) non-native species (refer Appendix H and Appendix I).

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 identified 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 in particular have the potential to outcompete, replace and exclude native flora species within such environments.

4.5.1.2 NC Act conservation significant and special least concern flora species

Excluding MNES species, one conservation significant flora species, listed under the provision of the NC Act, was recorded within the ecology study area: Swamp tea-tree (*Melaleuca irbyana*). This species was particularly common within the fragmented landscapes of Ebenezer (to the east of Calvert) through to areas south of Purga towards Peak Crossing. Throughout this area, Swamp tea-tree grew in dense associations as part of Category B and C regulated vegetation associated with REs 12.3.18 and 12.9-10.11 (refer Photograph 4.1) as well as isolated individuals within an agricultural setting (refer Photograph 4.2). However, it is noted that whilst this species often grow as part of dense stands (refer to EIS Appendix K: Matters of National Environmental Significance Technical Report for further information related the Swamp Tea tree (*Melaleuca irbyana*) threatened ecological community), it also occurred as isolated individuals with fragmented and highly disturbed landscapes.

In addition, ten SLC flora species were observed throughout the ecology study area. Whist these species were relatively common, they were most abundant in areas associated with the Teviot Range. Table 4.23 summarises the conservation significant and SLC flora species identified during EIS field assessments. Figure 4.17 illustrates the location of observed conservation significant flora species (excluding MNES species). Information related to the occurrence of MNES flora species (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix K: Matters of National Environmental Significance Technical Report.

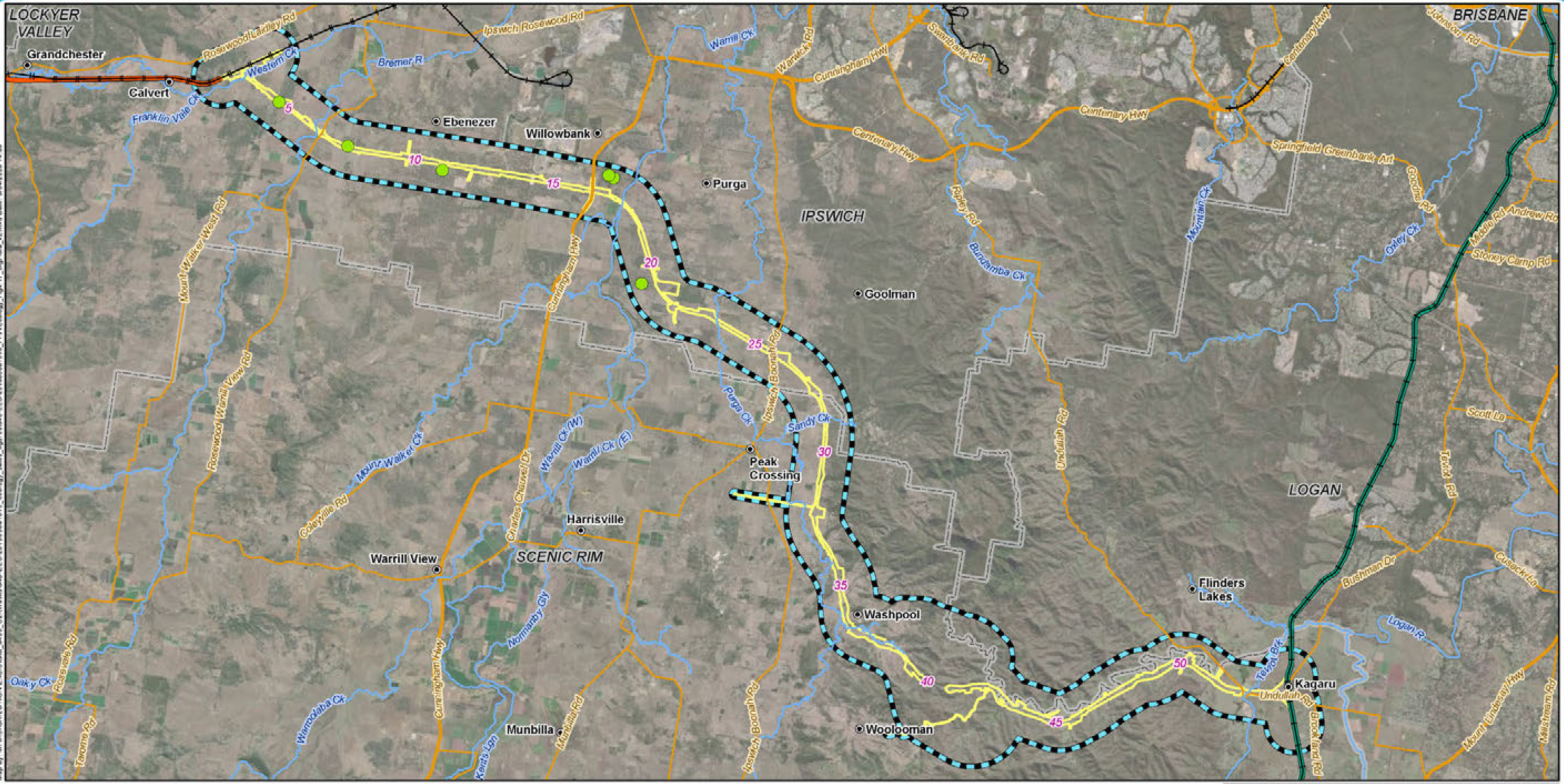
Field investigations also confirmed the presence of habitat, including:

- Slender Milkvine (*Marsdenia coronata*) – presence of moist areas of open forest, especially in eucalypt forest associated with the Teviot Range
- Bailey's cypress (*Callitris baileyi*) – the presence of rocky slopes, and hilly/mountainous areas, particularly within the Teviot Range
- Swamp tea-tree (*Melaleuca irbyana*) – presence of habitat in the form of flat areas that are periodically waterlogged on poorly draining, heavy clay soils.

The availability of habitat types and their relevance to MSES flora is discussed further in Section 4.5.3.

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

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



Map by: MFJ/AO/GN/LCT/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_calcs_figures\340-EEC-201905081615_FFJVEcology_Fig4.17_SigFlora_v2.mxd Date: 8/04/2020 14:35

Legend

- 5 Chainage (km)
- Localities

Significant Flora

- Melaleuca irbyana

- Existing rail
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads

- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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

Photograph 4.1 Swamp tea-tree (*Melaleuca irbyana*) growing as part of Category B regulated vegetation (Jacobs-GHD 2016a)

Photograph 4.2 Swamp tea-tree (*Melaleuca irbyana*) growing as an isolated tree within an agricultural setting (Eco Logical 2019)

Table 4.23 Conservation significant flora species observed within the ecology study area

Family	Species name	Common name	NC Act status
Adiantacae	*Adiantum hispidium*	Rough maidenhair fern	SLC
Adiantacae	*Cheilanthes sieberi*	Rock fern	SLC
Myrtaceae	*Melaleuca irbyana*	Swamp tea-tree	E
Orchidaceae	*Cymbidium canaliculatum*	Black orchid	SLC
Orchidaceae	*Dockrillia linguiformis*	Tongue orchid	SLC
Campanulaceae	*Lobelia purpurascens*	White root	SLC
Campanulaceae	*Wahlenbergia gracilis*	Sprawling bluebell	SLC
Malvaceae	*Brachychiton populneus*	Kurrajong	SLC
Menyanthaceae	*Nymphoides* sp.	floating heart	SLC
Nymphaeaceae	*Nymphaea* sp.	Lily pad	SLC
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	Johnson's grass tree	SLC

Table notes:

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

4.5.1.3 Weed species

The WildNet database search identified five Category 3 restricted matter flora species (under the Biosecurity Act) within the ecology study area (refer Appendix E). EIS field assessments identified an additional 24 restricted matters flora species (refer Table 4.24). Of the total restricted matters, 18 are listed as Weeds of National Significance (WoNS). A total of 69 introduced flora species were identified during the Project EIS field investigations (refer Appendix F and Appendix I). 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.

Table 4.24 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 ecology study area	Areas containing greatest densities within ecology study area
Anacardiaceae	*Schinus terebinthifolius*	Broadleaved peppertree	Category 3	No	Occasional to common	Riparian forest and bushland
Aristolochiaceae	*Aristolochia elegans*	Dutchman's pipe	Category 3	No	Uncommon	Riparian forest and bushland
Asparagaceae	*Asparagus africanus*	Asparagus fern	Category 3	Yes	Common	All areas containing bushland
Asparagaceae	*Asparagus asparagoides*	Bridal creeper	Category 3	Yes	Scattered presence	All areas containing bushland
Asteraceae	*Ambrosia artemislfolia*	Annual ragweed	Category 3	No	Uncommon	Riparian forest and bushland
Asteraceae	*Baccharis halimifolia*	Groundsel bush	Category 3	Yes	Common	Disturbed areas including grazing land
Asteraceae	*Parthenium hysterophorus*	Parthenium weed	Category 3	Yes	Uncommon	Disturbed areas including grazing land
Asteraceae	*Senecio madagascariensis*	Fireweed	Category 3	Yes	Common	Disturbed areas including grazing land
Basellaceae	*Anredera cordifolia*	Madeira vine	Category 3	Yes	Common	Riparian forest and bushland
Bignoniaceae	*Tecoma stans*	Yellow bells	Category 3	No	Uncommon	Riparian forest and bushland
Cactaceae	*Opuntia aurantiaca*	Tiger pear	Category 3	Yes	Uncommon	Disturbed areas including grazing land
Cactaceae	*Opuntia dillenii*	Prickly pear	Category 3	Yes	Uncommon	Disturbed areas including grazing land
Cactaceae	*Opuntia stricta*	Common pest pear	Category 3	Yes	Common	Disturbed areas including grazing land
Cactaceae	*Opuntia tomentosa*	Velvety tree pear	Category 3	Yes	Common	Disturbed areas including grazing land
Crassulaceae	*Bryophyllum delagoense*	Mother of millions	Category 3	Yes	Common, occasional to severe infestation	Disturbed areas including grazing land
Fabaceae	*Vachellia nilotica*	Prickly acacia	Category 3	Yes	Uncommon to common	Riparian forest, bushland and disturbed areas
Lauraceae	*Cinnamomum camphora*	Camphor laurel	Category 3	No	Common	Riparian forest and bushland
Oleaceae	*Ligustrum lucidum*	Broad-leaved privet	Category 3	No	Common	Riparian forest and bushland
Poacae	*Sporobolus fertilis*	Giant Paramatta grass	Category 3	Yes	Very common	Disturbed areas including grazing land
Poacae	*Sporobolus pyramidalis*	Giant rats-tail grass	Category 3	Yes	Common	Disturbed areas including grazing land
Pontederiaceae	*Eichhornia crassipes*	Water hyacinth	Category 3	Yes	Common	Farm dams
Salviniaceae	*Salvinia molesta*	Salvinia	Category 3	Yes	Common	Farm dams
Sapindaceae	*Cardiospermum grandiflorum*	Balloon vine	Category 3	No	Common	Riparian areas

Family name	Species name	Common name	Schedule 2 of the Biosecurity Act	Weeds of National Significance	Relative abundance within ecology study area	Areas containing greatest densities within ecology study area
Solanaceae	*Lycium ferocissimum*	African boxthorn	Category 3	Yes	Common	Disturbed areas including grazing land
Ulmaceae	*Celtis sinensis*	Chinese Celtis	Category 3	No	Occasional to common	Riparian forest and bushland
Verbenaceae	*Lantana camara*	Lantana	Category 3	Yes	Very common, occasional to severe infestation	Bushland
Verbenaceae	*Lantana montevidensis*	Creeping lantana	Category 3	No	Common, occasional to severe infestation	Bushland

Table notes:

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.

4.5.1.4 Aquatic flora

Aquatic flora species were relatively poorly represented (i.e. low diversity) within the ecology study area (refer Photograph 4.3, Photograph 4.4, Photograph 4.5 and Photograph 4.6).

The Project EIS field assessments identified nine aquatic flora species from the ecology study area (refer Table 4.25 and Appendix E). All aquatic species identified were generally common and widespread where suitable conditions for their colonisation were available (i.e. permanent water).

Photograph 4.3 Un-named waterway, upstream of the Project alignment displaying poor diversity of aquatic macrophytes

Photograph 4.4 Teviot Brook River over a road crossing illustrating the lack of aquatic flora

Photograph 4.5 Private rural farm dam illustrating the poor representation of aquatic flora

Photograph 4.6 Un-named waterway, at a proposed crossing location illustrating the poor diversity of aquatic flora species

Table 4.25 Aquatic flora identified within the ecology study area

Family name	Species name	Common name
Hydrocharitaceae	*Elodea* sp.	Canadian pondweed
Juncaceae	*Juncus* sp.	Rush
Plantaginaceae	*Callitriche* sp.	Starwart
Polygonaceae	*Persicaria* sp.	Knotweed
Menyanthaceae	*Nymphoides* sp.	Floatingheart
Nymphaeaceae	*Nymphaea* sp.	Lilypad
Potamogetonaceae	*Potamogeton sulcatus*	Pondweed

Family name	Species name	Common name
Potamogetonaceae	*Potamogeton crispus*	Curled pondweed
Salviniaceae	*Salvinia molesta*	Salvinia

4.5.2 Fauna

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

4.5.2.1 Species richness

Project EIS field investigations identified a total of 172 fauna species (refer Appendix F and Appendix J), including 164 (95.3 per cent) native species and eight (4.65 per cent) non-native species, six of which are restricted matters (refer Section 4.5.2.3). Recorded species consisted of 122 (70.93 per cent) birds, 24 (13.95 per cent) mammals, 16 (9.30 per cent) reptiles, five (2.91 per cent) amphibians and five (2.91 per cent) fish.

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.

4.5.2.2 NC Act conservation significant and special least concern fauna species

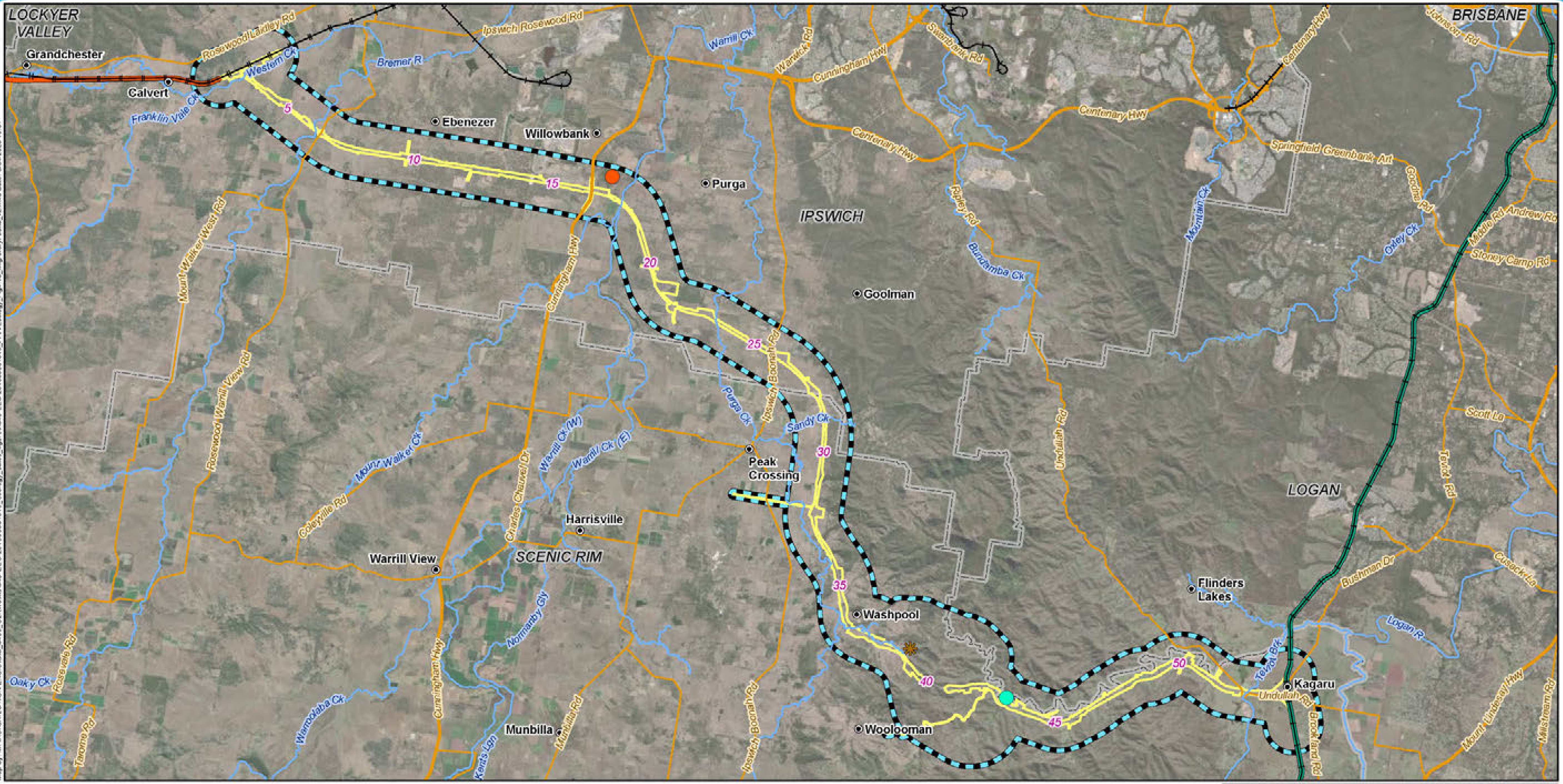
Excluding MNES, two conservation significant fauna species (i.e. Glossy-black cockatoo (*Calyptorhynchus latham*i) and Powerful owl (*Ninox strenua*)), were identified within the ecology study area. The Glossy-black cockatoo was identified during investigations undertaken by GHD-Jacobs (2016a) via the detection of unique feeding signs characteristic of the species (i.e. chewed fruit of *Allocasuarina* sp.) (refer Photograph 4.7 and Appendix F) and was associated with areas within and proximate to the Teviot Range. In addition, the Powerful owl was detected by AECOM (2010) during investigations associated with the SFRC, via call-playback sampling, and whilst the specimen was associated with the Teviot Range, the actual location of this record remains undefined.

Two migratory species were identified within the ecology study area during field investigations:

- Rufous fantail (*Rhipidura rufifrons*) – typically associated with forested areas and drainage lines on the Teviot Range
- Glossy ibis (*Plegadis falcinellus*) – typically associated with wetland areas

The location of observed NC Act threatened species (excluding MNES species) and EPBC Act listed migratory species provided in Figure 4.18.

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



Legend

- 5 Chainage (km)
- Localities
- Glossy ibis
- Rufous fantail

Glossy black-cockatoo observations

- Signs of feeding activity (ort)
- Existing rail
- H2C project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas

A3 scale: 1:150,000

0 1 2 3 4 5km

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

Field investigations also confirmed the presence of habitat (foraging and breeding) for migratory and conservation significant species, 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, larger open forest to woodland remnants associated with the Teviot Range and larger patches of Category C regulated vegetation
- 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 Teviot Range and along road reserves
- Powerful owl (*Ninox strenua*) – large tracts of forest or woodland within the Teviot Range, and large hollows and foraging habitat within more fragmented landscapes
- Echidna (*Tachyglossus aculeatus*) – occurrence of forests, woodlands and grasslands with areas suitable for breeding burrows.

The availability of habitat types and their relevance to MSES fauna is discussed further in Section 4.5.3.

This information was used to inform the predictive habitat modelling and mapping for each of the threatened and migratory fauna species (refer Appendix G for species habitat maps). Potential habitat for NC Act conservation significant and EPBC Act migratory fauna species is spread throughout the Project alignment but is typically associated with the Teviot Range.

It is noted that whilst all areas of the ecology study area were not accessible, information derived from historic and concurrent surveys (refer Table 3.3) 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 K: Matters of National Environmental Significance Technical Report.

Photograph 4.7 Feeding remnants (i.e. ort) indicative of the presence of a Glossy-black cockatoo identified within the ecology study area (Jacobs-GHD 2016a)

4.5.2.3 Invasive animals

Eight non-native fauna species, including six declared as restricted matters (invasive animals) under the Biosecurity Act, were identified within ecology study area during field investigations (refer Table 4.26 and Appendix F). 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 4.4.4 for further details).

Table 4.26 Non-native fauna species identified within the ecology study area

Family name	Species name	Common name	Restricted matter (Biosecurity Act)	Relative abundance within ecology study area
Bufonidae	*Rhinella marina*	Cane toad	No	Very common
Canidae	*Canis lupus familiaris*	Dog	Yes	Common
Suidae	*Sus scrofa*	Pig	Yes	Common
Canidae	*Vulpes vulpes*	Fox	Yes	Common
Leporidae	*Lepus europaeus*	European hare	Yes	Common
Leporidae	*Oryctolagus cuniculus*	European rabbit	Yes	Uncommon
Muridae	*Rattus rattus*	Black rat	No	Common
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	Yes	Very common

Table note:

Restricted matters = 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.

4.5.2.4 Aquatic fauna

The Project EIS field assessments identified six 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 of MNES fauna species (e.g. Australian lungfish (*Neoceratodus forsteri*)) (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix K: Matters of National Environmental Significance Technical Report.

Table 4.27 Aquatic fauna identified within the ecology study area

Family name	Species name	Common name
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish
Eleotriadae	*Hypseleotris galii*	Fire-tail gudgeon
Eleotriadae	*Hypseleotris klunzingeri*	Western carp gudgeon
Eleotridae	*Gobiomorphus australis*	Striped gudgeon
Poeciliidae	*Gambusia holbrooki*	Mosquitofish
Terapontidae	*Leiopotherapon unicolor*	Spangled perch

4.5.3 Predicted habitat for NC Act conservation significant and EPBC Act migratory flora and fauna species

Predictive habitat mapping for NC Act conservation significant and migratory species (refer Sections 3.3.4.1 and 3.3.4.2 and Appendix A) indicates that potential habitat for six conservation significant species (including one SLC mammal species), and 11 EPBC Act listed migratory species occurs within the ecology study area (refer Table 4.28 and Table 4.29 respectively). Predicted habitat mapping for NC Act conservation significant and EPBC Act listed migratory species is presented Appendix G. 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 matters of national environmental significance) within the ecology study area

Species name	Common name	NC Act status	Predicted habitat within the ecology study area (ha)* (12,442.24 ha)				Predicted habitat within the disturbance footprint (ha)* (972.49 ha)			
			Total habitat	General	Essential	Core	Total habitat	General	Essential	Core
NC Act conservation significant flora										
Callitris baileyi	Bailey's cypress	NT	**993.00**	993.00	0.00	0.00	**11.43**	11.43	0.00	0.00
Marsdenia coronata	Slender milkvine	V	**602.55**	602.55	0.00	0.00	**61.85**	61.85	0.00	0.00
Melaleuca irbyana	Swamp tea-tree	E	**3,254.61**	2,293.02	318.82	642.76	**237.73**	132.42	45.69	59.63
NC Act conservation significant fauna										
Adelotus brevis	Tusked frog	V	**104.91**	104.91	0.00	0.00	**10.21**	10.21	0.00	0.00
Calyptorhynchus lathami	Glossy-black cockatoo	V	**807.20**	786.61	20.59	0.00	**50.63**	49.96	0.68	0.00
Ninox strenua	Powerful owl	V	**204.29**	204.29	0.00	0.00	**21.54**	21.54	0.00	0.00
NC Act special least concern animals										
Tachyglossus aculeatus	Echidna	SLC	**2,147.34**	2,147.34	0.00	0.00	**67.64**	67.64	0.00	0.00

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 disturbance footprint.

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)* (12,442.24 ha)			Predicted habitat within the disturbance footprint (ha)* (972.49 ha)		
				Total habitat	Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat
EPBC Act migratory species									
Pandion haliaetus	Osprey	SLC	M	**592.72**	527.68	65.04	**42.43**	42.43	0.00
Cuculus optatus	Oriental cuckoo	SLC	M	**162.31**	157.06	5.25	**7.60**	7.60	0.00
Myiagra cyanoleuca	Satin flycatcher	SLC	M	**162.31**	157.06	5.25	**7.60**	7.60	0.00
Rhipidura rufifrons	Rufous fantail	SLC	M	**162.31**	157.06	5.25	**7.60**	7.60	0.00
Monarcha melanopsis	Black-faced monarch	SLC	M	**162.31**	157.06	5.25	**7.60**	7.60	0.00
Symposiachrus trivirgatus	Spectacled monarch	SLC	M	**162.31**	157.06	5.25	**7.60**	7.60	0.00
Motacilla flava	Yellow wagtail	SLC	M	**684.43**	521.02	163.41	**45.33**	42.43	2.90
Actitis hypoleucos	Common sandpiper	SLC	M	**684.43**	521.02	163.41	**45.33**	42.43	2.90
Calidris acuminata	Sharp-tailed sandpiper	SLC	M	**684.43**	521.02	163.41	**45.33**	42.43	2.90
Gallinago hardwickii	Latham's snipe	SLC	M	**684.43**	521.02	163.41	**45.33**	42.43	2.90
Plegadis falcinellus	Glossy ibis	SLC	M	**684.43**	521.02	163.41	**45.33**	42.43	2.90

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 disturbance footprint.

4.5.4 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. 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.

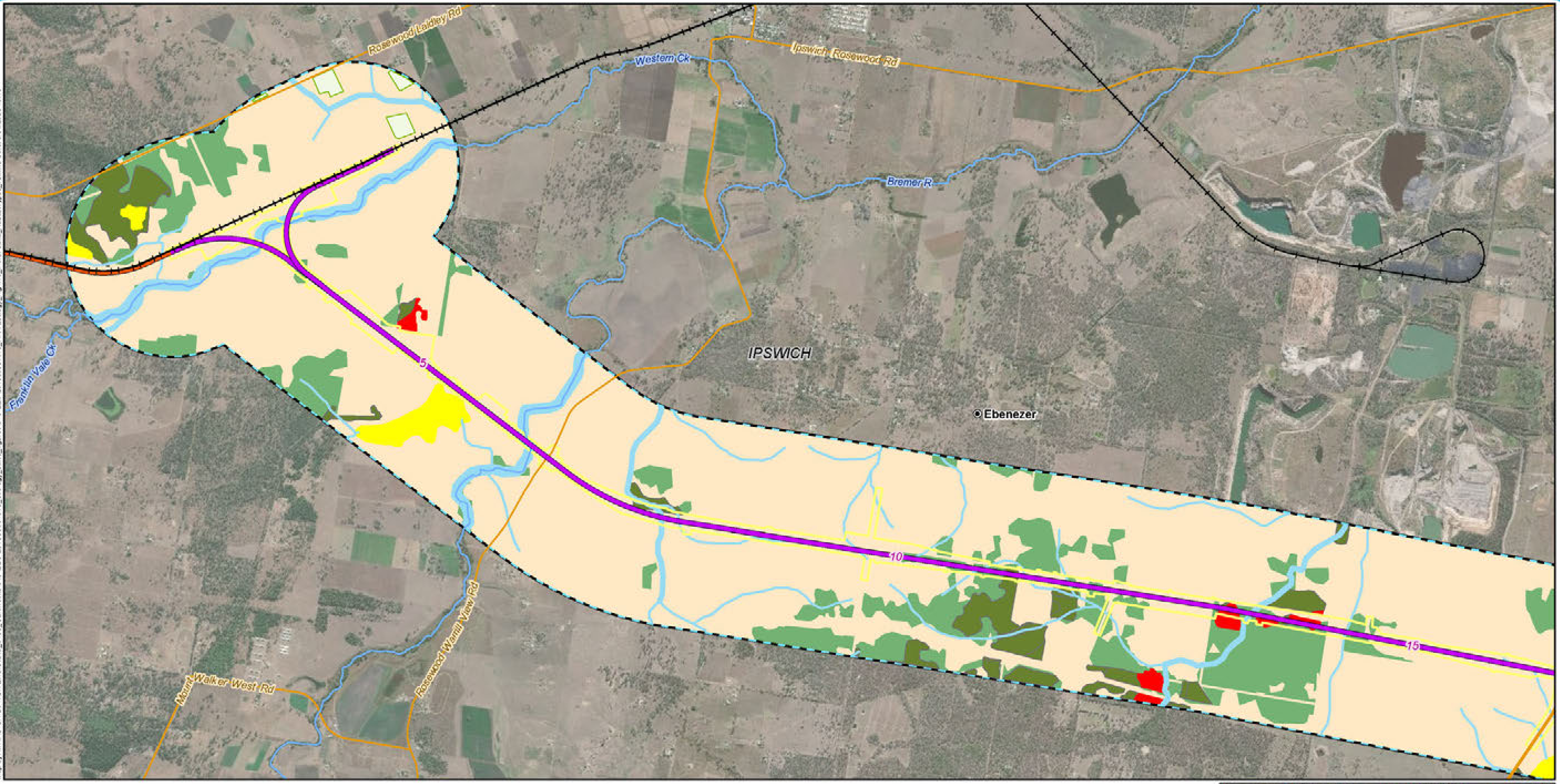
Mature eucalypt open forest and woodland is the dominant forest/woodland habitat type in the ecology study area. Areas of habitat ranged in size from small fragments less than 1 ha in size, which are often degraded as a result of cattle grazing and selective logging or thinning of trees leading to weed invasion and structural simplification, to larger tracts of forest/woodland with typically associated with steep topography (e.g. Teviot Range).

Each broad habitat type is discussed in further detail below and shown in Figure 4.19. An analysis of the quantity of fauna habitat contained within the ecology study area and within the disturbance footprint is presented in Table 4.30.

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

Habitat type (refer Figure 4.19)	Analogous REs (Category B regulated vegetation)	Extent (ha)	
		Ecology study area	Disturbance footprint
Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)	12.3.3, 12.3.3d, 12.3.19, 12.8.24, 12.9-10.2, 12.9-10.3, 12.9-10.7, 12.9-10.17, 12.9-10.17a, 12.9-10.27	1,025.45	11.17
Mature eucalypt riparian open forest and woodland	12.3.7, 12.3.7c	18.09	1.39
Araucarian notophyll/ microphyll and microphyll vine forest	12.9-10.16	4.34	0.00
Melaleuca low open woodland	12.3.18, 12.9-10.11	80.27	30.31
Wetlands	N/A - Defined by referable wetland layers	69.00	0.75
Grassland (modified non-remnant habitats)	N/A - Defined by aerial photography and ground-truthing	8,144.91	729.10
Riparian zones/waterways	N/A – defined by buffers to mapped waterways	1,050.08	73.44
Cultivated land (modified non-remnant habitats)	N/A - Defined by aerial photography and ground-truthing	332.09	32.36
Regrowth communities	N/A – defined by Category C regulated vegetation	1,690.39	93.87
No habitat present	N/A – defined by aerial photography. Areas such as quarried that would provide no functional habitat value	27.60	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



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Cultivated land
- Grassland
- Regrowth communities
- Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)
- Melaleuca low open woodland
- Riparian zones / waterways
- Wetlands

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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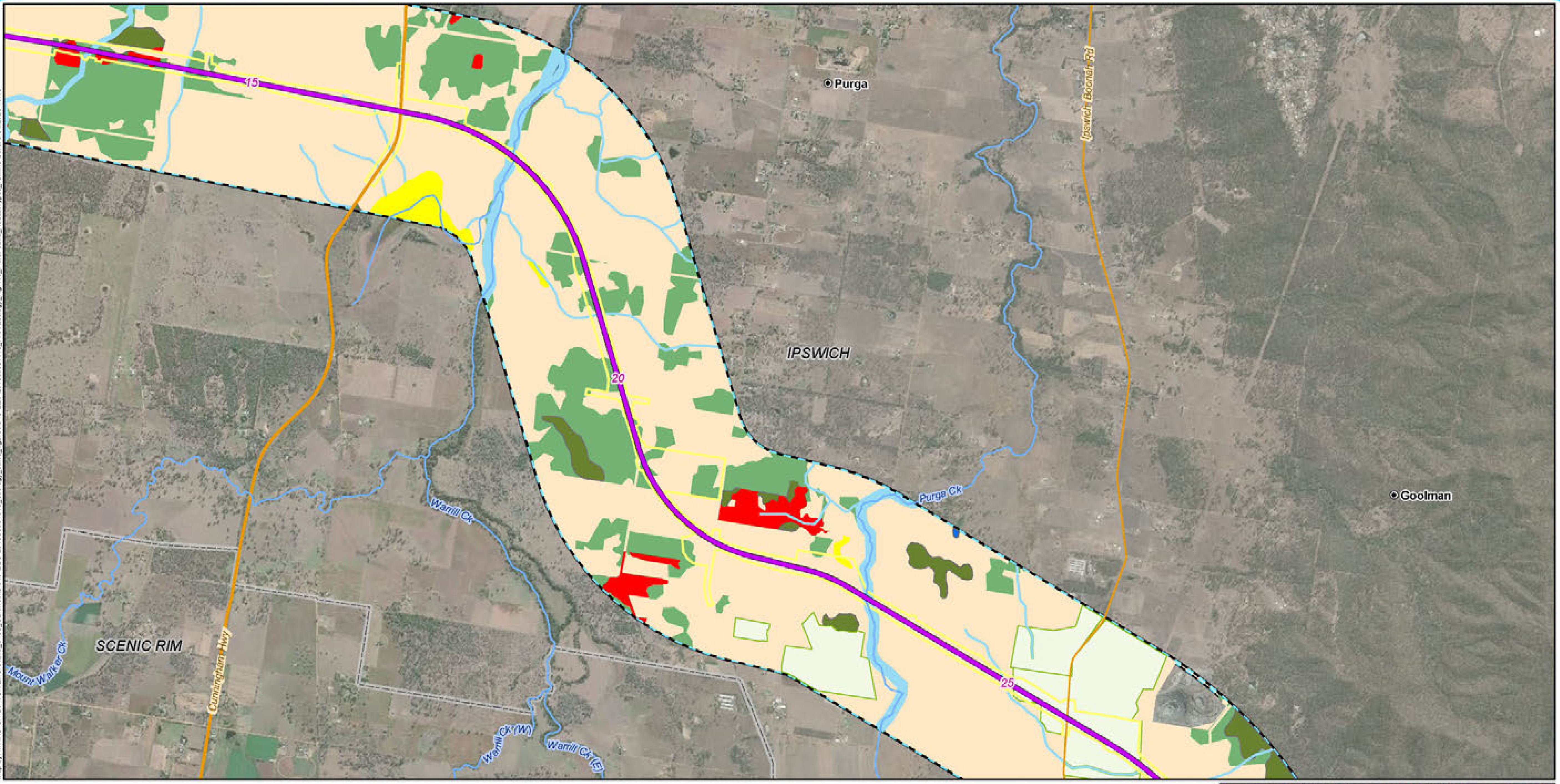
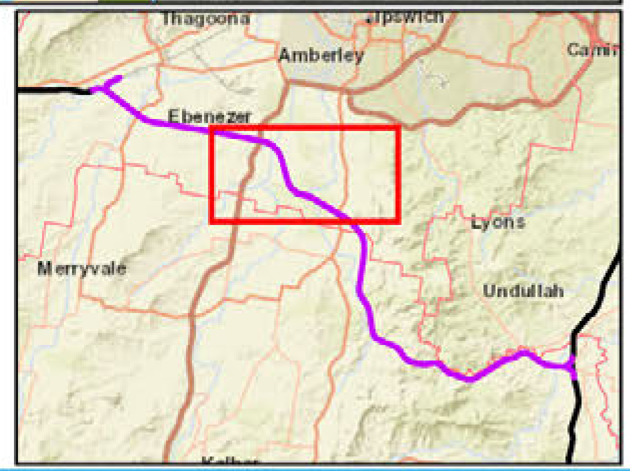
Calvert to Kagaru

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

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
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- 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

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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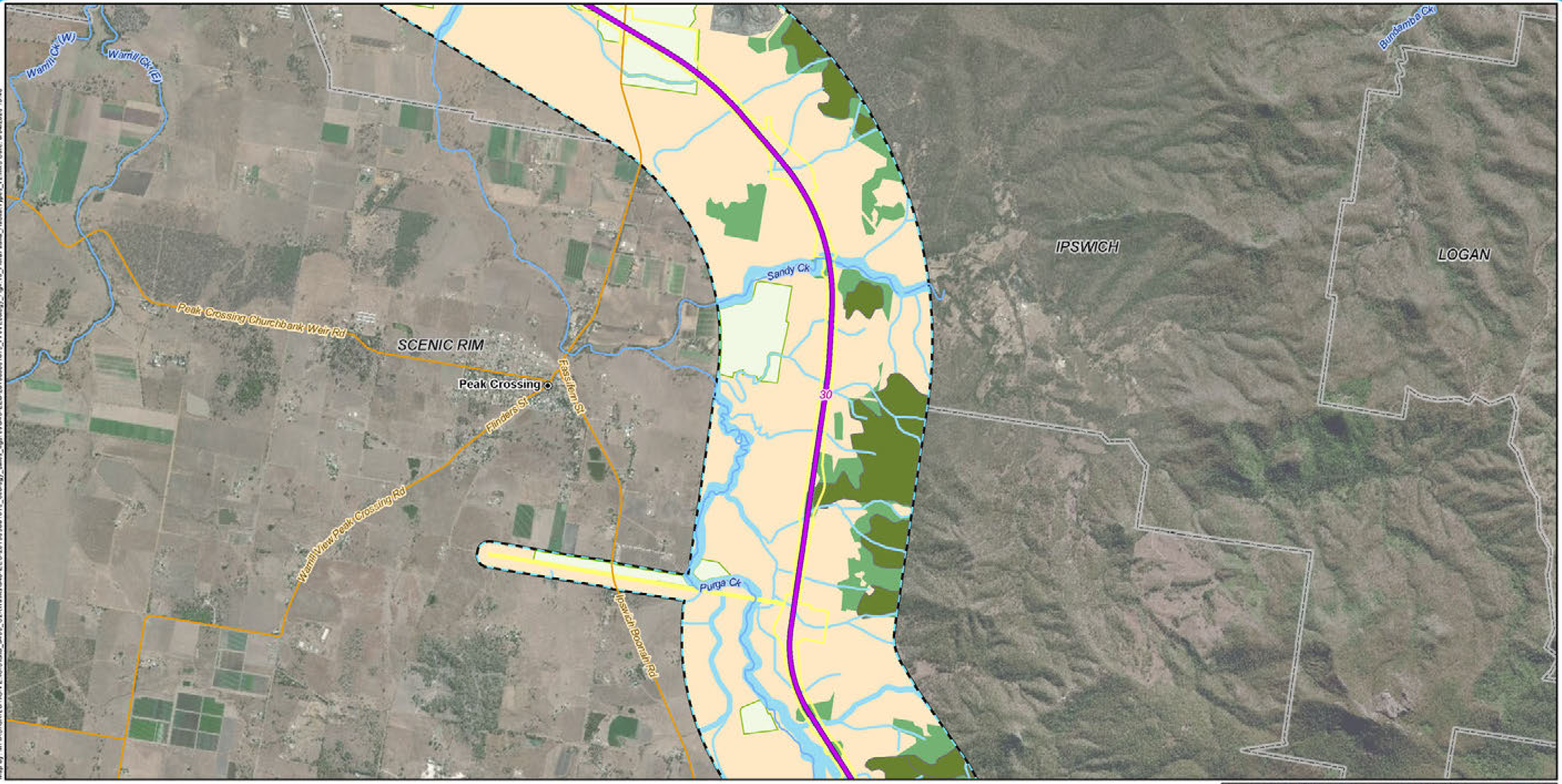
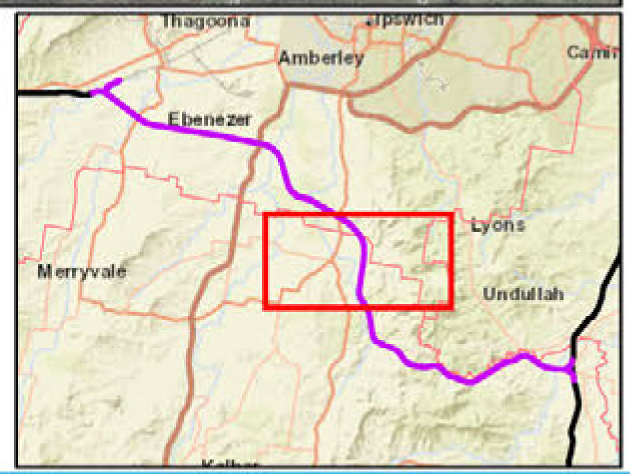
Figure 4.19b: Location of flora and fauna habitat types contained within the ecology study area derived from desktop assessments

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
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Cultivated land
- Grassland
- Regrowth communities
- Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on alluvial plains)
- Riparian zones / waterways

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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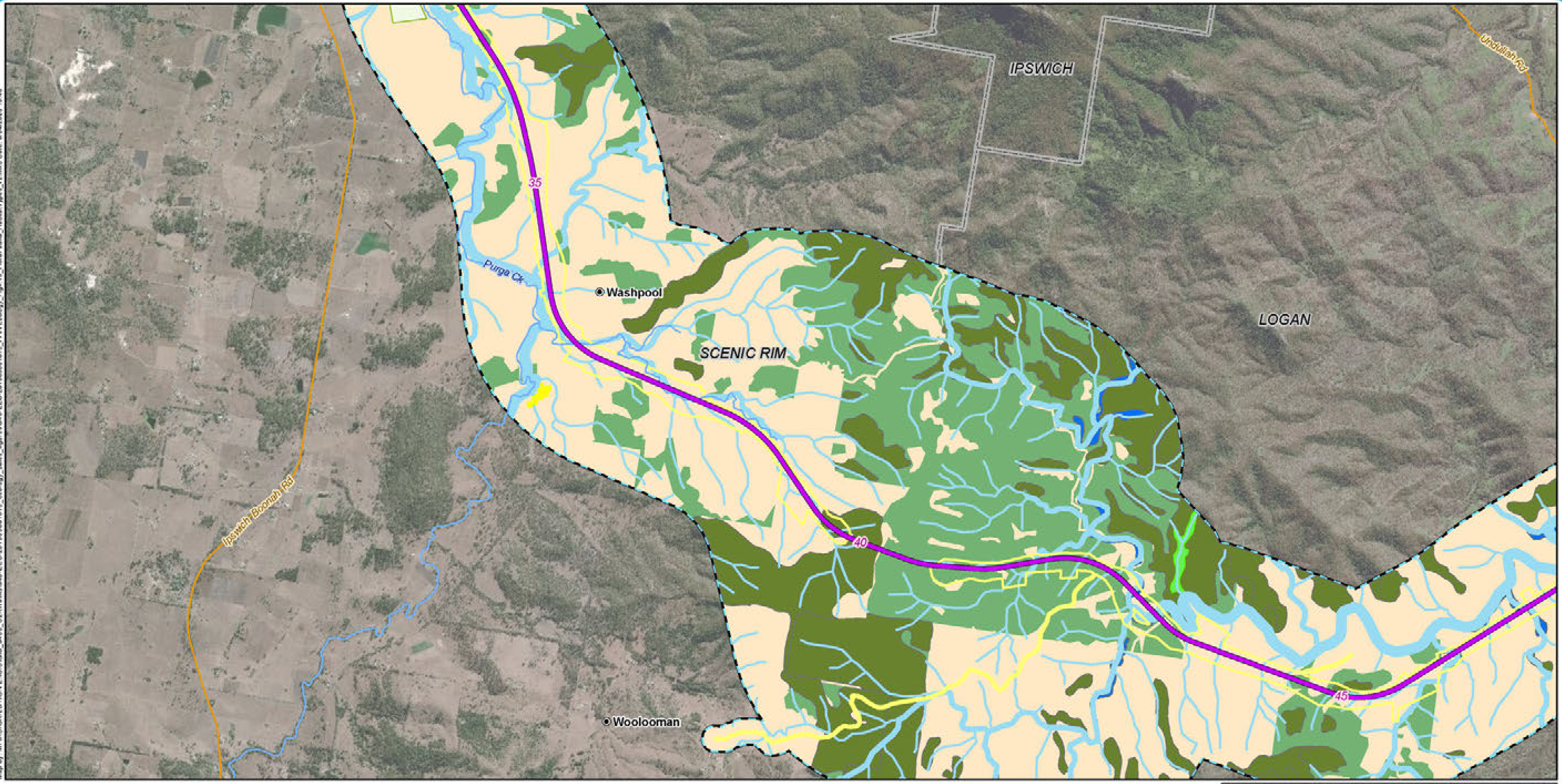
Figure 4.19c: Location of flora and fauna habitat types contained within the ecology study area derived from desktop assessments

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: MF/AD/GN/LCT/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_calcs_figures\340-EEC-201905081615_FFJV\Ecology_Fig4.19_FloraFauna_HabitatTypes_v2.mxd Date: 8/04/2020 15:48



Legend

- 5 Chainage (km)
- Localities
- C2K project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Araucarian notophyll/microphyll and microphyll vine forest
- 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

Note that due to topography constraints and the realignment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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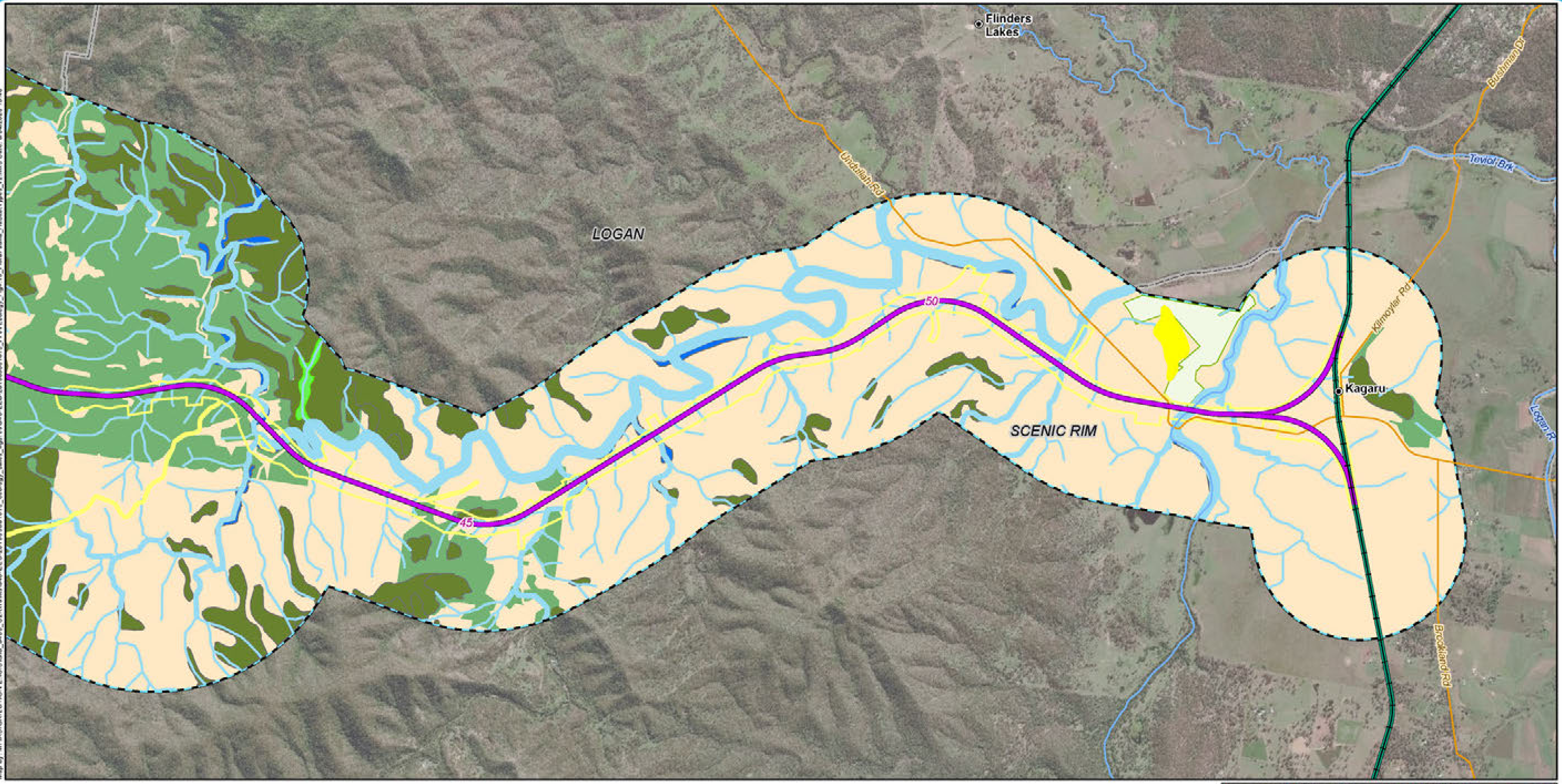
Calvert to Kagaru

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

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: MFJ/ADIGN/LCT/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EEC-201905081615_ecology_calcs_figures\340-EEC-201905081615_FFJ\Ecology_Fig4.19_FloraFauna_HabitatTypes_v2.mxd Date: 8/04/2020 15:48

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- K2ARB project alignment
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Araucarian notophyll/microphyll and microphyll vine forest
- 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

Note that due to topography constraints and the realignment of Wild Pig Creek Road and to minimise impacts on Dugandan Creek, there is a small area not within the disturbance footprint between Chainage 42 and 44.

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

Calvert to Kagaru

Figure 4.19e: Location of flora and fauna habitat types contained within the ecology study area derived from desktop assessments

1.1.1.1 Mature Eucalypt open forest and woodland

On sedimentary and igneous rocks

This habitat is dominant in the elevated areas associated with the Teviot range in the eastern portion of the ecology study area (refer Figure 4.19). Areas of mature eucalypt open forest and woodland on sedimentary and igneous rocks within the ecology study area include areas dominated by Narrow-leaved ironbark (*Eucalyptus crebra*), Grey gum (*Eucalyptus major*), White mahogany (*Eucalyptus acmenoides*), Grey ironbark (*Eucalyptus siderophloia*), Spotted gum (*Corymbia citriodora*), Brush box (*Lophostemon confertus*), and Swamp box (*Lophostemon suaveolens*) and coincides with the following REs: 12.8.24, 12.9-10.2, 12.9-10.3, 12.9-10.7, 12.9-10.17, 12.9-10.17a and 12.9-10.27 (refer Photograph 4.8 and Photograph 4.9 for images of this habitat type).

Photograph 4.8 Brush box/Swamp box dominated open forest in Teviot Range (Jacobs-GHD 2016a)

Photograph 4.9 Spotted gum dominated woodland with Lantana camara understorey

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 (logging, cattle grazing and vegetation thinning), to a complex vegetation structure with all strata (canopy, mid-storey and understorey) essentially intact. Invasive weeds including Lantana (*Lantana camara*) and Creeping lantana (*Lantana montevidensis*), and *Opuntia* species were noted as commonly occurring in this habitat with dense infestations noted in some areas.

Important microhabitat refugia provided by this habitat type includes rocky escarpments and outcrops, boulder piles, hollow logs and termitaria (arboreal and terrestrial). In addition, important nectar resources may be provided by myrtaceous species such as Grey ironbark and Spotted gum.

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 (on sedimentary and igneous rock) 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.

Areas of mature eucalypt open forest and woodland (on sedimentary and igneous rock) within the ecology study area may provide suitable habitat for a range of NC Act listed species including the Powerful owl (*Ninox strenua*), Glossy black-cockatoo (*Calyptorhynchus lathami*), Short-beaked echidna (*Tachyglossus aculeatus*), Slender Milkvine (*Marsdenia coronata*) and Bailey's cypress (*Callitris baileyi*) where the required microhabitat features are present. In addition, these areas may also provide important migratory habitat for EPBC Act listed migratory species such as Oriental cuckoo (*Cuculus optatus*), Satin flycatcher (*Myiagra cyanoleuca*), Rufous fantail (*Rhipidura rufifrons*), Black-faced monarch (*Monarcha melanopsis*) and the Spectacled monarch (*Symposiachrus trivirgatus*).

On alluvial plains

Areas of mature eucalypt open forest and woodland on alluvial plains largely occur within the ecology study area include areas dominated by Queensland bluegum (*Eucalyptus tereticornis*) and coincides with the following REs: 12.3.3, 12.3.3d and 12.3.19 (refer Photograph 4.10).

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 livestock use, and the understorey very sparse with an open canopy of large *Eucalyptus tereticornis*. However, mature eucalypt trees on alluvial plains are known to retain large hollows and provide important habitat. In particular, large *Eucalyptus tereticornis* are known to provide an important nectar source for species such as honeyeaters, parrots, flying foxes, gliders and insects and important shelter in the form of variable sized tree hollows. Threatened and migratory fauna species that may occur in eucalypt open forest and woodland on alluvial plains within the ecology study area include Powerful owl (*Ninox strenua*), Glossy black-cockatoo (*Calyptorhynchus lathami*), Short-beaked echidna (*Tachyglossus aculeatus*), Oriental cuckoo (*Cuculus optatus*), Satin flycatcher (*Myiagra cyanoleuca*) and the Rufous fantail (*Rhipidura rufifrons*).

Furthermore, during the wet season 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 ducks, geese, grebes, snipe, crakes, rails, egrets and herons. Migratory fauna species that may utilise flooded eucalypt open forest and woodland on alluvial plains include the Glossy ibis (*Plegadis falcinellus*).

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 4.10 Alluvial woodland dominated by Queensland blue gum and Grey gum in western alignment (Jacobs-GHD 2016a)

4.5.4.1 Mature eucalypt riparian open forest and woodland

Eucalypt riparian open forest and woodlands within the ecology study area include open forests and woodlands dominated by Queensland bluegum fringing drainage lines with associated species including *Melaleuca* spp., Moreton Bay ash (*Corymbia tessellaris*), *Angophora* spp. and River she-oak (*Casuarina cunninghamiana*) and coincides with the following REs: 12.3.7 and 12.3.7c (refer Photograph 4.11 and Photograph 4.12).

Photograph 4.11 Tall riparian forest on Woollaman Creek (upstream of alignment) in the Teviot Range (FFJV 2017)

Photograph 4.12 Degraded riparian forest at alignment crossing with *Lantana camara* dominant shrub layer (Jacobs-GHD 2016a)

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 often structurally complex at all strata levels and potentially supports the greatest fauna diversity per hectare. Nevertheless, these areas have been subject to high levels of disturbance in the past and currently from cattle grazing activity including caused by tree clearing (often to the edge of this habitat) and stock access to water. Weed infestation is often prominent and dense infestations of *Lantana camara* are common.

A range of fauna, including birds, mammals, and reptiles, 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. Threatened and migratory species that may occur in mature eucalypt riparian open forests and woodland include the Glossy black-cockatoo (*Calyptorhynchus lathami*), Satin flycatcher (*Myiagra cyanoleuca*), Black-faced monarch (*Monarcha melanopsis*), Spectacled monarch (*Symposiachrus trivirgatus*).

4.5.4.2 Araucarian notophyll/microphyll and microphyll vine forest

Araucarian notophyll/microphyll and microphyll vine forest within the ecology study area includes Araucarian notophyll/microphyll vine forest and microphyll vine forest. Within the ecology study area, this habitat occurs as a single patch in the Teviot Range. It does not occur within the disturbance footprint. Dominant species include Hoop pine (*Araucaria cunninghamiana*), Booyong (*Argyrodendron* sp.), Queensland kauri pine (*Agathis robusta)*, Carrol (*Backhousia myrtifolia*) and Tuckeroo (*Cupaniopsis parvifolia*). Areas of remnant Araucarian notophyll/microphyll and microphyll vine forest within the ecology study area are represented by RE 12.9- 0.16.

This habitat type typically occurs on the steep slopes of south-facing gullies with Cainozoic and Mesozoic sediments. Structural complexity is generally very high, with a closed shrub layer, sub-canopy and canopy, with or without emergent Hoop pine (*Araucaria cunninghamiana*). A broad range of microhabitat refugia are often present, including tree hollows, hollow logs, rock crevices, and dense vine thickets. Araucarian notophyll/microphyll and microphyll vine forest within the ecology study area provides habitat to forest-dependent fauna, which prefer dense, undisturbed habitat. Fruiting trees are often abundant, providing important foraging habitat for frugivorous birds and bats. Conservation significant and migratory species that may utilise Araucarian notophyll and microphyll vine forest within the ecology study area includes the Slender Milkvine (*Marsdenia coronata*), Rufous fantail (*Rhipidura rufifrons*), Black-faced monarch (*Monarcha melanopsis*) and the Spectacled monarch (*Symposiachrus trivirgatus*).

4.5.4.3 Melaleuca low open woodland

Melaleuca low open woodland within the ecology study area includes low open woodland and tall shrubland dominated by Swamp tea-tree (*Melaleuca irbyana*). Areas of remnant *Melaleuca* low open woodland within the ecology study area are represented by REs 12.9-10.11 and 12.3.18. Within this habitat type Swamp tea-tree forms a closed shrub layer or sub-canopy with a sparse understorey. An open canopy of emergent eucalypts (e.g. Queensland blue gum) is sometimes present. This habitat type provides foraging and nesting habitat for a range of bird 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. This habitat provides limited value for threatened and migratory fauna species but constitutes the primary habitat for the NC Act listed endangered Swamp tea-tree.

Photograph 4.13 Melaleuca low open woodland (adjacent to of alignment) in the vicinity of Purga (EMM 2018)

Photograph 4.14 Structural components of the Melaleuca low open woodland (Eco Logical 2018)

4.5.4.4 Wetlands

Wetland habitat within the ecology study area is generally limited in extent with some larger areas mapped in the western floodplain between Willowbank and Calvert and a riverine wetland area located near Kagaru.

Wetland habitats within the ecology study area include dams and reservoirs (lacustrine) (refer Photograph 4.15), wetlands associated with the floodplains of major watercourses (riverine) and vegetated swamps (palustrine) (refer Photograph 4.16). Anthropogenic wetlands (i.e. farm dams), which are abundant across agricultural landscapes, are included as they potentially provide suitable wetland alternatives for vertebrate fauna (including fish and turtles). 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*).

Palustrine wetlands within the ecology study area typically occur on alluvial floodplains and are dominated by grasses (*Poaceae*), rushes (*Restionaceae*) and sedges (*Cyperaceae*). Areas of remnant Palustrine wetland within the ecology study area are represented by RE 12.3.8.

Wetland habitats within the ecology study area are considered to provide suitable habitat for a variety of fish, amphibian, reptile (incl. turtles) and bird species. Larger palustrine-wetlands potentially provide important refuge habitat for many bird species, including migratory and dispersive species. Migratory species that may potentially use wetland areas include Yellow wagtail (*Motacilla flava*), Common sandpiper (*Actitis hypoleucos*), Sharp-tailed sandpiper (Calidris acuminata), Latham's snipe (*Gallinago hardwickii*), Osprey (*Pandion haliaetus*) and the Glossy ibis (*Plegadis falcinellus*).

No springs mapped on the Queensland wetland mapping layer (DES 2019) were identified within the ecology study area.

Photograph 4.15 Minimally vegetated farm dam located downstream of alignment

Photograph 4.16 Ephemeral swampland area within the ecology study area

4.5.4.5 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 (refer Photograph 4.17). 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 Rats-tail grass (*Sporobolus sp.*), Forest bluegrass (*Bothriochloa bladhii*), Blue grass (*Dichanthium sericeum*) and Blady grass (*Imperata cylindrica*).

Photograph 4.17 Typical non-native grassland occurring in ecology study area

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*), Blue grass (*Dichanthium sericeum*), Digitaria (*Digitaria divaricatissima*) and Pitted bluegrass (*Bothriochloa decipiens*). However, exotic pasture grasses sometimes occur, such as Rhodes grass (*Chloris gayana*).

Non-native and native derived grasslands are considered as one fauna habitat type due to similarities in structure and floristics. Grassland is the most extensive fauna habitat within the ecology study area and is typically located on alluvial floodplains and creek flats. These grassland habitats are commonly utilised for agricultural purposes, including livestock grazing and fodder harvesting.

Grasslands within the ecology study area provide 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. Grasslands may provide important habitat or refuge for migratory bird species when flooded.

4.5.4.6 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. When water temperature increases dissolved oxygen levels decrease, creating conditions which are difficult to endure for poikilothermic animals whose metabolic rates may exceed available oxygen in the rising temperatures. More sunlight in the riparian zone also increases the growth of soft leaved vigorous weeds and algae that can choke the stream channel.

In addition, riparian zones within the ecology study area are highly variable in condition due to the impacts of surrounding land use, weed invasion (particularly *Lantana camara*), cattle access and erection of man-made infrastructure (refer Photograph 4.18 and Photograph 4.19). Healthy examples of this community typically contain well developed vegetation communities and complex structural components (i.e. well-developed canopy, sub-canopy, shrub and ground layers) which provides important habitat for smaller species such as insectivorous birds, reptiles and mammals. In addition, proximity to permanent water sources also increases the importance of these areas as habitat.

Vegetation associated with riparian zones provides an important role in facilitating fauna movement in otherwise fragment environments and as such are pivotal in the movement of genetic material within populations and ecosystems and ensures correct ecosystem function and processes are maintained. These areas have the potential to provide habitat to species such as the Tusked frog *(Adelotus brevis*).

Photograph 4.18 Riparian community with limited structure at large pool at Warrill Creek at alignment crossing

Photograph 4.19 Regrowth eucalypt community in Teviot Range with dense understorey of *Lantana camara*

4.5.4.7 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. Cultivated land typically occurs in low-lying areas on fertile clays and provides habitat for generalist bird species such as Torresian crow (*Corvus orrus*), 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*).

4.5.4.8 Regrowth communities

Areas of regrowth vegetation are present throughout the ecology study area but with concentrations in the western section of the Teviot Range and lands in the Ebenezer to Purga areas. Extant patches of regrowth vegetation within the ecology study area are typically in poor ecological condition, suffering from extensive weed invasion and disturbance from cattle grazing practices. However, in instances where patches contain mature larger trees with hollows, the ecological value of these areas significantly increases. 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. Where large, isolated hollow bearing trees are present, these features may provide nesting and denning sites for arboreal mammals and birds.

4.5.5 Aquatic physical habitat values and species diversity

The ecological site values at the 16 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. 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 (refer Figure 3.3)	Waterbody	Habitat assessment score	Category
C2K 1A	Western Creek	57.5%	Fair
C2K 1A (alt)	Western Creek	51.5%	Fair
C2K 2A	Bremer River	62.5%	Fair
C2K 3A	Warrill Creek	70%	Fair
C2K 5A	Impoundment	41.5%	Poor
C2K 5A (alt)	Un-named watercourse	47%	Poor
C2K 6A	Un-named tributary of Purga Creek	45.5%	Poor
C2K 7A	Dugandan Creek	50.5%	Fair
C2K 7A (alt)	Un-named watercourse	60.5%	Fair
C2K 8A	Dugandan Creek	55%	Fair
C2K 9A	Woollaman Creek	56%	Fair
C2K 10A	Teviot Brook	55%	Fair
C2K 11A	Impoundment	43%	Poor
C2K 12A	Un-named watercourse	43%	Poor
C2K 13A	Un-named tributary of Purga Creek	51%	Fair
C2K 14A	Un-named tributary of Purga Creek	48%	Fair

A description and photograph of this each of the sampling locations is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

4.5.5.1 C2K 1A - Western Creek

Overview

C2K 1A sampling location is located on Western Creek, at the proposed alignment waterway crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 1A, the site habitat assessment scored 57.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 1A was compromised due to poor bank stability and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.32 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 1A.

Table 4.32 C2K 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)	17
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	8
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20

Habitat variable	Condition category	Score
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	Good: The bends in the stream length two to three times longer than if it was in a straight line	11
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60 to 100% of bank has erosional scars	Left bank: 1 Right bank: 1
Vegetation protection	Good: 70 to 90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 7 Right bank: 7
Riparian zone score	Good: Width or riparian zone 12 to 18 m; human activities have impacted the riparian zone only minimally	Left bank: 6 Right bank: 6
Total low gradient stream habitat score		**115/200** **Fair** **(57.5%)**

Site characteristics

The C2K 1A assessment reach did not have any distinct bedform features as the creek was dry.

The assessment reach was characterised by a deepened '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 steep bank slope (i.e. between 60° and 80°) and the right bank a moderate slope (i.e. between 30° and 60°). Bank stability was potentially affected by cleared vegetation adjacent to the riparian zone, stock access, human access and feral animals. People exclusion fencing was present as an artificial bank protection measure but part of the fence adjacent to the road was missing, showing signs of major damage to the bank from cattle.

The creek bed within the assessment reach was considered to have a 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, there was no water present, therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have no fish passage at base and low flow, and a very restricted fish passage at high flow. There were no identified barriers to fish movement and no bars present within the assessment reach.

The assessment reach did not support macrophyte vegetation. 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' due to the surrounding land use, proximal to the riparian vegetation. The riparian vegetation (excluding grass cover) occurred as continuous vegetation on the left bank and the 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 50 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 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 80 per cent native vegetation and 20 per cent exotic vegetation.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing, adjacent road and banks badly damaged by cattle.

4.5.5.2 C2K 1A (alt) - Western Creek

Overview

C2K 1A (alt) sampling location is located on Western Creek, downstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 1A (alt), the site habitat assessment scored 51.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 1A (alt) 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 (low gradient stream) for assessment site C2K 1A (alt).

Table 4.33 C2K 1A (alt) 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)	16
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	Fair: Shallow pools much more prevalent than deep pools	5
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.	2
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	18
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 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 to 100% of bank has erosional scars	Left bank: 2 Right bank: 2
Vegetation protection	Good: 70 to 90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 7 Right bank: 7
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		**103/200** **Fair** **(51.5%)**

Site characteristics

Majority of the C2K 1A (alt) assessment reach was dry and approximately 40 per cent was defined by bedform features, including a pool area where the stream widens or deepens and current declines.

The assessment reach was characterised by a deepened 'U' shaped channel which had channel modifications present, associated with reinforcements at the bridge. The left and right banks of the assessment reach had a convex shape with a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and a road crossing. Artificial bank protection measures present include a timber wall present associated with the present bridge.

The creek bed within the assessment reach was considered to have a low compaction, 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 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 was considered to have no fish passage at base and low flow, and moderately restricted at high flow. Barriers to fish movement included litter (tyres and metal drums) and debris that has raised the creek bed by approximately 1 m. 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' due to the surrounding land use, proximal to the riparian vegetation. The riparian vegetation (excluding grass cover) occurred as 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 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 60 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 70 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 90 per cent native vegetation and 10 per cent exotic vegetation. Riparian shading of the assessment reach was more than 75 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

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

4.5.5.3 C2K 2A - Bremer River

Overview

C2K 2A sampling location is located on the Bremer River, at the proposed Project alignment waterway crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 2A, the site habitat assessment scored 62.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 2A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.34 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 2A.

Table 4.34 C2K 2A 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)	19
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	Fair: Shallow pools much more prevalent than deep pools	10
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	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Channel sinuosity	Good: The bends in the stream length 2 to 3 times longer than if it was in a straight line	13
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 5 Right bank: 5
Vegetation protection	Good: 70 to 90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 8 Right bank: 8
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		**125/200** **Fair** **(62.5%)**

Site characteristics

The C2K 2A assessment reach bedform features were not definitive as the creek bed was dry.

The assessment reach was characterised by a deepened 'U' shaped channel which had channel modifications present, associated with a barbed wire fence across the channel. The left and right banks of the assessment reach had a concave shape with a flat bank slope (i.e. less than 10°). Bank stability was potentially affected by cleared vegetation, stock access, human access and feral animals. Artificial bank protection measures were present in the form of a dam wall.

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 creek bed was dry, therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have no fish passage at base and low flow and fish passage would be moderately restricted at high flow. Barriers to fish movement include the barbed wire fence across the channel. There were no bars present within the assessment reach.

The assessment reach did not support macrophyte vegetation. Approximately 30 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 60 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 90 per cent native vegetation and 10 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 per cent and 75 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing in an adjacent paddock. No stock were visible at the site at the time of assessment, however signs of stock accessing the reach were noted.

4.5.5.4 C2K 3A - Warrill Creek

Overview

C2K 3A sampling location is located on Warrill Creek, at the proposed Project alignment waterway crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 3A, the site habitat assessment scored 70 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 3A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.35 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 3A.

Table 4.35 C2K 3A 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)	20
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	20
Pool variability	Fair: Shallow pools much more prevalent than deep pools	10
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	Excellent: Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	16
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 to 2 times longer than if it was in a straight line	8
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 4 Right bank: 4

Habitat variable	Condition category	Score
Vegetation protection	Good: 70 to 90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 7 Right bank: 7
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		**140/200** **Fair** **(70%)**

Site characteristics

The C2K 3A 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 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, human access, feral animals and irrigation draw-down. There were no artificial bank protection measures 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 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 at baseflow or near baseflow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was clear.

The assessment reach was considered to have an unrestricted fish passage. No barriers to fish movement were identified and no bars present within the assessment reach.

Approximately 84 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Rush *(Juncus* sp.*)* and *Persicaria* sp. Submerged macrophyte vegetation included *Potamogeton sulcatus.* 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 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 60 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 were not present. Ground cover vegetation, including grass species, had a vegetative cover of approximately 40 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 90 per cent native vegetation and 10 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 per cent and 75 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing and water extraction.

4.5.5.5 C2K 5A - Impoundment

Overview

C2K 5A sampling location is located on a private dam, downstream of the Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 5A, the site habitat assessment scored 41.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 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 (low gradient stream) for assessment site C2K 5A.

Table 4.36 C2K 5A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10 to 30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	8
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	6
Pool variability	Fair: Shallow pools much more prevalent than deep pools	7
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	17
Channel flow status	Good: Water fill less than 75% of the available channel; on more than 25% of the channel substrate s exposed	13
Channel alteration	Poor: Banks shored with gabion or cement; over 80% of the stream reach channelised and disrupted. Instream habitat greatly altered or removed entirely	2
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance	0
Bank stability	Excellent: Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. Less than 5% of bank affected	Left bank: 9 Right bank: 9
Vegetation protection	Fair: 50 to 70% 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		**83/200** **Poor** **(41.5%)**

Site characteristics

The C2K 5A assessment reach bedform features were defined by a pool area.

The assessment reach was characterised by a widened channel shape which had channel modifications present in the form of dams and diversions. The left and right banks of the assessment reach had a concave shape with a flat bank slope (i.e. less than 10°). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and there was likely to be water pumped from the dam. Artificial bank protection measures were present in the form of an approximate 20 m section of concrete channel lining along the bank.

The bed substrate within the assessment reach was considered to have a 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 no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was clear.

The assessment reach was considered to have no fish passage and potentially very restricted at high flow as a result of the dam and potential overflow. Barriers to fish movement included the present dam. There were no bars present within the assessment reach.

Approximately 2 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Rush *(Juncus)* and *Persicaria* sp. Approximately 1 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 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 5 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 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 1 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 10 per cent native vegetation and 90 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing and a farm dam.

4.5.5.6 C2K 5A1 - Un-named watercourse

Overview

C2K 5A1 sampling location is located on an unnamed waterway, at the proposed Project alignment waterway crossing. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 5A1, the site habitat assessment scored 47 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 5A1 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 4.37 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 5A1.

Table 4.37 C2K 5A1 habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10 to 30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	10
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	16
Pool variability	Poor: Majority of pools small-shallow or pools absent	0

Habitat variable	Condition category	Score
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	18
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 one to two times longer than if it was in a straight line	8
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 3 Right bank: 3
Vegetation protection	Fair: 50 to 70% 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: 3 Right bank: 3
Riparian zone score	Fair: Width or riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal.	Left bank: 5 Right bank: 5
Total low gradient stream habitat score		**94/200** **Poor** **(47%)**

Site characteristics

The C2K 5A1 assessment reach did not have any visible bedform features present as the creek bed was dry.

The assessment reach was characterised by a deepened ‘U’ shaped channel which had 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°) on the left bank and the right bank a steep slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and a dam present downstream. No artificial bank protection measures are 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 therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have no fish passage present during low and base flow and was also considered to be partly restricted at high flow. Barriers to fish movement included the undulating terrain, sediment deposition within the creek and the road crossing fences. There were no bars present within the assessment reach.

The assessment reach did not support macrophytes vegetation. 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 regularly spaced 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 70 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 50 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 60 per cent native vegetation and 40 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 per cent and 75 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included the bed level crossing, grazing and fences along the creek width with debris caught within the structure.

4.5.5.7 C2K 6A - Un-named tributary of Purga Creek

Overview

C2K 6A sampling location is located on the UT Purga Creek, upstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 6A, the site habitat assessment scored 45.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 6A 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 (low gradient stream) for assessment site C2K 6A.

Table 4.38 C2K 6A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30 to 50% 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	15
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
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	3
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 to 2 times longer than if it was in a straight line	10
Bank stability	Poor: Unstable; many eroded areas; ‘raw’ areas frequent along straight sections and bends; obvious bank sloughing; 60 to 100% of bank has erosional scars	Left bank: 1 Right bank: 1

Habitat variable	Condition category	Score
Vegetation protection	Fair: 50 to 70% 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: 4 Right bank: 4
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		**91/200** **Poor** **(45.5%)**

Site characteristics

Majority of the C2K 6A assessment reach creek bed was dry but 10 per cent of the site had bedform features that 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 an infilled channel modifications present, associated with a reinforced bank with concrete for the road crossing. The left and right banks of the assessment reach had a concave shape with the left bank a steep bank slope (i.e. between 60° and 80°) and the right bank 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 crossing and associated culvert (approximately 30 cm in diameter). Artificial bank measures include a rock layer associated with the road crossing.

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 dislodged very easily. The sediment was matrix dominated, with less than 80 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, there were isolated pools but no water flow at the site. 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 was considered to have no fish passage at base and low flow and very restricted passage at high flow. Barriers to fish movement included the reinforced concrete pipe (RCP) culvert associated with the road crossing and the concrete lined channel up to the culvert and present blue rock. There were no bars present within the assessment reach.

The assessment reach did not support macrophyte vegetation. 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 ‘very 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 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 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 1 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 50 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 80 per cent native vegetation and 20 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing and the road crossing and associated culvert approximately 30 cm in diameter.

4.5.5.8 C2K 7A - Dugandan Creek

Overview

C2K 7A sampling location is located on Dugandan Creek, upstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 7A, the site habitat assessment scored 50.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 7A 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 4.39 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 7A.

Table 4.39 C2K 7A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30 to 50% 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	14
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
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	Fair: Water fills 25 to 75% 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 to 2 times longer than if it was in a straight line	9
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60 to 100% of bank has erosional scars	Left bank: 0 Right bank: 2
Vegetation protection	Fair: 50 to 70% 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: 4 Right bank: 4
Riparian zone score	Left bank: Fair: Width or riparian zone 6 to 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: 4 Right bank: 1
Total low gradient stream habitat score		**101/200** **Fair** **(50.5%)**

Site characteristics

The C2K 7A assessment reach bedform features were defined by a pool area where the stream widens or deepens and current declines. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

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 vertical bank slope (i.e. between 80° and 90°). Bank stability was potentially affected by cleared vegetation, stock access, human access and feral animals. There were no artificial bank protection measures present at site.

The creek bed within the assessment reach was considered to have a low compaction, with a limited range of sediment sizes, little overlapping, some packing and structure but 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 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 turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have no fish passage present at low and base flow with a moderately restricted passage at high flow. Barriers to fish movement and no bars present within the assessment reach.

Approximately 25 per cent of the assessment reach supported floating macrophyte vegetation. Macrophyte vegetation included *Potamogeton sulcatus.* 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 60 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 50 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 40 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 between 26 per cent and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing and a road adjacent to the creek.

4.5.5.9 C2K 7A (alt) - Un-named watercourse

Overview

C2K 7A (alt) sampling location is located on an unnamed waterway, upstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 7A (alt), the site habitat assessment scored 60.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 7A (alt) 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 4.40 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 7A (alt).

Table 4.40 C2K 7A (alt) 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)	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	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	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Channel sinuosity	Excellent: The bends in the stream increase the stream length three to four times longer than if it was in a straight line (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas).	18
Bank stability	Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 6 Right bank: 6
Vegetation protection	Fair: 50 to 70% 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: 4 Right bank: 4
Riparian zone score	Left bank: Good: Width or riparian zone 12 to 18 m; human activities have impacted the riparian zone only minimally. Right bank: Fair: Width or riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal.	Left bank: 7 Right bank: 5
Total low gradient stream habitat score		**121/200** **Fair** **(60.5%)**

Site characteristics

The C2K 7A (alt) assessment reach did not have any distinct bedform features, as the creek was dry.

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 moderate bank slope (i.e. between 30° and 60°). Bank stability was potentially affected by stock access, human access and feral animals. There were no artificial bank protection measures present.

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 a matrix filled contact framework, with 5 per cent to 32 pe cent fine sediment present with moderate availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, there was no water present and the creek bed was dry. There were therefore no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have no fish passage at low and base flow and very restricted passage during high flow. Barriers to fish movement included fences with a build-up of woody debris from previous flood events. There were no bars present within the assessment reach.

The assessment reach 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 'moderate 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 60 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 75 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 20 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 26 per cent and 60 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included native forest along the left and right banks. Local impacts noted at the assessment site included grazing, litter, anthropogenic debris such as plastic and corrugated iron sheets and a road adjacent to the creek.

4.5.5.10 C2K 8A - Dugandan Creek

Overview

C2K 8A sampling location is located on Dugandan Creek, at the proposed Project alignment crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 8A, the site habitat assessment scored 55 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 8A was compromised by disturbances to the poor bank stability and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.41 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 8A.

Table 4.41 C2K 8A 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)	16
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	16
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
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.	3
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 one to two times longer than if it was in a straight line	7
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 3 Right bank: 3
Vegetation protection	Fair: 50 to 70% 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 to 12 m; human activities have impacted the riparian zone a great deal.	Left bank: 5 Right bank: 5
Total low gradient stream habitat score		**110/200** **Fair** **(55%)**

Site characteristics

The extent of the C2K 8A assessment reach bedform features were defined by 10 per cent of the site depicting 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 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 people and livestock access and feral animals. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have a moderate level of compaction. The sediment was defined by a matrix filled contact framework, with 5 per cent to 32 per cent fine sediment present with moderate availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded. Within the assessment reach there were two distinct areas of rounded cobble, pebble and gravel, then a transition to boulder/bedrock.

At the time of assessment, there was no water flow and small isolated pools were present. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was opaque, with water clarity reduced by suspended material.

The assessment reach did not have a fish passage at base and low flow but was considered to have a moderately restricted passage at high flow. Barriers to fish movement included bedrock and boulder outcrops. There were no bars present within the assessment reach.

Approximately 6 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included *Persicaria* sp. and floating macrophytes included Lillypads *(Nympodia* 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 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 70 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 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 50 per cent native vegetation and 50 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 per cent and 25 per cent.

The left bank of the assessment reach was not covered by bedrock outcrops, and the right bank was approximately 15 per cent covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site were grazing.

4.5.5.11 C2K 9A - Woollaman Creek

Overview

C2K 9A sampling location is located on Woollaman Creek, upstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3

Following assessment of the condition and extent of habitat variables present at C2K 9A, the site habitat assessment scored 56 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 9A 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 (low gradient stream) for assessment site C2K 9A.

Table 4.42 C2K 9A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30 to 50% 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	13
Pool variability	Fair: Shallow pools much more prevalent than deep pools	7
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	18
Channel flow status	Good: Water fill less than 75% of the available channel; on more than 25% of the channel substrate s exposed	14
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelization, i.e. dredging (greater than 20 years) may be present, but recent channelization is not present	13
Channel sinuosity	Fair: The bends in the stream increase the stream one to two times longer than if it was in a straight line	7
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 4 Right bank: 4
Vegetation protection	Fair: 50 to 70% 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: 4 Right bank: 4
Riparian zone score	Left bank: Fair: Width of riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal Right bank: Good: Width of riparian zone 12 to 18 m; human activities have impacted the riparian zone minimally	Left bank: 4 Right bank: 8
Total low gradient stream habitat score		**112/200** **Fair** **(56%)**

Site characteristics

C2K 9A is situated within the Woollaman Creek system.

The C2K 9A 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, in the form of rock and concrete surrounding a bridge. The left and right banks of the assessment reach had a stepped shape with a moderate bank slope (i.e. between 30° and 60°). Bank stability was potentially affected by cleared vegetation, stock access, feral animals and cattle were noted drinking at the site. Rip rap was present along the bank as a bank protection measure.

The creek bed within the assessment reach was considered to have a low compaction with a limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment and 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 at baseflow or near baseflow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was clear.

The assessment reach was considered to have no fish passage at baseflow, very restricted passage at low flow and a moderately restricted passage at high flow. Bars were not present within the assessment reach.

Approximately 10 per cent of the assessment reach supported macrophytes. Emergent macrophyte vegetation included Rush (*Juncus* sp.) and floating macrophyte vegetation present were Starwart *(Callitriche* sp.). 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 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 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 15 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 50 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 40 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 50 per cent native vegetation and 50 per cent exotic vegetation. Riparian shading of the assessment reach was between 26 per cent and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

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

4.5.5.12 C2K 10A - Teviot Brook

Overview

C2K 10A sampling location is located on the Teviot Brook, at the proposed Project alignment crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 10A, the site habitat assessment scored 55 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 10A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.43 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 10A.

Table 4.43 C2K 10A 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	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	8
Pool variability	Fair: Shallow pools much more prevalent than deep pools	9
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	17
Channel flow status	Fair: Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	10
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 to 2 times longer than if it was in a straight line	6
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 3 Right bank: 3
Vegetation protection	Fair: 50 to 70% 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 of riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal	Left bank: 5 Right bank: 5
Total low gradient stream habitat score		**110/200** **Fair** **(55%)**

Site characteristics

The C2K 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 two-staged shaped channel which had reinforced and infilled channel modifications. The left and right banks of the assessment reach had a stepped 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 drawdown of water from construction trucks accessing water for the purposes of dust suppression works. Artificial bank measures were present in the form of a rock wall, fence structures and remains of a sediment fence were present.

The creek bed within the assessment reach was considered to have a low compaction, with a limited range of sediment sizes, little overlapping, some packing and structure, but can be dislodged very easily. The sediment was matrix dominated, with less than 60 per cent fine sediment and 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 no sediment oils but water oils were present from a visible sheen. Sediment odours or water odours were not present within the assessment reach. Water within the assessment reach was opaque, with water clarity reduced by suspended material.

The assessment reach was considered to have a very restricted fish passage that was potentially partly restricted at high flow. Barriers to fish movement included three round concrete pipe culverts, approximately 1 m in diameter each, and rock material downstream from the culvert which has slipped into the waterway. There were no bars present within the assessment reach.

Approximately less than 5 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Lillypads *(Nympodia* sp.*)*. Approximately 5 per cent of the assessment reach was covered several large degrading trees were present.

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 less than 5 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 50 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 35 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 70 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 between 26 per cent and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included a road and associated culvert. A truck was also present extracting water when at site.

4.5.5.13 C2K 11A - Impoundment

Overview

C2K 11A sampling location is located on a private dam (on Lockyer Creek), downstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 11A, the site habitat assessment scored 43 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 11A was compromised by disturbances artificial modifications to the watercourse (i.e. creation of a dam) and very limited integrity and cover of vegetation within the riparian zone.

Table 4.44 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 11A.

Table 4.44 C2K 11A habitat assessment (low gradient stream

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30 to 50% 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	13
Pool variability	Good: Majority of pools large-deep; very few shallow	14
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	Good: Water fill less than 75% of the available channel; on more than 25% of the channel substrate s exposed	14
Channel alteration	Poor: Banks shored with gabion or cement; over 80% of stream channelised and disrupted. Instream habitat instream habitat greatly altered or removed entirely	0
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance	0
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 5 Right bank: 5

Habitat variable	Condition category	Score
Vegetation protection	Poor: Less than 50% of the streambank surfaces covered by vegetation; disruption of stream vegetation	Left bank: 1 Right bank: 1
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: 0
Total low gradient stream habitat score		**86/200** **Poor** **(43%)**

Site characteristics

The C2K 11A assessment reach bedform features were defined by a pool area.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with a dam. The left and right banks of the assessment reach had a concave shape with a flat bank slope (i.e. less than 10°). Bank stability was potentially affected by cleared vegetation, human access, stock access and feral animals. The artificial bank protection measure present was the dam wall.

The bed substrate within the assessment reach was considered to have a low compaction, with a loose array of sediment sizes, no overlapping, no packing and structure, and can be easily dislodged with moderate. The sediment was matrix dominated, with less than 60 per cent fine sediment present 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 no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach clear.

There was no fish passage present at the assessment reach. Barriers to fish movement included the dam which completely disabled any fish movement up and down stream. There were no bars present within the assessment reach.

Approximately 30 per cent of the assessment reach supported macrophytes. Emergent macrophytes included Rush *(Juncus* sp.*)* and *Persicuria* sp., submerged macrophytes included Canadian pondweed *(Elodea* sp.*)* and floating macrophytes included *Nymphiodes* sp. There were no logs and branches greater than 10 cm in diameter present at the site.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'extreme disturbance'. The riparian vegetation (excluding grass cover) was absent from the left and right bank of the assessment reach. Regeneration of native canopy species was not applicable for the riparian zone. The riparian zone of the assessment reach did not support any vegetation but pastoral grasses. Riparian shading of the assessment reach was between less than 5 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included water extraction from the dam and grazing.

4.5.5.14 C2K 12A - Un-named watercourse

Overview

C2K 12A sampling location is located on the unnamed waterway, upstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 12A, the site habitat assessment scored 43 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 12A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion, sediment deposition and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.45 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 12A.

Table 4.45 C2K 12A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: 30 to 50% 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	Good: Mixture of soft sand, mud or clay; mud may be dominant some root mats and submerged vegetation present	13
Pool variability	Fair: Shallow pools much more prevalent than deep pools	10
Sediment deposition	Poor: Majority of pools small-shallow or pools absent	1
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 two to three times longer than if it was in a straight line	13
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60 to 100% of bank has erosional scars.	Left bank: 2 Right bank: 2
Vegetation protection	Fair: 50 to 70% 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: Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities Right bank: Fair: Width or riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal.	Left bank: 2 Right bank: 3
Total low gradient stream habitat score		**86/200** **Poor** **(43%)**

Site characteristics

The C2K 12A assessment reach was majority dry with approximately 5 per cent of the bedform features 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 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 stock access, human access and feral animals. There were no artificial bank protection measures 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 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 rounded.

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

The assessment reach did not have a fish passage at base and low flow but at high flow it was moderately. Barriers to fish movement included material from eroded banks due to stock access creating barriers. Pipes along the width of the creek were also present with an artificial bank approximately 2 m high. There were no bars present within the assessment reach.

The assessment reach 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 '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 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 5 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 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.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use and impacts along the assessment reach included cleared and modified landscapes for grazing along the left and right banks.

4.5.5.15 C2K 13A - Un-named tributary of Purga Creek

Overview

C2K 13A sampling location is located on the un-named tributary of Purga Creek, at the proposed alignment crossing location. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 13A, the site habitat assessment scored 51 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K 13A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion.

Table 4.46 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 13A.

Table 4.46 C2K 13A 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)	16
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	16
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% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	5

Habitat variable	Condition category	Score
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 one to two times longer than if it was in a straight line	10
Bank stability	Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60 to 100% of bank has erosional scars.	Left bank: 1 Right bank: 1
Vegetation protection	Fair: 50 to 70% 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: 3 Right bank: 3
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: 1
Total low gradient stream habitat score		**102/200** **Fair** **(51%)**

Site characteristics

The C2K 13A 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 and infilled channel modifications present, associated with the road crossing. The left and right banks of the assessment reach had a concave shape with the left bank depicting a moderate bank slope (i.e. between 30° and 60°) and the right bank a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, road crossing and associated bridge, feral animals a high level of stock animals accessing the water and contributing to overall bank erosion. A rock layer was present associated with the road crossing as an artificial bank measure and concrete channel lining was also present.

The creek bed within the assessment reach was considered to have a packed, unarmoured compaction, with an array of sediment sizes, little overlapping, tightly packed but can be dislodged with moderate effort. The sediment was defined by an open framework, with 0 per cent to 5 per cent fine sediment, high 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 clear.

The assessment reach was considered to have no fish passage but potentially a moderately restricted passage at high flow. Barriers to fish movement included the road crossing and small culvert, sediment deposition forming barriers and rocks along the banks. There were no bars present within the assessment reach.

Approximately 75 per cent of the assessment reach supported macrophytes vegetation. Emergent macrophytes included Rush *(Juncus* sp.*)* and submerged macrophytes included Pondweed *(Potamogeton* sp.). 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 '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 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 5 per cent within the riparian zone of the assessment reach and shrubs were not present. 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 pers cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 26 per cent and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included the road crossing and associated culvert. The culvert was approximately 30 cm in diameter.

4.5.5.16 C2K 14A - Un-named tributary of Purga Creek

Overview

C2K 14A sampling location is located on un-named tributary of Purga Creek, downstream of the proposed Project alignment. A description and photograph of this site is provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Following assessment of the condition and extent of habitat variables present at C2K 14A, the site habitat assessment scored 48 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of C2K14A was compromised by disturbances to the poor bank stability and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.47 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site C2K 14A.

Table 4.47 C2K 14A 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)	16
Pool substrate characterisation	Excellent: Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	16
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	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	7
Channel sinuosity	Fair: The bends in the stream increase the stream one to two times longer than if it was in a straight line	8
Bank stability	Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 3 Right bank: 3
Vegetation protection	Fair: 50 to 70% 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	Left bank: Good: Width or riparian zone 12 to 18 m; human activities have impacted the riparian zone only minimally. Right bank: Fair: Width or riparian zone 6 to 12 m; human activities have impacted the riparian zone a great deal.	Left bank: 8 Right bank: 5
Total low gradient stream habitat score		**96/200** **Fair** **(48%)**

Site characteristics

The C2K 14A assessment reach did not have any distinct bedform features as the creek bed was dry.

The assessment reach was characterised by a box shaped channel which had channel modifications present in the form of concrete and rock associated with Allans Road crossing. The left bank of the assessment reach had a concave shape with a steep bank slope (i.e. between 60° and 80°) and the right bank of the assessment reach had a convex shape, also with a steep bank slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation, stock access, human access, feral animals and a bed level crossing with six associated box culverts. Artificial bank protection measures were present in the form of concrete and rock reinforcement along the road crossing.

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 defined by a matrix filled contact framework, with 5 per cent to 32 per cent fine sediment present with moderate 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, therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have a very restricted fish passage at low and base flow and partly restricted passage at high flow. Barriers to fish movement included an approximate 1 m height to the road crossing and the six box culverts with debris caught within the culverts. There were no bars present within the assessment reach.

The assessment reach 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 75 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 70 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 30 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 26 per cent and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared and modified landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included grazing and the bed level crossing and six associated culverts.

4.5.6 Field assessment surface water quality results

The baseline water quality results for the assessments are provided in Table 4.48.

Table 4.48 Baseline water quality results for Project water quality monitoring sites

Site	Date	pH	EC (µs/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)
Logan River catchment								
Logan River WQO	**-**	**6.5 – 8.0**	**< 780**	**n/a**	**< 10**	**n/a**	**n/a**	**85 – 110**
8A Dugandan Creek	27/09/2017	7.04	-	20.5	11.4	-	-	-
	28/02/2018	7.47	232.5	23.4	108	0.11	7.33	86.8
	13/03/2019	Dry at time of sampling						
9A Woollaman Creek	25/09/2017	7.83	-	25.0	10.2	-	-	-
	27/02/2018	7.59	176.3	24.5	88	0.08	7.09	85.1
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)						
10A Teviot Brook	25/09/2017	6.93	-	18.5	10.2	-	-	-
	27/02/2018	6.85	78.3	26.1	90	0.03	0.9	16
	13/03/2019	7.52	2,775	27.2	7.8	1.37	5.55	71.5
11A Dam	25/09/2017	7.4	-	22.4	7.2	-	-	-
	27/02/2018	6.85	78.3	26.1	90	0.03	0.9	16
	13/03/2019	No access to site at sampling						
12A Un-named watercourse	28/09/2017	7.51	-	19	11.5	-	-	-
	28/02/2018	7.54	202.6	24.7	101.1	0.1	7.5	92
	13/03/2019	Dry at time of sampling						
Bremer River catchment								
Western Creek/ Bremer River WQO	**-**	**6.5 – 8.0**	**< 770**	**n/a**	**< 17**	**n/a**	**n/a**	**85 – 110**
1A alt Western Creek	29/09/2017	7.49	-	18	5.9	-	-	-
	2/03/2018	7.82	338.4	25.5	76.2	0.16	3.63	44.1
	12/03/2019	Dry at time of sampling						
2A Bremer River	29/09/2017	Dry at time of sampling						
	28/02/2018	7.39	235	26.1	140	0.11	3.98	51
	12/03/2019	Dry at time of sampling						
5A Dam	26/09/2017	7.84	-	24.6	2.8	-	-	-
	28/02/2018	9.3	356.6	32.4	14.4	0.14	8.7	118.2
	13/03/2019	9.14	782	28.7	46.5	0.35	7.72	101.1
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling						
	28/02/2018	6.75	156	26.1	77.5	0.07	0.55	7.7
	13/03/2019	Dry at time of sampling						
6A Un-named tributary of Purga Creek	28/09/2017	7.66	-	19.2	5.3	-	-	-
	28/02/2018	7.52	321.9	27.2	105	0.15	6.2	77
	13/03/2019	7.49	3,206	23.5	39.6	1.72	1.45	17.1
7A Dugandan Creek	27/09/2017	7.42	-	20.8	13.9	-	-	-
	27/02/2018	7.54	224	24.3	130	0.11	8.15	99
	13/03/2019	Dry at time of sampling						

Site	Date	pH	EC (µs/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling						
	28/02/2018	7.26	160.5	23.6	95.5	0.08	6.75	79
	13/03/2019	Dry at time of sampling						
13A Un-named tributary of Purga Creek	26/09/2017	7.49	-	19.6	1.3	-	-	-
	28/02/2018	7.4	213.6	26.9	130	0.11	5.29	71
	13/03/2019	7.53	2,110	24.5	35.7	1.09	4.56	53.9
14A Un-named tributary of Purga Creek	27/09/2017	Dry at time of sampling						
	28/02/2018	7.46	252.6	25.8	61.4	0.12	6.91	85
	13/03/2019	Dry at time of sampling						
Warrill Creek WQO	**-**	**6.5 – 8.0**	**< 500**	**n/a**	**< 5**	**n/a**	**n/a**	**85 – 110**
3A Warrill Creek	28/09/2017	8.01	-	21.2	0.4	-	-	-
	28/02/2018	Dry at time of sampling						
	13/03/2019	No access to site at sampling						

Source WQO: DERM (2010a; 2010b)

Table notes:

Highlighted colour where value is above WQO or outside WQO range where applicable.

NTU = Nephelometric turbidity unit ppt = Parts per thousand µs/cm = microsiemens per centimetre

4.5.7 Laboratory assessed surface water quality results

The summary of the laboratory results for the baseline water quality assessments for the ecology study area are provided in Table 4.49 and Table 4.50.

Table 4.49 Key laboratory results for Project water quality monitoring sites

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll *a* (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
Logan River catchment														
Logan River WQO	**-**	**6.5 – 8.0**	**< 780**	**< 5**	**< 0.05**	**0.02**	**< 6**	**< 10**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**< 0.5**
7A Dugandan Creek	27/09/2017	8	1,500	<5	<0.05	<0.05	9.9	7.3	0.03	<0.02	<0.02	0.7	0.7	0.7
	27/02/2018	7.7	180	<5	0.09	<0.05	14	120	0.03	0.07	<0.02	0.9	0.9	0.97
	13/03/2019	Dry at time of sampling												
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling												
	28/02/2018	7.4	140	<5	0.07	<0.05	10	90	<0.01	<0.02	0.03	0.5	0.5	0.5
	13/03/2019	Dry at time of sampling												
8A Dugandan Creek	27/09/2017	7.9	1,200	<10	<0.05	<0.05	12	6.6	0.06	<0.02	<0.02	0.5	0.6	0.6
	28/02/2018	7.4	180	<5	0.07	<0.05	7.7	99	0.02	0.06	<0.02	0.7	0.7	0.77
	13/03/2019	Dry at time of sampling												
9A Woollaman Creek	25/09/2017	8.2	940	<5	<0.05	<0.05	15	5.2	0.04	<0.02	<0.02	<0.02	0.7	0.7
	27/02/2018	7.4	160	<5	0.08	<0.05	45	140	0.03	0.04	<0.02	0.8	0.8	0.86
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)												
10A Teviot Brook	25/09/2017	7.8	990	<5	<0.05	<0.05	6.8	5	0.02	0.09	<0.02	0.4	0.4	0.4
	27/02/2018	8	470	6	0.06	<0.05	14	9	0.02	<0.02	<0.02	0.5	0.5	0.5
	13/03/2019	8.2	2,700	<5	0.01	0.01	13	7.4	<0.01	<0.02	<0.02	0.29	0.3	0.29
11A Dam	25/09/2017	6.9	100	580	<0.05	<0.05	110	35	<0.01	<0.02	<0.02	2.3	2.3	2.3
	27/02/2018	6.8	49	<5	0.18	<0.05	33	32	0.05	<0.02	<0.02	0.6	0.6	0.6
	13/03/2019	Dry at time of sampling												

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll *a* (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05 0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
12A Un-named watercourse	28/09/2017	8.1	5,400	12	0.25	<0.05	11	2.4	0.89	<0.02	<0.02	1.6	2.5	2.5
	28/02/2018	7.3	180	<5	0.08	<0.05	6.4	97	0.07	0.19	<0.02	0.6	0.7	0.89
	13/03/2019	Dry at time of sampling												
Bremer River catchment														
Western Creek/ Bremer River WQO	**-**	**6.5 – 8.0**	**< 770**	**< 5**	**< 0.05**	**<0.02**	**< 6**	**< 17**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**< 0.5**
1A alt Western Creek	29/09/2017	8.1	910	33	0.17	0.11	14	5.9	0.04	0.03	<0.02	1.0	1	1
	2/03/2018	7.7	290	<5	0.48	0.92	22	58	0.02	0.2	0.05	1.0	1	1.3
	12/03/2019	Dry at time of sampling												
2A Bremer River	29/09/2017	Dry at time of sampling												
	28/02/2018	7.4	200	<5	0.54	0.36	49	95	0.07	0.05	<0.02	0.7	0.8	0.85
	12/03/2019	Dry at time of sampling												
5A Dam	26/09/2017	8.1	280	<5	0.19	0.12	8	8.4	0.08	<0.02	<0.02	1.4	1.5	1.5
	28/02/2018	8.5	270	11	0.07	<0.05	25	7.9	0.28	<0.02	<0.02	1.2	1.5	1.5
	13/03/2019	9.1	380	32	0.01	0.01	36	21	<0.01	<0.02	<0.02	1.6	1.6	1.6
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling												
	28/02/2018	6.8	130	<5	0.12	0.07	17	56	0.19	<0.02	<0.02	1.1	1.1	1.1
	13/03/2019	Dry at time of sampling												
6A Un-named tributary of Purga Creek	28/09/2017	8.1	2,800	<10	<0.05	<0.05	4.9	3.2	0.02	<0.02	<0.02	0.6	0.6	0.6
	28/02/2018	7.6	250	<5	0.08	<0.05	26	98	0.02	<0.02	<0.02	0.7	0.7	0.7
	13/03/2019	8.3	3,400	<5	0.02	0.01	42	34	0.67	0.06	<0.02	1.2	1.9	1.9

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll *a* (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
13A Un-named tributary of Purga Creek	26/09/2017	8.2	2,100	<5	<0.05	<0.05	3.8	0.3	0.03	<0.02	<0.02	0.3	0.3	1
	28/02/2018	7.6	200	<5	0.07	<0.05	95	120	<0.01	<0.02	<0.02	0.6	0.6	0.6
	13/03/2019	8.4	2,000	20	0.01	0.01	24	9.7	<0.01	<0.02	<0.02	0.59	0.6	0.59
14A Un-named tributary of Pura Creek	27/09/2017	Dry at time of sampling												
	28/02/2018	7.6	220	<5	0.09	<0.05	9.3	62	0.02	<0.02	<0.02	0.7	0.7	0.7
	13/03/2019	Dry at time of sampling												
Lower Warrill Creek WQO	**-**	**6.5 – 8.0**	**< 500**	**< 5**	**< 0.05**		**< 6**	**< 5**	**< 0.02**	**-**	**-**	**< 0.06**	**-**	**< 0.5**
3A Warrill Creek	28/9/2017	8.3	980	<10	0.07	0.05	3.5	1.1	<0.01	<0.02	<0.02	0.4	0.4	0.4
	28/02/2018	Dry at time of sampling												
	13/03/2019	No access to site at sampling												

Source WQO: DERM (2010a; 2010b)

Table notes:

Highlighted colour where value is above WQO or outside WQO range where applicable

NTU = Nephelometric turbidity unit

µs/cm = microsiemens per centimetre

µg/L = microgram per litre

1 Chlorophyll *a* concentrations were recorded as <10 or <5 at concentrations below <10 µg/L

2 Limit of reporting changes for total phosphorous occurred between field assessments 2 (September 2018) and 3 (March 2019)

Table 4.50 Dissolved metal and indicative polycyclic aromatic hydrocarbons laboratory results for Project water quality monitoring sites

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
Logan River catchment										
Logan River WQO	**-**	**0.024**	**0.0002**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
8A Dugandan Creek	27/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.01	<0.001
	13/03/2019	Dry at time of sampling								
9A Woollaman Creek	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	0.009	<0.001
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)								
10A Teviot Brook	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
11A Dam	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
12A Un-named watercourse	28/09/2017	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
Bremer River catchment										
Western Creek/ Bremer River WQO	**-**	**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
1A alt Western Creek	29/09/2017	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	02/03/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.004	0.008	<0.001
	12/03/2019	Dry at time of sampling								

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
2A Bremer River	29/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.004	<0.001	<0.0001	0.004	<0.005	<0.001
	12/03/2019	Dry at time of sampling								
5A Dam	26/09/2017	0.003	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.002	0.009	<0.001
	13/03/2019	Dry at time of sampling								
6A Un-named tributary of Purga Creek	28/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.001	0.006	<0.001
	13/03/2019	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
7A Dugandan Creek	27/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	0.001	0.001	<0.0001	0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
13A Un-named tributary of Purga Creek	26/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.001	0.011	<0.001
	13/03/2019	0.006	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
14A Un-named tributary of Pura Creek	27/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	<0.005	<0.001
	13/03/2019	Dry at time of sampling								

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
Lower Warrill Creek WQO	**-**	**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
3A Warrill Creek	28/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	02/09/2018	Dry at time of sampling								
	13/03/2019	No access to site at sampling								

Source WQO: DERM (2010a; 2010b)

Table note:

Highlighted colour where value is above WQO or outside WQO range where applicable.

4.5.8 Springs and groundwater dependant ecosystems

GDEs 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 GDE Atlas (BoM 2018) 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 GDE Atlas is modelled at a large scale (i.e. typically at the 1:100,000 or 1:50,000 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 (DES 2019) 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.

No springs were observed during field assessments associated with surface water or identified from the GDE 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 ground-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.

4.5.9 Wetlands

No HES or high environmental value wetlands (MSES wetlands) occur within the disturbance footprint. A total of 66 ha of mapped MSES wetlands occur within the ecology study area. Despite this, anthropogenic wetlands in the form of farm dams were prevalent within the ecology study area (refer Sites 5A and 11A). These areas have the potential to act as important resources for local faunal species.

4.6 Environmental values and sensitive environmental receptors

4.6.1 Environmental values

Consistent with the relevant legislation as stated in Section 2, the overarching environmental values adopted for the ecology study area:

- Queensland's natural environmental and native flora and fauna
- Finite natural resources, including conservations parks, and wetlands
- Land conducive to the maintenance of existing landforms, ecological health, biodiversity, riverine and wetland areas
- Biodiversity.

4.6.2 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 G and the area of predicted habitat contained within the ecology study area is provided in Table 4.28. 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 these species are considered low. The sensitive environmental receptors identified for terrestrial and aquatic ecology within the ecology study area are identified in Table 4.51 along with their assigned sensitivity value as determined by Table 3.7.

Table 4.51 Identified sensitive environmental receptors within the ecology study area

Associated environmental 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 landforms, ecological health, connectivity, riverine and wetland areas ▪ Biodiversity.	Protected areas: ▪ Crossing Nature Refuge ▪ Purga Nature Reserve ▪ Gum Tips Nature Refuge.	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impacts.
	Endangered REs (Category B): ▪ 12.3.3 ▪ 12.3.3d ▪ 12.3.18 ▪ 12.3.19 ▪ 12.8.24 ▪ 12.9-10.11 ▪ 12.9-10.27.	High	▪ Protected by State legislation ▪ Important for biodiversity ▪ Uncommon ▪ High sensitivity, high exposure to impacts.
	Of concern REs (Category B): ▪ 12.3.8 ▪ 12.9-10.3 ▪ 12.9-10.7 ▪ 12.9-10.16.	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact.
	Least concern REs (Category B): ▪ 12.3.7 ▪ 12.3.7c ▪ 12.9-10.2 ▪ 12.9-10.17 ▪ 12.9-10.17a.	Low	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact.
	High Value Regrowth vegetation (HVR) (Category C)	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact.

Associated environmental value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
	Migratory fauna species listed under the provisions of the EPBC Act[1] (including habitat): ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) ▪ Yellow wagtail (*Motacilla flava*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Osprey (*Pandion haliaetus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Rufous fantail (*Rhipidura rufifrons*)	High	▪ Protected by Commonwealth legislation ▪ Uncommon ▪ High sensitivity, high vulnerability.
	Conservation significant terrestrial fauna species listed under the provisions of the NC Act including SLC species (including habitat): ▪ Tusked frog (*Adelotus brevis*) ▪ Powerful owl (*Ninox strenua*). ▪ Glossy-black cockatoo (*Calyptorhynchus lathami*) ▪ Short-beaked echidna (*Tachyglossus aculeatus*)	High	▪ Protected by State legislation ▪ Uncommon ▪ High sensitivity, high vulnerability.
	Conservation significant terrestrial flora and fauna species listed under the provisions of the NC Act (including habitat): ▪ *Callitris baileyi* (Bailey's cypress) ▪ *Marsdenia coronata* (Slender milkvine) ▪ *Melaleuca irbyana* (Swamp tea-tree).	High	▪ Protected by State legislation ▪ Uncommon ▪ 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 uncommon, low extinction risk ▪ Low sensitivity, high exposure to impact.

Associated environmental value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
	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 uncommon, 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 landforms, ecological health, connectivity, riverine and wetland areas ▪ Biodiversity.	MSES wildlife habitat, State significant vegetation and bioregional corridors.	High	▪ Important for biodiversity ▪ High sensitivity, high exposure to impact.
	Nature Conservation (Koala) Conservation Plan 2017 mapping, including: ▪ Koala Priority Areas ▪ Koala Habitat Areas ▪ Koala Habitat Restoration Areas ▪ Locally Refined Koala Habitat Areas	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.
	Natural wetlands and watercourses, including: ▪ Nationally significant wetlands ▪ State significant wetlands (HES) ▪ MSES Watercourses ▪ Groundwater dependant ecosystems.	High	▪ Protected by State legislation ▪ Important for biodiversity ▪ High sensitivity, high exposure to impacts.

Table note:

1 These receptors may also be listed as Special Least Concern under the provisions of the Queensland *Nature Conservation Act 1992*.

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 3.4.

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 storage	Medium term
		Installation of offices, hardstands etc	Medium term
		Stockpiling	Medium term
		Artificial impoundment dewatering	Permanent
	Utility diversions	Excavation	Temporary
		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 waterways	Medium term
		Road/rail bridge construction	Medium term

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
	Civil works	Cutting construction	Medium term
		Embankment construction using cut to fill from rail alignment and borrow to fill from external borrow sources, where required	Medium term
		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
		Ballast installation	Short term
		Sleeper placement	Short term
		Rail placement	Short term
		Installation 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
		Blasting	Temporary
		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	Permanent
		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

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
Operation	Train operations	Train movement along rail	Permanent
	Operational maintenance	Ongoing vehicle movement within rail corridor	Permanent
Decommissioning	Lines 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 and degradation 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) and is particularly relevant to species with small home ranges, or reduced ability to disperse (e.g. small mammals and reptiles). 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 species listed under the provisions of the NC Act, as well as migratory species listed under the EPBC Act (including their associated habitats) identified in this assessment.

Of the Project's 972.49 ha that encompasses the disturbance footprint, 33.55 ha is mapped as remnant vegetation and 118.0 ha is mapped as regrowth vegetation (HVR). The remaining 820.94 ha has been heavily modified (clearing for agriculture/cattle grazing and classified as Category X non-remnant vegetation. Whist it is acknowledged that the southeast Queensland 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 significant. Vegetation clearing and habitat loss that cannot be avoided, particularly in high constraint areas (e.g. Biodiversity corridors, wetlands and areas providing habitat for threatened species), 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 (Furrer and Pasinelli, 2016). 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 Powerful owl (*Ninox strenua*), Glossy black-cockatoo (*Calyptorhynchus lathami*) and Short-beaked echidna (*Tachyglossus aculeatus*) (i.e. K-selected species) and is less pronounced in those that are R-selected (e.g. those species with high fecundity and shorter lifespans such as non-native invasive species) (Oli, 2004).

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). Species most at risk of injuries and mortality are those that are cryptic, difficult to detect and with poorly developed dispersal mechanisms. However, larger species with defined territories and movement patters (e.g. Southern greater glider are less likely to be at risk to direct mortality where appropriate mitigation measures are applied (i.e. pre-clearance surveys and the use of fauna spotters during clearing).

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 fauna species listed under the provisions of the NC Act, Least concern fauna species listed under the provisions of the NC Act and migratory species listed under the EPBC Act.

Some diurnal (active during the day) and mobile species, such as birds, 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 fauna are nesting. However, other listed species that are less mobile (i.e. ground-dwelling reptile, mammal species), or those that are nocturnal and nest or roost in tree or tree hollows during the day (i.e. Powerful owl (*Ninox strenua*)), may find it difficult to move away from roosts or active breeding places.

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. Mammals, reptiles, amphibians and birds are all at risk of vehicle strike, particularly common species (e.g. macropods) that are tolerant of disturbance and/or those species that can utilise roads for movement pathways or as foraging habitat.

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 (Ayres and Wallace 1997; Doody et al. 2003; Woinarski et al. 2006). Species most likely to become trapped in pits or other excavations during development of the Project are ground dwelling species that are capable of moving across modified areas and arboreal which ascend to the ground to disperse.

The unmitigated potential occurrence of fauna species injuries or mortalities resulting from the Project can be permanent, where mortality to the species occurs, or temporary where the species is rehabilitated and re-released (refer Table 3.6 for definitions associated with timeframes).

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 consistency (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 flora such as the Swamp tea-tree (*Melaleuca irbyana*), Slender Milkvine (*Marsdenia coronata*) and Bailey's cypress (*Callitris baileyi*). Impacts to soil may also have flow on effects to other threatened 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 2005). This will act directly upon recruitment processes and may impact upon a species/communities ability to recolonise following disturbance.

Soil biota may also be affected by compaction, for example earthworm numbers and activity can be reduced in compacted soils (Pizl 2002) and compaction may impact upon the growth of fungi which are important for ecosystem function. 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 (refer Table 3.6 for definitions associated with timeframes).

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. . In addition, weeds may result in impact to the Swamp Tea-tree (*Melaleuca irbyana*) through competitive processes and displacement, altering nutrient cycling and outcompeting for limited resources. Pest species can also damage native vegetation by grazing and trampling (Adair and Groves 1998; Clarke et al. 2001; Thorp and Lynch 2011) or through 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 threatened flora and fauna 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 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 during the operation phase of the Project.

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 disturbance footprint, including affecting the quality and integrity of remnant vegetation, habitat for conservation significant species, wetlands and waterways.

Non-native species comprised 27.5 per cent of the flora species recorded in the ecology study area (refer Appendix E). Of these, 27 flora species were restricted matters, listed under the provisions of the Queensland *Biosecurity Act 2014* (some of which are also listed as Weeds of National Significance (WoNS)). Weed species such as *Lantana camara* are noted as a potential threat to a number of threatened species (e.g. Slender Milkvine (*Marsdenia coronata*)) and were identified as common throughout the ecology study area (refer Section 4.5.1.3). Without appropriate management strategies, the Project activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited, occur in low densities, or have high specific habitat requirements where weed encroachment has been identified as a threatening process.

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 those occupied by the Swamp Tee-tree (*Melaleuca irbyana*) (refer Appendix C).

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 intact remnant vegetation that currently has low weed diversity and abundance.

Unmitigated Project activities have the potential to disperse pest (animal) species from the 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 (refer Table 3.6 for definitions associated with timeframes).

5.1.2.5 Reduction in the connectivity of biodiversity corridors

Biodiversity corridors (including those associated with waterways) 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 and fragmentation of such corridors have been identified as important threatening process to many threatened species including the Powerful owl (*Ninox strenua*) and Glossy black-cockatoo (*Calyptorhynchus lathami*)

Queensland corridor mapping for the SEQ Biodiversity Planning Assessments (Version 4.1, 2016) depicts regional and State corridors within the ecology study area (refer Figure 4.12), which portrays vegetation that is significant for the spread and movement of flora and fauna. Connectivity is present north and south of the ecology study area, and this is particularly evident in areas associated with steep topography and drainage lines.

However, most of the ecology study area exists in generally fragmented environment. Despite this, 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.

The potential impacts of linear infrastructure traversing these biodiversity corridors include habitat fragmentation, edge effects and barrier effects, resulting in reduced population size and connectivity. 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 (migratory) and NC Act (threatened and near-threatened), 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, in large habitat patches with low edge to area ratios (e.g. in the Teviot Range), Project activities (vegetation clearing, temporary and permanent) may result in fragmentation and reduction of existing habitat along with associated edge effects.

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. Glossy black-cockatoo (*Calyptorhynchus lathami*), Slender Milkvine (*Marsdenia coronata*) and Swamp tea-tree (*Melaleuca irbyana*)).

It is anticipated that threatened species and wetland and waterway may be impacted greatest from edge effects, where avoidance of vegetated areas is not practicable.

It is anticipated that sensitive environmental receptors involving conservation significant species, 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 long term and irreversible (refer Table 3.6 for definitions associated with timeframes).

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 (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 associated edge effects and reduction in habitat. Sensitive environmental receptors involving conservation significant species, regionally significant vegetation, bioregional corridors and wildlife refugia may be impacted upon the most from habitat fragmentation. 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.

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 and 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. It should be noted localised fragmentation may have a greater impact on remnant vegetation communities.

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. Sensitive environmental receptors that are most vulnerable to barrier effects include the Short-beaked echidna (*Tachyglossus aculeatus*) and small, insectivorous migratory birds that depend on interconnect tracts of vegetation to facilitate migratory movements.

Various Project activities may create temporary and/or permanent barrier effects, particularly those that may create a hard barrier that restricts fauna movement (e.g. operational and construction access tracks, temporary waterway barrier works such as the construction of culverts within watercourses, operational rail corridor, construction laydown areas, etc.). Mobile species such as larger mammals, birds (e.g. Powerful owl (*Ninox strenua*)), 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, 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. Noting that the waterway barrier works for the Project are expected to be restricted to bridge infrastructure works within the construction phase. The bridge infrastructure works are to occur along major watercourses, with corresponding major risk category for waterway barrier works. Unmitigated impacts are likely to cause major impact to waterway works however bridge construction will incorporate piling of pre-fabricated structures outside low-flow areas of the watercourses, and inherently avoid fully unmitigated impact.

Similarly, barrier effects may be experienced by native animals in the form of increased patrolling and predation by pest animals (e.g. foxes and wild dogs) along barriers, such as a cleared corridor, as prey becomes more exposed and easier to detect and catch (Catling and Burt 1995).

The unmitigated potential impacts of barrier effects resulting from the Project are considered to be in most cases short term and temporary 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 of Project activities during all phases and may also have cumulative effects. The scientific 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 decreases in aquatic health in 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) or indirect impacts related to altered foraging and habituation in areas exposed to increased lighting. Light impacts associated from construction will be temporary in nature, however operational lighting impacts may be long-term and very 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 Microchiropterian bats, by attracting nocturnally flying insects upon which this species feeds.

Sensitive environmental receptors affected by these potential impacts include all threatened flora (impacts associated with dust) and terrestrial fauna species (impacts associated with noise and vibration) listed under the provisions of the NC Act. The Swamp Tea-tree (*Melaleuca irbyana*) is likely to be impacted to a lesser extent and these impacts are likely to be associated with dust alone (ie reducing photosynthetic processes following settlement of dust on leaves). 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, poses threats to human health and is aesthetically displeasing. 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) and as such negatively impact aquatic species.

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 2019).

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

Without mitigation activities related to the construction and operation of the Project are likely to impact water quality, thereby degrading habitats for aquatic fauna and flora. Erosion and sedimentation, 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. 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.

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.

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. Correspondingly, depending on existing conditions, there is the potential to increase exposure of sensitive environmental receptors to contaminants which could result in a bio-accumulation of contaminants.

EIS Chapter 9: Land Resources identifies potential existing contamination sources and associated potential receptors and indicates where there is a potential for bioaccumulation of contaminants due to direct contact or consumption of contaminants by terrestrial and aquatic receptors. Potential sources of existing contamination are associated with:

- Agricultural use and storage of chemicals and hydrocarbons
- Activities in the existing rail corridor
- UXO (although this is considered unlikely).

EIS Chapter 9: Land Resources also identifies potential land contamination sources associated with proposed Project activities both during construction and operation. Potential sources of impacts on terrestrial and aquatic receptors include hydrocarbon and hazardous materials use and storage, biosecurity management and waste storage (including storage of sewage tanks).

EIS Chapter 13: Surface Water and Hydrology further identifies the low post-mitigation risk of potential for mobilisation of sediment-bound metals and other substances, acting as contaminants from standard construction and operational phase activities. These potential sources are considered to be derived from physical land and stream disturbances, clearing activities, accidental spills, dewatering activities and standard rail maintenance and operating procedures.

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.

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. In addition, species such as the Tusked frog (*Adelotus brevis*) may be adversely impacted by degradation of aquatic habitats.

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 also be damaging to the ecological health of waterways and may be a proximate cause of environmental degradation. Mobilised coarse 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 and degrade this critical refuge habitat.

In addition to secondary impact of erosion and sedimentation on aquatic habitats, the primary impact of erosion on terrestrial habitat has the 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 localised direct impact on terrestrial habitat. 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 – Teviot Range

The construction and operation of the proposed tunnel through the Teviot 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. There are no MSES flora identified as present in the tunnel area. The tunnel is proposed to be 1,015 m long with an excavated cross-section of approximately 135 m² (internal space dimensions are driven by ventilation requirements). The maximum cover of rock above the tunnel is approximately 90 m.

The tunnel intersects the Gatton Sandstone (part of the Marburg Subgroup), which is a sedimentary rock comprising medium-coarse grained sandstone (refer EIS Chapter 9: Land Resources for further detail). Aboveground subsidence or surface cracking may result from both the tunnelling process itself, or as a result of settlement caused by subsequent groundwater drawdown processes caused by the tunnel. Potential subsidence is unlikely to have any significant impacts upon flora, fauna or local ecological communities.

Geotechnical survey works within the tunnel area have so far been limited (refer Jacobs-GHD 2016b and Golder 2019). Nevertheless, initial interpretation of results indicates the potential for minimal settlement and therefore damage to vegetation communities due to subsidence from the tunnel appears to be low. However, ongoing geotechnical investigations will further assess the potential for settlement/subsidence and will inform the final design of the tunnel.

Groundwater monitoring in the Teviot Range area indicates groundwater levels in the Gatton Sandstone ranges from 20.2 metres below ground level (mbgl) to 72 mbgl in the vicinity of the tunnel itself, to 16.9 mbgl approximately 4 km east of the tunnel (Jacobs-GHD 2016b; Golder 2019). The vegetation in the range at the tunnel area comprises remnant and regrowth eucalypt woodland 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.

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 west and south side of the west portal of the tunnel. It is noted the mapped GDEs have not been confirmed as present. Preliminary predictive numerical modelling of the drained tunnel through the Teviot 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 three structural features) drawdown impacts may extend up to 1,000 m laterally either side of the tunnel, with a potential GDE within the predicted 5 m drawdown extent. Ongoing and further investigations are anticipated to confirm that risks posed to potential GDEs are acceptable. Should this not be the case, works will be completed during subsequent phases (i.e. detailed design and early works) to develop mitigation and management strategies that achieve acceptable residual risks (refer EIS Chapter 14: Groundwater for further information).

Potential ground-borne vibration and associated ground-borne noise due to tunnel construction works and during operations (train movements) 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 sensitive (human) receptors to the tunnel were not expected to experience vibration or ground-borne noise levels that could trigger the assessment criteria. There are no guidelines regarding potential impacts of ground vibration to fauna. A tunnelling Project in New Zealand adopted human vibration limit criteria to identify potential impact zones on wetland bird species and thereby informing fauna relocation activities (NDY 2020). Vibration impacts are very likely to be similar to those described for noise (refer EIS Chapter 15: Noise and Vibration). Following the completion of construction vibration will be restricted to train movements (i.e. regular events of relatively short duration). As such, any potential impact on MSES fauna is considered likely to be minor at worst.

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 generally located within the existing SFRC, which was gazetted as a future rail corridor in 2010. The Project design has been developed to utilise the existing rail corridor protection and minimise land severance and impacts to natural and rural landscapes to the greatest extent possible.
- The Project has avoided direct impacts on nationally or regionally protected areas such as the Flinders-Goolman Conservation Estate
- Clearing of vegetation will be restricted to the minimum required to enable the safe and efficient 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
  - Riparian vegetation
  - Steep slopes and
  - Instream habitats.
- The Project incorporates bridge and culvert structures to maintain existing flow paths and flood flow distributions. Twenty-one bridge structures over watercourses are to be constructed to minimise disturbance of aquatic habitats.
- The Project has been developed to minimise impacts to watercourses, riparian vegetation and instream habitats by adopting a crossing structure hierarchy where bridges are preferred to culverts to maintain connectivity for threatened species such and riparian fauna conduits that are important to MSES species
- 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 threatened species has been avoided wherever possible.

- Fauna crossing opportunities have been co-located with waterway crossing structures to maintain habitat connectivity across the rail corridor. Where possible, these align with regional, State and locally significant fauna movement corridors or areas of important fauna habitat. Six crossing points have been selected for dedicated fauna infrastructure including bridge sites on Western Creek, Bremer River, Warrill Creek, Woollaman Creek and Teviot Brook. A sixth area within the Teviot Range has been selected for a rope bridge crossing point where the alignment is located within a cutting area. The six locations have been assessed as providing movement opportunities for the greatest number of species. Opportunities to incorporate fauna infrastructure and fauna fencing at these and other potential crossing points (such as large culverts) will be considered during the detailed design process.
- Avoidance of natural movement corridors (e.g. Teviot Range associated with the tunnel) will maintain connectivity for species which have habitat with the broader region. For example, the rail tunnel (1,015 m long) occurs where the alignment crosses a higher point in the Teviot Range. Fauna will be able to utilise the unimpacted section of the range over the tunnel as a movement corridor.

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 (refer footnotes to Table 5.2). It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis.

A review has been undertaken of 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; Carlvalho 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, 2015c; van der Grift et al. 2015). Criteria that can be used to measure effectiveness include:

- Rates of vehicle strike
- 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: Draft 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 and management 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: ▪ Slender milkvine (*Marsdenia coronata*) ▪ Bailey's cypress (*Callitris baileyi*) ▪ Swamp tea-tree (*Melaleuca irbyana*) 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: ▪ Short-beaked echidna (*Tachyglossus aculeatus*) ▪ Powerful owl (*Ninox strenua*) ▪ Glossy-black cockatoo (*Calyptorhynchus lathami*) 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.
		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.

Delivery phase	Environmental value impacted	Mitigation and management measures
		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.
		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 (e.g. sodosols near Ebenezer, vertosols near Purga and Willowbank, saline hazard areas, and potential for acid sulfate soils near artificial waterbodies or impoundments) ▪ 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 – 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.).

Delivery phase	Environmental value impacted	Mitigation and management measures
		▪ 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.
	Riparian vegetation and aquatic habitats	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. ▪ 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.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Fauna passage[1,2]	Refine fauna passage locations and associated rehabilitation areas in the design to maintain infrastructure permeability, particularly at the six 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.
	Fauna fencing	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.
	Aquatic fauna	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.
		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.
	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

Delivery phase	Environmental value impacted	Mitigation and management measures
	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.
	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, 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 ▪ 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

Delivery phase	Environmental value impacted	Mitigation and management measures
		- 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 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 Iimported 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 - 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 local government Biosecurity Plans (City of Ipswich Biosecurity Plan 2018-2023 and City of Logan Biosecurity Plan 2017-2022) - 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.

Delivery phase	Environmental value impacted	Mitigation and management measures
	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 (refer Appendix K of this Report: Environmental Offset Delivery Strategy QLD).
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 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.
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.

Delivery phase	Environmental value impacted	Mitigation and management measures
	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. 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 six 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.

Delivery phase	Environmental value impacted	Mitigation and management measures
	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 six 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.

Delivery phase	Environmental value impacted	Mitigation and management measures
	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 ▪ 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 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]. Fauna fencing 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 (e.g. DTMR's Fauna Sensitive Road Design Manual (DTMR 2000)) and mitigation measures used on similar projects that have been subject to legislative approval (refer footnotes to Table 5.2). 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 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.

EIS 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

Potential flora and fauna impacts during construction, commissioning/reinstatement and operation have been assessed in accordance with the qualitative impact assessment methodology outlined in Section 3.5 and EIS Chapter 4: Assessment Methodology.

Potential impacts to environmental values due to construction of the Project have been assessed in Sections 5.1.1 and 5.1.2. For the purposes of impact assessment, the maximum potential disturbance to each sensitive environmental receptor (e.g. areas identified using the predictive habitat mapping or the maximum extent government certified mapping) have been used. This mapping assumes the presence of species if habitat has been identified as being present (i.e. habitat has been used as a proxy for species presence) or assumed the level of accuracy of the government endorsed datasets. This represents an application of the precautionary principle and represents a highly conservative estimate of Project impacts. Given the highly conservative approach adopted, impacts identified represent the maximum potential impact and assume a "worst-case" scenario in relation to the Project's disturbance. The impacts identified during this assessment are likely to be significantly reduced during the Project stages following the primary approval phase.

The initial significance assessment is undertaken on the assumption that the design measures factored into the Project design (refer Section 5.2.1) have been implemented. The residual significance level of the potential impacts is reassessed taking into consideration the implementation of the proposed mitigation measures listed in Table 5.2. This has been split into consideration of the construction phase, the commissioning and reinstatement phase, and operations. Environmental Offsets in response to residual impacts are discussed in Section 5.4.

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 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 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 state and local based sensitive environmental receptors – 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.

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 disturbance footprint (ha)* (972.49 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										
Pandion haliaetus	Osprey	SLC	M	42.43	42.43	0.00	**7.16**	8.04	0.00	Moderate
Cuculus optatus	Oriental cuckoo	SLC	M	7.60	7.60	0.00	**4.68**	4.84	0.00	Moderate
Myiagra cyanoleuca	Satin flycatcher	SLC	M	7.60	7.60	0.00	**4.68**	4.84	0.00	Moderate
Rhipidura rufifrons	Rufous fantail	SLC	M	7.60	7.60	0.00	**4.68**	4.84	0.00	Moderate
Monarcha melanopsis	Black-faced monarch	SLC	M	7.60	7.60	0.00	**4.68**	4.84	0.00	Moderate
Symposiachrus trivirgatus	Spectacled monarch	SLC	M	7.60	7.60	0.00	**4.68**	4.84	0.00	Moderate
Motacilla flava	Yellow wagtail	SLC	M	45.33	42.43	2.90	**6.62**	8.14	1.77	Moderate
Actitis hypoleucos	Common sandpiper	SLC	M	45.33	42.43	2.90	**6.62**	8.14	1.77	Moderate
Calidris acuminata	Sharp-tailed sandpiper	SLC	M	45.33	42.43	2.90	**6.62**	8.14	1.77	Moderate
Gallinago hardwickii	Latham's snipe	SLC	M	45.33	42.43	2.90	**6.62**	8.14	1.77	Moderate
Plegadis falcinellus	Glossy ibis	SLC	M	45.33	42.43	2.90	**6.62**	8.14	1.77	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 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 disturbance footprint (ha)* (972.49 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	11.43	11.43	0.00	0.00	**1.15**	1.15	0.00	0.00	Low
Marsdenia coronata	Slender milkvine	V	61.85	61.85	0.00	0.00	**10.26**	10.26	0.00	0.00	Moderate
Melaleuca irbyana	Swamp tea-tree	E	237.73	132.42	45.69	59.63	**7.30**	5.77	14.33	9.28	Moderate
NC Act conservation significant fauna											
Adelotus brevis	Tusked frog	V	10.21	10.21	0.00	0.00	**9.73**	9.73	0.00	0.00	Moderate
Calyptorhynchus lathami	Glossy-black cockatoo	V	50.63	49.96	0.68	0.00	**6.27**	6.35	3.28	0.00	Moderate
Ninox strenua	Powerful owl	V	21.54	21.54	0.00	0.00	**10.54**	10.54	0.00	0.00	Moderate
NC Act special least concern animals											
Tachyglossus aculeatus	Short-beaked echidna	SLC	67.64	67.64	0.00	0.00	**3.15**	3.15	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 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 sensitive environmental receptors (excluding threatened and migratory species) identified for the Project

Sensitive environmental receptor	Total coverage of sensitive environmental receptor within the ecology study area (ha) (12,442.24 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (972.49 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)#
Protected areas	98.86	0.36	0.36	Negligible
Regulated vegetation (VM Act)				
Endangered remnant vegetation (REs) (Category B)	154.94	10.56	6.82	Moderate
Of concern remnant vegetation (REs) (Category B)	725.78	9.02	1.24	Low
Least concern remnant vegetation (REs) (Category B)	874.60	13.97	1.60	Low
High value regrowth vegetation (HVR) (Category C)	1,779.10	118.00	6.63	Moderate
MSES wildlife habitat	1,381.79	88.97	6.44	Moderate
Essential habitat	1,259.38	25.89	2.05	Moderate
Nature Conservation (Koala) Conservation Plan 2017 mapping				
Koala Priority Areas	3,770.56	258.48	6.86	Moderate
Koala Habitat Areas	3,006.09	145.57	4.84	Moderate
Koala Habitat Restoration Areas	3,636.14	295.13	8.12	Moderate
Locally Refined Koala Habitat Areas	327.42	27.92	8.53	Moderate
Wetlands				
State significant wetlands (HES)	66.00	0.00	0.00	N/A
Least concern flora and fauna* (NC Act) and Priority Back on Track flora and fauna species				
Least concern flora and fauna	12,442.24	972.49	7.82	Moderate
Priority Back on Track species (not listed under the EPBC Act or NC Act)	12,442.24	972.49	7.82	Moderate

Sensitive environmental receptor	Total coverage of sensitive environmental receptor within the ecology study area (ha) (12,442.24 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (972.49 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)				
BPA habitat values for EVNT taxa (state)	1,110.92	116.92	10.52	Moderate
BPA habitat values for EVNT taxa (regional)	293.23	1.35	0.46	Negligible
Regional Terrestrial corridors	1,005.86	87.86	8.73	Moderate
State Riparian corridors	510.72	40.86	8.00	Moderate
State Terrestrial corridors	1,809.17	119.80	6.62	Moderate

Table notes:

* 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 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.

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: Air Quality), surface water and hydrology (refer EIS Chapter 13: Surface Water and Hydrology), groundwater (refer EIS Chapter 14: Groundwater) and noise and vibration (refer EIS Chapter 15: Noise and Vibration). 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 proposed mitigation measures.

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 Guidelines (for migratory species) or MSES Guidelines to confirm the initial impact assessment results (refer Section 5.3.3 and Section 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): ▪ Osprey (*Pandion haliaetus*) ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Rufous fantail (*Rhipidura rufifrons*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) ▪ Yellow wagtail (*Motacilla flava*)	High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Noise, dust, and light impacts Increase in litter (waste) Aquatic habitat degradation	High	Major	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Moderate	High

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]
■ Common sandpiper (*Actitis hypoleucos*) ■ Sharp-tailed sandpiper (*Calidris acuminata*) ■ Latham's snipe (*Gallinago hardwickii*) ■ Glossy ibis (*Plegadis falcinellus*)		Commissioning and reinstatement	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts Aquatic habitat degradation	Low	Moderate	■ Flora and fauna (detailed design, pre-construction and construction and commissioning) ■ Weeds and pests (pre-construction and construction and commissioning) ■ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ■ Erosion and sediment control (pre-construction and construction and commissioning) ■ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ■ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts 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	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	High	Major	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning)	Moderate	High
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	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	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
State significant ecological constraint (VM Act): Of concern remnant vegetation (REs) (Category B)	Moderate	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	Moderate	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning)	Low	Low
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed 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	Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Negligible	Low
State significant ecological constraint (VM Act): Least concern remnant vegetation (REs) (Category B)	Low	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	Moderate	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning)	Low	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]
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Negligible
		Operation	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	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste) Aquatic habitat degradation	High	High	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning)	Moderate	Moderate
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	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]
		Operation	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
State significant ecological constraint (VM Act): ▪ MSES wildlife habitat ▪ Essential habitat	High	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	Moderate	High	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning)	Low	Moderate

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	Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	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 ▪ Koala Habitat Restoration Areas ▪ Locally Refined Koala Habitat Areas	High	Construction	Displacement of flora and fauna species from invasion of weed and pest species Barrier effects Noise, dust, and light impacts	Moderate	High	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning)	Low	Moderate
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	Displacement of flora and fauna species from invasion of weed and pest species 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]
State Significant Ecological Constraint (species listed as threatened under the NC Act): **Flora**: ▪ Bailey's cypress (*Callitris baileyi*)	High	Construction	Habitat loss from vegetation clearing/removal Displacement of flora and fauna species from invasion of weed and pest species Barrier effects Noise, dust, and light impacts	Moderate	High	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning)	Low	Moderate
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	Displacement of flora and fauna species from invasion of weed and pest species 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]
State Significant Ecological Constraint (species listed as threatened under the NC Act): **Flora:** ▪ Slender milkvine (*Marsdenia coronata*) ▪ Swamp tea-tree (*Melaleuca irbyana*) **Fauna:** ▪ Tusked frog (*Adelotus brevis*) ▪ Powerful owl (*Ninox strenua*) ▪ Glossy Black-cockatoo (*Calyptorhynchus lathami*)	High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Noise, dust, and light impacts Increase in litter (waste) Aquatic habitat degradation	High	Major	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning)	Moderate	High

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	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts Aquatic habitat degradation	Low	Moderate	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (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 (Special Least concern fauna species): ▪ Echidna (*Tachyglossus aculeatus*)	Moderate	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Noise, dust, and light impacts Increase in litter (waste) Aquatic habitat degradation	High	High	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Moderate	Moderate
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	Displacement of flora and fauna species from invasion of weed and pest species 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	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Noise, dust, and light impacts Increase in litter (waste) Aquatic habitat degradation	High	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Aquatic fauna (detailed design and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Moderate	Low
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	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	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts 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	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Noise, dust, and light impacts Increase in litter (waste) Aquatic habitat degradation.	High	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Aquatic fauna (design and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Moderate	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]
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Negligible
		Operation	Fauna species injury or mortality Displacement of flora and fauna species from invasion of weed and pest species Noise, dust, and light impacts 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 taxa	High	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste) Aquatic habitat degradation	High	Major	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Moderate	High
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	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 for Endangered, Vulnerable and Near Threatened taxa (regional)	Moderate	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	Moderate	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Low	Low
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	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 significant corridors	High	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste) Aquatic habitat degradation	High	Major	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Moderate	High
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Negligible	Low
		Operation	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 significant corridors	Moderate	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora and fauna species from invasion of weed and pest species Edge effects Habitat fragmentation Barrier effects Increase in litter (waste)	Low	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Fauna passage (detailed design and construction and commissioning) ▪ Fauna fencing (detailed design and construction and commissioning)	Negligible	Low
		Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (detailed design, pre-construction and construction and commissioning) ▪ Weeds and pests (pre-construction and construction and commissioning) ▪ Erosion and sediment control (pre-construction and construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	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	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 Section 3.5.1 and Section 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 matters of national environmental significance (migratory species)

This section assesses the potential for significant residual impacts from the Project upon non-threatened EPBC Act listed migratory species (i.e. MNES that are not a controlling provision of the Project), using the relevant criteria outlined in the MNES Guidelines. In accordance with the MNES Significant Impact Guideline, the Project is likely to have a significant impact upon a non-threatened 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 ecology study area using the criteria set out in the MNES Significant Impact Guideline.

There are 11 migratory species relevant to the ecology study area (i.e. that are identified in desktop searches, have predicted habitat within the ecology study area, and are not listed as threatened under the EPBC Act). These include:

- Three marine migrant species (i.e. Common sandpiper (*Actitis hypoleucos*), Sharp-tailed sandpiper (*Calidris acuminata*) and Latham's snipe (*Gallinago hardwickii*))
- Five woodland migrant species (i.e. Rufous fantail (*Rhipidura rufifrons*), Oriental cuckoo (*Cuculus optatus*), Spectacled monarch (*Symposiachrus trivirgatus*), Black-faced monarch (*Monarcha melanopsis*) and Satin flycatcher (*Myiagra cyanoleuca*))
- Three wetland migrant species (i.e. Yellow wagtail (*Motacilla flava*), Eastern osprey (*Pandion haliaetus*) and Glossy ibis (*Plegadis falcinellus*)).

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 presented in Appendix B and summarised in Section 5.3.3.1 (marine migrants), Section 5.3.3.2 (woodland migrants) and Section 5.3.3.3 (wetland migrants). Relevant Commonwealth documents applicable to each species including threat abatement plans, approved conservation advice, and recovery plans are 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, specimen records and habitat requirements (refer Appendix B and Sections 5.3.3.1, 5.3.3.2 and 5.3.3.3)
- Predictive habitat modelling for each species (refer Appendix G) based on the habitat assumptions associated with each species (refer Appendix A), along with the findings of ecological surveys. 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 (refer Section 1.1 and Section 1.5)
- Information on potential impacts of Project during construction and operation (refer Section 5.1.2)
- Proposed Project mitigation measures (refer 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		
Marine migrants (refer Section 5.3.3.1 for more details)				
Common sandpiper (*Actitis hypoleucos*)	M	SLC	No significant impact likely	Table 5.8
Sharp-tailed sandpiper (*Calidris acuminata*)	M	SLC	No significant impact likely	Table 5.8
Latham's snipe (*Gallinago hardwickii*)	M	SLC	No significant impact likely	Table 5.8
Woodland migrants (refer Section 5.3.3.2 for more details)				
Rufous fantail (*Rhipidura rufifrons*)	M	SLC	No significant impact likely	Table 5.9
Oriental cuckoo (*Cuculus optatus*)	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		
Spectacled monarch (*Symposiachrus trivirgatus*)	M	SLC	No significant impact likely	Table 5.9
Black-faced monarch (*Monarcha melanopsis*)	M	SLC	No significant impact likely	Table 5.9
Satin flycatcher (*Myiagra cyanoleuca*)	M	SLC	No significant impact likely	Table 5.9
Wetland migrants (refer Section 5.3.3.3 for more details)				
Yellow wagtail (*Motacilla flava*)	M	SLC	No significant impact likely	Table 5.10
Eastern osprey (*Pandion haliaetus*)	M	SLC	No significant impact likely	Table 5.10
Glossy ibis (*Plegadis falcinellus*)	M	SLC	No significant impact likely	Table 5.10

Table notes:

M = migratory SLC = Special least concern

It is unlikely that the thresholds outlined in the guideline will be exceeded in relation to important habitat for each of the 11 migratory species (refer Table 4.29). 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 Marine migrants

This section provides a summary of information related each of the three marine migratory species that have potential of occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Common sandpiper (*Actitis hypoleucos*)

Common sandpiper is a small migratory wader, typically 20cm in length. They mostly eat molluscs, crustaceans and insects. This species does not breed in Australia. 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 (Pizzey and Knight 2003).

Important habitat nationally for migratory shorebirds birds has been described in the Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment (2015). 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 2,000 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, 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).

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. Database records do not indicate the presence of this species within the disturbance footprint or within the ecology study area. The nearest record is located approximately 20 km to the north-east of the disturbance footprint near Ipswich and is dated from 1991. A recent record (2017) is located approximately 20 km west of the disturbance footprint at Laidley. Other records within a 50 km buffer of the disturbance footprint occur predominantly to the north-west, north, north-east and east with no records to the south to the west. Most records for this species occur closer to the coast with few records from inland.

It is unlikely that habitat associated with the disturbance footprint is likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the 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 5.8.

Sharp-tailed sandpiper (*Calidris acuminata*)

Sharp-tailed sandpiper is a medium-sized summer migratory wader, typically 20cm in length. This species does not breed in Australia. 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 (Pizzey and Knight 2003).

Important habitat nationally for migratory shorebirds birds has been described in the Wildlife Conservation Plan for Migratory Shorebirds (DotE 2015). 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. Threats identified include loss or degradation of habitat, disturbance 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).

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 disturbance footprint or within the ecology study area. Few records occur within a 50 km buffer of the disturbance footprint with the most recent record (2015) occurring at the Gold Coast. Another record occurs approximately 50 km from the disturbance footprint from 2009 at Victoria Point, Brisbane. No database records exist inland and this is a coastal species. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

It is unlikely that habitat associated with the disturbance footprint and the wider ecology study area is likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. 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 5.8.

Latham’s snipe (*Gallinago harwickii*)

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 2020b).

Important habitat nationally for migratory shorebirds birds has been described in the Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment. Habitat supporting Latham's snipe is treated differently to other migratory wader species due to its different habits and habitat use (it generally occurs solitarily on wetlands rather than coastal habitats and may occur on inland habitats). Important habitat for this species is described as areas that have previously been identified as internationally important for the species, or areas that support at least 18 individuals of the species (DotE 2015). No important habitat has been identified within the ecology study area. 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 disturbance footprint or within the ecology study area. Few records occur within a 50 km buffer of the disturbance footprint. No database records exist inland and this is a coastal species. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

While the species is likely to occur occasionally on wetlands (including vegetated farm dams) habitat associated with the disturbance footprint is not likely to support an ecologically significant proportion of a population (i.e.18 individuals), hold critical importance for breeding or is at the limit of the 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 5.8.

Table 5.8 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	Approximately 2.90 ha of important habitat has been mapped within the disturbance footprint (refer Table 4.29) through the predictive habitat modelling process which is proposed to be disturbed. However, this value equates to less than 0.1% of the total important habitat for marine migrants at a national level. Most of the Marine migrants are coastal in nature and as such are not likely to utilise areas away from the cost for any significant period of time. Therefore, the Project is not likely to substantially modify, destroy or isolate important habitat for the marine migrants.
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 Plan will mitigate the impacts of invasive species on these species. If the abundance of feral predators (i.e. cats and foxes) increases due to the Project, it is unlikely to have any impact
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	These species breed in Siberia. 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 on its migratory journey. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of marine migrant species.
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

5.3.3.2 Woodland migrants

This section provides a summary of information related each of the five woodland migratory species that have potential of occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species

Oriental cuckoo (*Cuculus optatus*)

The Oriental cuckoo does not breed in Australia, it migrates to from north-east Asia during its non-breeding season which occurs from September to May (DAWE 2020b). 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 2020b) 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 ha internationally and 1,000 ha 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, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020b). A review of the available literature does not reveal any impacts from invasive species on the Oriental cuckoo.

There are no database records within the disturbance footprint or from within the ecology study area for this species. The nearest record is approximately 10 km north of the western section of the alignment north of Rosewood and is dated 2007. The next nearest record occurs to the south of the alignment at Harrisville approximately 20 km from the disturbance footprint dated 1990. Historical records occur in all directions of the disturbance footprint with the majority of these existing between Ipswich and Brisbane. Very few records occur adjacent to the Project and the ones that do are sparse.

There is no habitat identified as important for woodland migrant species within the disturbance footprint, however, approximately 7.60 ha of potential habitat has been identified with the ecology study area (refer Table 4.29). This species is associated with coastal habitat in northern and eastern Australia, this is evident by a large density of specimen backed records closer to the coast and a lack of records inland.

Assessment against the significant impact criteria for Oriental cuckoo is shown in Table 5.9.

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 2020b). 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, south-east Queensland and near Lake Entrance in south-east Victoria (DAWE 2020b). 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 (BirdLife Australia 2019).

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 (individuals) 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, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020b). Threats to this species include collision with windows (Taplin 1991) and lighthouses (Makin 1961). 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 2020b).

Database records indicate this species occurs within the ecology study area but does not occur within the disturbance footprint. A record exists from 2002 to the south of the disturbance footprint near the Teviot Range. A number of records, including recent (2019) occur within approximately 5 km north of the disturbance footprint at the Teviot Range. There is an abundance of records within a 50 km buffer of the disturbance footprint in all directions.

There is no habitat identified as important for woodland migrant species within the disturbance footprint, however, approximately 7.60 ha of potential habitat has been identified with the ecology study area (refer Table 4.29).

Assessment against the significant impact criteria for Black-faced monarch is shown in Table 5.9.

Satin flycatcher (*Myiagra cyanoleuca*)

Satin flycatchers tree species including paperbarks, eucalypts and banksias for nest building constructing nests in the outer branches (Gilbert 1935, (BirdLife Australia 2019). 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 (BirdLife Australia 2019). 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 2020b).

This species generally occupies eucalypt forest that occurs near wetlands or waterways. Compared to other flycatcher species they tend to occupy forests that are taller and wetter frequently in gullies (DAWE 2020b). 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 (individuals) 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, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020b). 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). 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 2020b).

Database records indicate this species does not occurs within the ecology study or the disturbance footprint. The nearest record is located approximately 15 km north of the western section of the disturbance footprint at Marburg and is dated 1981. Records from more recently (2017) occur approximately 20 km north of the disturbance footprint east of Ipswich. Records are sparse but occur in all directions around the disturbance footprint within a 50 km buffer with most of these occurring to the north east between Ipswich and Brisbane. Records are largely confined to forested reserves and national parks.

There is no habitat identified as important for woodland migrant species within the disturbance footprint, however, approximately 7.60 ha of potential habitat has been identified with the ecology study area (refer Table 4.29).

Assessment against the significant impact criteria for Satin flycatcher is shown in Table 5.9.

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 2020b).

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 2020b).

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 (individuals) 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, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020b). 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 2020b).

Database records indicate this species does not occurs within the ecology study or the disturbance footprint. The nearest record is located within approximately 10 km north of the eastern section of the disturbance footprint near the Teviot Range and is dated 2006. A number of records exists within this area with dates as recent as 2019. Records occur in all directions within a 50 km buffer of the disturbance footprint with the majority of these restricted to forested reserves and national parks. The majority of records exists to the north-east between Ipswich and Brisbane and to the south-east at the Gold Coast Hinterland.

There is no habitat identified as important for woodland migrant species within the disturbance footprint, however, approximately 7.60 ha of potential habitat has been identified with the ecology study area (refer Table 4.29).

Assessment against the significant impact criteria for Spectacled monarch is shown in Table 5.9.

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 4,800 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).

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). 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 2020b).

Database records indicate this species occurs within the ecology study area to the north of the disturbance footprint at the Purga Nature Reserve recently (2019) and to the west of the footprint near Peak Crossing from 2002. No records occur within the disturbance footprint. Records within a 50 km buffer of the disturbance footprint occur in all directions with the highest densities of records occurring near or within nature reserves and national parks. Records occur outside forested areas but are sparser.

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. Few records occur within and around the ecology study area compared to those in the surrounding areas, it is unlikely that a significant proportion of the population will be impacted. There is no habitat identified as important for woodland migrant species within the disturbance footprint, however, approximately 7.60 ha of potential habitat has been identified with the ecology study area (refer Table 4.29). Given this species occupies forests and woodlands that provide dense understory vegetation areas of open forest and woodland are not contained within the ecology study area.

Assessment against the significant impact criteria for Rufous fantail is shown in Table 5.9.

Table 5.9 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	Important habitat for woodland migrants does not occur within the disturbance footprint (refer Table 4.29). Therefore, such habitat will not be substantially modified, destroyed or isolated. The total area of predicted habitat considered important for woodland migrants that occurs within the disturbance footprint is below the guideline threshold for all species outlined above.
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 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	Whilst breeding habitat for woodland migrants may occur within the disturbance footprint, the predicted area for various habitats may not be representative of the actual breeding habitat available for these species. Therefore, the areas provided are likely to be a vast over estimation, furthermore these areas fall below the guideline thresholds. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of woodland migrant species.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a ‘significant impact’ on woodland migrants will result from the Project.

5.3.3.3 Wetland migrants

This section provides a summary of information related each of the three wetland migratory species that have potential of 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 3-6 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 2020). Australian breeding habitat types include vegetated swamps in the semi-arid and arid regions. In Queensland this species breeds in Channel Country and wetlands of the Bulloo, Diamantina and Georgina River systems, occasionally including Cooper Creek (DAWE 2020b).

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 freshwater 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.

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. Invasive species that have the potential to impact the Glossy ibis include invasive plants that can alter or degrade the health of wetland ecosystems and exotic fish (tilapia) species that may outcompete with food resources (DAWE 2020b). 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.

Database records indicate this species occurs within the ecology study area to the north and south of the disturbance footprint east of the Ipswich Motorsport Precinct with two records dated 1999 and 2019. Another record occurs at the edge of the ecology study area near Goolman however, this is an old record (1979) and has a great degree of spatial uncertainty. Records occur in all directions within a 50 km buffer of the disturbance footprint and coincide with waterways. The majority of records occur to the north of the disturbance footprint between Toowoomba and Brisbane. Whilst records exist to the south of the disturbance footprint these are sparser.

The Project will intersect a number of waterways/watercourses and various construction phase activities are likely to impact water quality (refer EIS Appendix M: Surface Water Quality Technical Report). A total of 34 waterways will be crossed by the Project alignment, 7 of these will be intersected multiple times. Approximately 2.90 ha of important habitat will be removed as a result of the Project (refer Table 4.29).

Assessment against the significant impact criteria for Glossy ibis is shown in Table 5.10.

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 known to feed on crustaceans, insects, reptiles, birds and mammals (DAWE 2020b). 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 2020b). 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.

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 the ecology study area to the south of the eastern section of the disturbance footprint. This record is recent (2018) and occurs at Teviot Brook, a tributary of the Logan River. The next nearest record exists within approximately 10 km north of the disturbance footprint east of Rosewood and is dated 2012. Numerous records exist for this species within a 50 km buffer of the disturbance footprint with most of these occurring to the north-west, north, north-east, east and south-east. Whilst records occur to the south they are few, most records for this species occur along the eastern coastline. No raptor nests were identified during field investigaitons and therefore impacts to breeding individuals are unlikely to occur.

The Project will intersect a number of waterways/watercourses and various construction phase activities are likely to impact water quality (refer EIS Appendix M: Surface Water Quality Technical Report). A total of 34 waterways will be crossed by the Project alignment, 7 of these will be intersected multiple times. No important habitat for the Osprey will be removed as a result of the Project (refer Table 4.29).

Assessment against the significant impact criteria for Eastern osprey is shown in Table 5.10.

Yellow wagtail (*Motacilla flava*)

Yellow wagtails are a small passerine wagtail around 15-16cm long. Several races exist for this species however these are typically uniform grey-green or olive-green across the back and rump. The breast to vent underparts become bright yellow during breeding. This species does not breed in Australia and only breeding males are known to visit Australia. The species that breed in Europe, Siberia and Alaska migrate to Africa, south and south-east Asia, Indonesia and Papua New Guinea. They regularly migrate to the coastal regions of Australia during summer from Broome to north-east Queensland from November to April (Pizzey and Knight 2003). This species prefers open habitat near water, swamp margins, salt marshes, human modified landscapes such as sewage ponds and playing fields and can be found on drier inland plains (Morcombe 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. 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 occurrence 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 2020b).

Database records do not indicate that this species occurs within the disturbance footprint, ecology study area or from within a 50 km buffer of the disturbance footprint. The nearest records for this species occur a little more than 50 km north-east of the 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 2.90 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 5.10.

Table 5.10 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	There is no important habitat for the Osprey, while a total of 2.90 ha of important habitat for the Yellow wagtail and Glossy ibis will be removed as a result of the Project (refer Table 4.29). Compared to the available habitat in the surrounding landscape this area is not likely to be a significant reduction of habitat for these species. Therefore, no significant impact is anticipated as a result of the modification, destruction or isolation of 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 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	Whilst breeding habitat for wetland migrants (excluding Yellow wagtail) may occur within the disturbance footprint the predicted area for various habitats may not be representative of the actual breeding habitat available for these species. Therefore, the areas provided are likely to be a vast over estimation, furthermore these areas fall below the guideline thresholds. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of wetland migrant species.
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 matters of state environmental significance

The MNES Guideline Significant Residual Impact (SRI) 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 5.11 presents a preliminary significant residual impact assessment of the MSES identified as present in the desktop and field investigations, and in accordance with the SRI Guideline. The areas of significant impacts are based on the overall 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 disturbance footprint comprises 10 regional ecosystems as mapped by DNRME. This largely comprises eucalypt open forest and woodlands and Melaleuca low open woodland (refer Table 4.30). The analogous REs within this area include five listed as 'endangered', two listed as 'of concern' and three listed as 'least concern' (refer Section 4.4.18). There is also 118.00 ha of high value regrowth and 949.54 ha of non-remnant lands within the Project disturbance footprint (refer Table 4.17 and Table 4.18 for further information regarding REs within the 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 (the SRI Guideline) (DSDIP 2014). 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.

Assessment of significant residual impacts for MSES identified as present in the desktop and field review, and in accordance with the SRI Guideline is presented in Table 5.11

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 overall ecology study area and is likely to be a substantial overestimation of the final impact area following final design refinements for the Project.

Table 5.11 Preliminary significant residual impact assessment for matters for state environmental significance

MSES	Significant Residual Impact Guideline criteria	Significant impact
Regulated vegetation		
'Endangered' or 'of concern' regional ecosystem (RE)	An action is **LIKELY** to have a SRI on an 'endangered' or 'of concern' RE if the action will result in: (a) clearing of more than 5 ha 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 5 ha; **OR** (c) clearing that results in the physical separation of 'endangered' and 'of concern' RE communities within and on adjoining sites.	**Significant impact anticipated.** Under current Regulated Vegetation management (RVM) mapping the disturbance footprint encompasses 10.56 ha of 'endangered' and 9.02 ha of 'of concern' remnant vegetation (Category B) Clearing will result in the reduction of patches of 'endangered' vegetation to less than 5 ha The clearing will result in the physical separation of 'of concern' communities.
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)	**Remnant vegetation within the defined distance of a watercourse** An action is LIKELY to have a 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 1 ha 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 0.5 ha of an endangered or of concern RE, within the defined distance of a watercourse.	**Significant impact anticipated.** The defined distance for 1st and 2nd order, 3rd and 4th order, 5th order streams and greater in the disturbance footprint is 10 m, 25 m and 50 m respectively from a defined bank. The Project will require the permanent removal of 16.09 ha of Category B vegetation within the disturbance footprint.
Remnant vegetation intersection with a VM Act wetland	An action is **LIKELY** to have a 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 50 m of the defining bank of a defined wetland; **OR** (c) clearing involving the permanent removal of more than 50% of the vegetation located between 50 m and 100 m of the defining bank of a defined wetland.	**Significant impact anticipated.** There will be permanent removal of approximately 13.40 ha of Category B regulated vegetation within 100 m of the defining bank of a defined wetland within the disturbance footprint.

<table>
<tr><th>MSES</th><th>Significant Residual Impact Guideline criteria</th><th>Significant impact</th></tr>
<tr><td>Essential Habitat (EH)</td><td>An action is LIKELY to have a 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 approximately 25.89 ha of Category B regulated vegetation mapped as essential habitat within the disturbance footprint.</td></tr>
<tr><td colspan="3">Connectivity areas</td></tr>
<tr><td>Connectivity areas</td><td>In deciding if a 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 (5 km radius) given regard to the regional scale (20 km radius). Impact significance is measured by the reduction in the extent of remnant vegetation and increase in patchiness at the local scale.
In highly fragmented landscapes at the regional scale, a 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.</td><td>Significant impact anticipated.
The landscape Project impacts to the extent of remnant vegetation in the area have been analysed using DESs 'landscape fragmentation and connectivity' tool.
<u>Assessment result</u>
This analysis has determined a SIGNIFICANT impact on connectivity areas
(A significant reduction in core remnant at the local scale is False OR a change from core to non-core remnant at the site scale is True)
(Total area of RVM Cat B clearing is 27.29 hectares).</td></tr>
<tr><td>Wetlands and watercourses</td><td>An action is LIKELY to have a 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 50 m 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 200 m 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.</td><td>Significant impact not anticipated.
Several HES wetlands are recognised within the ecology study area (totalling 66 ha) with some in close proximity to the Project disturbance footprint. No areas of HES wetlands exist within the current disturbance footprint and will not be directly impacted from activities associated with the Project (refer EIS Appendix M: Surface Water Quality Technical Report).</td></tr>
<tr><td colspan="3">Designated precincts in Strategic Environmental Areas</td></tr>
<tr><td>Designated precincts in Strategic Environmental Areas</td><td>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</td><td>Significant impact not anticipated.
Outside of designated precincts in Strategic Environmental Areas.</td></tr>
</table>

MSES	Significant Residual Impact Guideline criteria	Significant impact
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 a 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 50 m 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 200 m 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 not anticipated.** The works are not considered to be in an 'urban area' as defined under Schedule 26 of the Sustainable Planning Regulation 2009. The works are located within 200 m of mapped HES wetlands located adjacent to Coveney Road (13 m from Project disturbance footprint), east of the Cunningham Highway (140 m from Project disturbance footprint) and east of Undullah Road (140 m from Project disturbance footprint). Whilst the project is in proximity to HES wetlands, it is unlikely that any potential impacts will permanent in consideration of proposed mitigation measures (refer to EIS Chapter 13: Surface Water and Hydrology).
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)** An action is UNLIKELY to have a 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 1000 m^2 not occurring in a relatively natural ecological situation (e.g. bushland), to a permanent retention area via an approved management plan. Refer to the assessment of the SRI Guideline significant impact criteria for threatened flora (refer Table 5.14)	**Significant impact anticipated.** Threatened flora and/or their associated habitat have been recorded in the disturbance footprint (*Marsdenia coronata* and *Melaleuca irbyana* and *Callitris baileyi*) during field surveys. However no comprehensive surveys have been undertaken to reliably determine the total number of threatened plants that will be removed as a result of the Project. At this stage it is assumed that translocation will not occur and that all plants within the site (i.e. disturbance footprint) will need to be removed.

MSES	Significant Residual Impact Guideline criteria	Significant impact
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 5.12) and Short-beaked echidna (refer Table 5.13).	**Significant impact anticipated.** There is potential for significant impacts to Powerful owl and Glossy-black cockatoo as suitable habitat for these species occur within the disturbance footprint. There are a number of other species which are also listed as MNES. These species have been assessed under the MNES Guidelines and as such are not assessed here (refer EIS Appendix K: Matters of National Environmental Significance Technical Report). The species specific assessments indicated there is a minor potential for significant residual impacts on Powerful owl and Glossy Black-cockatoo. **There is no Significant impact anticipated** for the Tusked frog or the Short-beaked echidna
Fish habitat area		
An area declared under the *Fisheries Act 1994* (Qld) to be a fish habitat area	An action is LIKELY to have a 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 disturbance footprint within the declared FHA and/or highly protected marine park zone of 40 m^2 or greater in area.	**Significant impact not anticipated.** No declared fish habitat areas mapped within the ecology study area.
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 a 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** 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 d) level that would increase stress on fish populations.	**Significant impact not anticipated.** There are 34 individual waterways which cross the Project alignment. Of these 11 are mapped as 'low', 11 are mapped as 'moderate', four are mapped as 'high' and eight are mapped as 'major'. Of these 34 waterways, seven are intersected multiple times. 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. 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 threatened species assessments

Sections 4.4.1.1 and 4.4.2.1 details the threatened species as known or possibly occurring within the ecology study area. The ecology study area provides possible habitat values for a number of threatened species, including a number of species listed as MNES and MSES. Assessment of the occurrence and potential impact significance of the Project to MNES species that are a controlling provision under the EPBC Act is provided within EIS Appendix K: Matters of National Environmental Significance Technical Report. The assessment of MNES that are not a controlling provision of the project (i.e. non-threatened migratory species) is provided in Section 5.3.3. The ecology study area provides habitat suitable for Powerful owl (vulnerable under the NC Act), Glossy-black cockatoo (vulnerable under the NC Act) and Short-beaked echidna (SLC under the NC Act). Predictive habitat mapping for these species has been based on publicly available datasets as well as ground-truthed data and is considered to constitute a conservative approach for assessment of impacts at the Primary approval stage of the Project (i.e. is likely to overestimate potential impacts as a result of the Project).

The SRI Guideline criteria for assessing significant impacts to vulnerable species are similar in some respects to the criteria set out for threatened species in the MNES Guidelines. Table 5.12 provides a significant impact assessment for Powerful owl, Glossy-black cockatoo, Table 5.13 provides an assessment for Short-beaked echidna and Table 5.14 provides an assessment for Bailey's cypress (*Callitris baileyi*), Slender milkvine (*Marsdenia coronata*) and Swamp tea-tree (*Melaleuca irbyana*) in accordance with the SRI Guideline criteria.

Table 5.12 Matters of State environmental significance significant residual impact criteria – Threatened fauna

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Tusked frog)
Lead to a long term decrease in the size of a local population of the species	Powerful owl has been recorded within the ecology study area previously (2011) where the alignment intersects the Teviot Range. There are several nearby recent sightings to the north of the Project in the Flinders Peak area, including a 2019 record from the Flinders-Goolman Conservation Estate approximately 3 km north of the disturbance footprint. There are a number of other specimen backed records from around the Project, including the eastern section of the alignment where records exist to the south, south-east and north of the Project. The surrounding areas immediately adjacent to the disturbance footprint include suitable habitat for the species and will not be disturbed by the Project. There is a total of 21.54 ha of suitable roosting and foraging habitat for the species within the disturbance footprint. This species occupies large home ranges (around 1,000 ha). The Project largely will follow an area that passes through previously disturbed lands (existing road). Whilst records exist within the ecology study area and surrounds there are none from within the disturbance footprint. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' large home range it is likely that the Project would only have a very minor impact on a local individual's home range, should the species occur in the disturbance footprint. The Project is not expected to lead to a long term decrease in the size of a local population.	Glossy-black cockatoo feeding signs were recorded from within the ecology study area, approximately 300 m north of the disturbance footprint on the western edge of the Flinders Peak area (GHD 2016). There are several database records from the surrounding region. The nearest specimen backed record is from Rosewood (1990) 4 km to the north of the Project. There are recent records (2015 and 2017) in the Grandchester area within 10 km to the west. In the east there are post-2000 records in the White Rock/Spring Mountain area with the most recent record from 2018. There is an estimated 50.63 ha of suitable habitat for the species within the disturbance footprint, although this is likely to be an overestimation. They feed almost exclusively on the seeds of species of she-oaks. In the ecology study area they will feed on *Allocasuarina littoralis* and *Casuarina cunninghamiana.* However, feeding areas are often restricted, to one or two species showing a strong fidelity to particular trees. This species is capable of traveling 10 km from roosting or nesting sites to feed trees and require large hollow trees for nesting. There is substantial remnant and regrowth vegetation surrounding the Project (particularly in the east). There are also a number of specimen backed records from 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. It is uncertain how many individuals may use habitat within the disturbance footprint. The need for large hollow bearing trees and *Allocasuarina/casuarina* food trees indicates that a reduction of these resources has the potential to reduce suitable habitat for the species. Nevertheless, given the small area that will be impacted within the disturbance footprint and 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.	Tusked frog has not been recorded from within the ecology study area or the disturbance footprint. The disturbance footprint comprises of 10.21 ha of suitable habitat for the species. The nearest database records for the species occur approximately 6.5 km north of the disturbance footprint at Teviot Range (near Mount Elliot). One of these records is old (1961) whilst the other is more recent (2011). Most database records within a 50 km buffer of the disturbance footprint occur within or close to national parks and forest reserves at Main Range, Lockyer Valley, D'Aguilar, Gold Coast hinterland and Mount Barney. These are most concentrated between Brisbane and surrounds as well as Gold Coast hinterland. In south-east Queensland the species has undergone serious declines due to amphibian chytrid fungus (Hines et al. 1999; Hines et al. 2004; Hines 2012). Within the Scenic Rim the species persists and is widespread in areas associated with lowlands and foothills east of the Great Dividing Range where it can be found in wet eucalypt forest, rainforest and occasionally dry eucalypt habitat in close proximity to suitable breeding habitat. Breeding habitat consists of ponds and slow-moving sections of streams (Cogger 2000; Meyer et al. 2001; Hines 2012). Habitat was confirmed to occur for this species within the Teviot Range. The alignment will intersect a total of 34 waterways, seven of which will be crossed multiple times. These constitute habitat for this species. Database records for the species could be an indication that a local population is present even though records are absent from the ecology study area and disturbance footprint. Whilst there is potential to impact habitat for the species these impacts will be temporary. Whilst there is potential to present a short-term impact the Project is not likely to lead to a long term decrease in the size of a local population of the species.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Tusked frog)
Reduce the area of occurrence of the species	It is likely the species occurs in the area given the specimen backed records from the ecology study area and surrounds. The disturbance footprint is estimated to contain 21.54 ha of habitat considered suitable for the species. The species occupies large home ranges (around 1,000 ha) and it is likely that the species occurs in the area given the specimen backed records. It is likely that the Project may reduce the area of occupancy of the species should it occur within the disturbance footprint but only to a very minor extent.	The disturbance footprint is estimated to contain 50.63 ha of habitat considered suitable for the species although this is likely to be a substantial overestimate. It is likely that the species occurs in the area given the specimen backed records. It is likely that the Project will 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 disturbance footprint is estimated to contain 10.21 ha of habitat considered suitable for the species. The Project is not considered likely to reduce the area of occurrence of the species. Although possible, it is unlikely that the species occurs in the area given a lack of database records and historical reduction in population sizes due to disease. There is potential for the Project to reduce the area of occupancy of the species but only to a very minor extent and therefore not considered to be significant.
Fragment an existing population	The disturbance footprint comprises of 21.54 ha of suitable roost/foraging habitat for the species representing only a minor proportion of an individual's home range. There are large areas of similar habitat to the north and south of the Project that would be considered suitable habitat for the species along with areas to the south. The linear nature of the Project has potential to fragment sedentary species, however Powerful owl is highly mobile. The Project is considered unlikely to fragment an existing population.	The disturbance footprint is predicted to contain 50.63 ha of habitat considered suitable for the species although this is likely to be a substantial overestimate. There are large areas adjacent to the north and south of the eastern half of the disturbance footprint that would be considered suitable habitat for the species along with areas to the south that include a number of specimen backed records. 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 disturbance footprint comprises 10.21 ha of suitable habitat for the species. There are extensive areas to the north of the Project associated with existing specimen backed records that would provide suitable habitat for the species and will be left undisturbed. Whilst it is possible the species occurs to the south of the Project where the alignment intersects the Teviot Range no database records exist to confirm this. The Project is linear and the species terrestrial, where the alignment intersects suitable habitat for the species there is potential to fragment as existing population. Nevertheless, the final design of the Project will incorporate fauna crossing structures allowing passage across the alignment. Given the small area of predicted habitat and final design considerations the Project is considered unlikely to fragment an existing population.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Tusked frog)
Result in genetically distinct populations forming as a result of habitat isolation	The disturbance footprint comprises 21.54 ha of suitable roost/foraging habitat for the species representing only a minor proportion of an individual's home range. There is extensive habitat to the north and south of the Project that would be considered suitable habitat. The linear nature of the Project could fragment existing populations; however, the species is highly mobile. The Project will not result in habitat isolation occurring on a local population of the species.	The disturbance footprint is predicted to contain 50.63 ha of habitat considered suitable for the species although this is likely to be a substantial overestimate. There are large areas adjacent to the north and south of the eastern half of the disturbance footprint that would be considered 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 disturbance footprint comprises 10.21 ha of suitable habitat for the species. There are extensive areas to the north of the Project associated with existing specimen backed records that would provide suitable habitat for the species and will be left undisturbed. Whilst it is possible the species occurs to the south of the Project where the alignment intersects the Teviot Range no database records exist to confirm this. The Project is linear and the species terrestrial, where the alignment intersects suitable habitat for the species there is potential to fragment as existing population. Nevertheless, the final design of the Project will incorporate fauna crossing structures allowing passage across the alignment. Given the small area of predicted habitat and final design considerations the Project is considered unlikely to 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	Prior to construction, a Biosecurity Management Plan will be developed and will incorporate measures to control the introduction and spread of weed and pest species across the ecology study area. The local landscape is already subject to extensive weed infestation with *Lantana camara* in forest habitats and exotic grasses in agricultural habitats. Measures provided in the Biosecurity Management Plan will aim to minimise the potential for weed invasion and ensure feral predators (i.e. wild dogs/dingo) are controlled in the area. 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 Biosecurity Management Plan will incorporate measures for 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	There is no State recovery plan for Powerful owl. The disturbance footprint comprises 21.54 ha of suitable roost/foraging habitat for the species representing a minor proportion of the home range of individuals, should any that occur in the area. The Project will not interfere with the recovery of the species.	There is no State recovery plan for Glossy Black-cockatoo. The disturbance footprint comprises a maximum of 50.63 ha of suitable roost/foraging habitat for the species which is likely to be an overestimate. There is abundant similar habitat in the surrounding area. The Project is considered unlikely to interfere with the recovery of the species.	There is no State recovery plan for the Tusked frog. The disturbance footprint comprises a maximum of 10.21 ha of suitable habitat for the species which is likely to be an overestimate. There is abundant similar habitat in the surrounding area. The Project is considered unlikely to interfere with the recovery of the species.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Glossy-black cockatoo)	Assessment against significance criteria (Tusked frog)
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 the species may breed. The species breeds from late autumn to mid-winter. The species has potential to be encountered during vegetation clearing for the Project. Where possible construction clearing in suitable habitat will be programmed to occur outside of the breeding season. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher during clearing, including pre-clearing surveys to investigate potential habitat features (such as tree hollows). Nevertheless, the Project has potential to disrupt an ecologically significant location.	Ecologically significant locations include large tree hollows in which this species relies on for breeding and *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 tree hollows). Nevertheless, the Project has potential to disrupt an ecologically significant location.	Ecologically significant locations for this species could include ponds and slow-moving streams in close proximity to rainforest and wet eucalypt habitat. Removal of vegetation where the alignment intersects waterways will be permanent and therefore the 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, including pre-clearing surveys to investigate the presence potential habitat and breeding sites. 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.
Assessment of potential for significant residual impacts	The species occupies large home ranges (around 1,000 ha). The Project will result in the clearance of 21.54 ha of habitat suitable for Powerful owl which has a very minor potential to reduce the area of occurrence of the species. Nevertheless, there is extensive suitable habitat surrounding the Project. This is not considered to be of an extent such that significant residual impacts on Powerful owl are likely to occur. The Project also has potential to disrupt an ecologically significant location (large tree hollows) should the species be found within the disturbance footprint. Mitigation measures will be applied; however, the Project still has a minor potential to cause a 'significant residual impact' on this species. **Project has potential to cause a 'significant residual impact' on this species**.	The Project will result in the clearance of 50.63 ha of 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**.	**No significant residual impacts are considered likely to occur for this species**.

Table 5.13 Matters of State environmental significance Guideline criteria – Special Least Concern fauna species

Criteria	Assessment against significance criteria (Short-beaked Echidna)
Lead to a long term decrease in the size of a local population of the species	Echidna has been recorded from within the ecology study area previously (1999) as well as the surrounding landscape. The disturbance footprint comprises of 67.64 ha of suitable habitat for the species. This is a wide ranging species which occurs all over Australia and 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). Specimen backed records indicate there is extensive suitable habitat surrounding the Project, particularly to the north, which will remain undisturbed. Whilst records exist within the ecology study area there are none from within the disturbance footprint. Given the relatively small amount of suitable habitat that is estimated to be removed when compared to the species' large home range it likely that the Project will only have a minor impact on a local individual's home range. 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 disturbance footprint is estimated to contain 67.64 ha of 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.
Fragment an existing population	The disturbance footprint comprises 67.64 ha of suitable habitat for the species. There are extensive areas to the north and south 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 that this is a terrestrial species there is potential to fragment populations to the north and south of the disturbance area. Nevertheless, the final design of the Project will incorporate fauna crossing structures allowing passage across the alignment. The Project is considered unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The disturbance footprint comprises of 67.64 ha of suitable habitat for the species representing a significant proportion of an individual's home range. There are extensive areas to the north and south 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 populations to the north and south of the disturbance area. Nevertheless, the final design of the Project will incorporate fauna crossing structures allowing passage across the alignment. The Project is considered unlikely to 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.
Assessment of potential for significant residual impacts	**No significant residual impacts are considered likely to occur for this species**.

Table 5.14 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 Slender milkvine (*Marsdenia coronata*)	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 previously (1987) within 500 m from the rail corridor. Whilst this is a reliable specimen back record there is a spatial uncertainty of 10,000 m. More recent records (2019) occur outside of the ecology study area. A total of 11.43 ha of general habitat for the species is estimated to be within the disturbance footprint (refer Table 4.28). Many specimen backed records occur in the surrounding area which will not be disturbed by the Project. Whilst records exist within the ecology study area there are none from within the disturbance footprint. 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.	*Marsdenia coronata* has been recorded within the ecology study area on two occasions (2001 and 2017) within 500 m and 1 km from the rail corridor. A total of 61.85 ha of general habitat for the species is estimated to be within the disturbance footprint (refer Table 4.28). Many specimen backed records occur to the north-east and east of the Project. Given that this species is restricted in its distribution to Southeast Queensland, occurrence records in relation to the Project are at the edge of its distribution. Any loss of individuals will result in a long term decrease in population size locally. Specimen backed records occur to the south of the Project however, these records have the potential to be genetically isolated from specimens near the Project.	*Melaleuca irbyana* has been recorded within the ecology study area previously (1970). 12 occurrence records exist for this species within the ecology study area more recently (2018) and no more than 50 m from the Project disturbance footprint. A total of 237.73 ha of total habitat (i.e. 132.42 ha general habitat, 45.69 ha essential habitat and 59.63 ha core habitat) (refer Table 4.28) for the species is estimated to be within the disturbance footprint. Specimen backed records occur around the Project except to the south. However it is to be noted that the species doe not occur uniformly across area of habitat, and may often occur as isolated plants or as dense stands. Further information related to *Melaleuca irbyana* is presented in EIS Appendix K: Matters of National Environmental Significance Technical Report Given that this species is restricted in its distribution to Southeast Queensland, occurrence records in relation to the Project are at the edge of its distribution. Any loss of individuals will result in a long term decrease in population size locally.
Reduce the area of occurrence of the species	The disturbance footprint is estimated to contain 11.43 ha of general habitat for the species (refer Table 4.28). There is potential for this species to occur within the ecology study area and it is likely that the Project will reduce the area of occupancy of the species but only to a minor extent.	The disturbance footprint is estimated to contain 61.85 ha of general habitat for the species and it is likely that the species occurs in the area given the specimen backed records. It is likely that the Project will reduce the area of occupancy of the species further restricting its south-western distribution locally.	The Project is estimated to contain 237.73 ha of total habitat for the species with the species known to occur within the disturbance footprint. Therefore, it is likely that the Project will result in a reduction of the area of occurrence for *M. irbyana* due to clearing activities.

Criteria	Assessment against significance criteria Bailey's cypress (*Callitris baileyi*)	Assessment against significance criteria Slender milkvine (*Marsdenia coronata*)	Assessment against significance criteria Swamp tea-tree (*Melaleuca irbyana*)
Fragment an existing population	The disturbance footprint comprises of 11.43 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. 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.	The disturbance footprint comprises of 61.85 ha of general habitat for the species. The Project, although linear in its design is not wide enough to separate this species into fragmented populations. Therefore, the Project is considered unlikely to fragment an existing population.	The disturbance footprint comprises of 237.73 ha of total habitat for the species. The Project, although linear in its design is not wide enough to separate this species into fragmented populations. Therefore, the Project is considered unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The disturbance footprint comprises of 11.43 ha of general habitat for the species. The Project, although linear in its design is not wide enough to separate this species into genetically distinct populations. The Project is not likely to produce genetically distinct populations through the process of habitat isolation.	The disturbance footprint comprises of 61.85 ha of general habitat for the species. The Project, although linear in its design is not wide enough to separate this species into genetically distinct populations. The Project is not likely to produce genetically distinct populations through the process of habitat isolation.	The disturbance footprint comprises of 237.73 ha of total habitat for the species. The Project, although linear in its design is not wide enough to separate this species into genetically distinct populations. The Project is not likely to produce genetically distinct populations through the process of habitat isolation.
Result in invasive species that are harmful to a vulnerable species becoming established in the species habitat	Prior to construction, a Biosecurity Management Plan will be developed and will incorporate measures to control the introduction and spread of weed and pest species across the ecology study area. The local landscape is already subject to extensive weed infestation with *Lantana camara*. 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 Biosecurity Management Plan will incorporate measures for 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. Given that the disturbance footprint comprises of 11.43 ha of general habitat for the species only a minor proportion of the overall distribution will be impacted.	No State recovery plan exists for *M. coronata*. 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 61.85 ha of general habitat may interfere with the recovery of this species locally.	No State recovery plan exists for *M. 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 237.73 ha of total habitat may interfere with the recovery of this species locally.

Criteria	Assessment against significance criteria Bailey's cypress (*Callitris baileyi*)	Assessment against significance criteria Slender milkvine (*Marsdenia coronata*)	Assessment against significance criteria Swamp tea-tree (*Melaleuca irbyana*)
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 potential for this species to be encountered during vegetation clearing for the Project although unlikely given the small area of suitable habitat for the species within the disturbance footprint.	Ecologically significant locations could be considered as small populations at risk of local extinction. There is potential for this species to be encountered during vegetation clearing for the Project given that there are two specimen backed records from within the ecology study area. Occurrence records from Flinder's Peak Conservation Park could consist of an isolated population resulting from historical land clearing to the east. Any loss of individuals would result in further reduction of this population and disruption to ecologically significant locations.	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 ecology study area. 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.
Assessment of potential for significant residual impacts	The Project will result in the clearance of 11.43 ha of general habitat for *C. baileyi* which has potential to reduce the area of occurrence of a small population particularly where SEVT occurs. **Project has potential to cause a 'significant residual impact' on this species.**	The Project will result in the clearance of 61.85 ha of general habitat for *M. coronata* which has potential to reduce the area of occurrence for the species locally. The Project also has potential to disrupt an ecologically significant location (localised range reduction). **Project has potential to cause a 'significant residual impact' on this species.**	The Project will result in the clearance of 237.73 ha of total suitable for *M. 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.**

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 Table 5.6), 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 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 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 offset 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 may occur:

- Endangered or Of concern REs
- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature)
- Remnant vegetation intersection with a VM Act wetland
- Essential Habitat
- Connectivity areas
- Protected wildlife habitat for the following species:
  - Bailey's cypress (*Callitris baileyi*)
  - Slender milkvine (*Marsdenia coronata*)
  - 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 5.15.

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 K within this report. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans.

Table 5.15 Quantification of anticipated significant residual impacts

Sensitive environmental receptor	Identified Significant residual Impact following assessment against the MSES Guidelines (refer Sections 5.3.3 and 5.3.4)
Regulated vegetation	
'Endangered' regional ecosystem (RE)	10.56 ha
'Of concern' regional ecosystem (RE)	9.02 ha
a prescribed RE (Category B other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature	16.09 ha
Remnant vegetation intersection with a VM Act wetland	13.40 ha
Essential Habitat	25.89 ha
Connectivity areas	
Regional Terrestrial corridors	87.86 ha
State Riparian corridors	40.86 ha
State Terrestrial corridors	119.80 ha
Protected wildlife habitat	
Flora	
Bailey's cypress (*Callitris baileyi*)	11.43 ha
Slender milkvine (*Marsdenia coronata*)	61.85 ha
Swamp tea-tree (*Melaleuca irbyana)*	237.73 ha
Fauna	
Glossy-black cockatoo (*Calyptorhynchus lathami*)	50.63 ha
Powerful owl (*Ninox strenua*)	21.54 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 Cumulative impact assessment

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 6.1).

The cumulative impacts of multiple projects occurring in the vicinity of the 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, 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 sensitive 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 6.1.

The results of the significance assessment of these cumulative impacts are presented in Table 6.2.

Table 6.1 Cumulative impacts as calculated for within the Cumulative impact study area

Sensitive environmental receptor	A. Extent within cumulative impact study area (50 km extent) (ha) (i.e. 1,280,613 ha)	B. Extent within cumulative impact disturbance footprint (defined projects (Figure 3.4)) (i.e 30,732 ha)	C. Extent within cumulative impact disturbance footprint (defined projects (Figure 3.4)) including the disturbance footprint	D. Percentage (%) total disturbance to sensitive environmental receptors within Cumulative impact study area	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact disturbance footprint	F. Magnitude of contribution to disturbance (refer Table 3.5 for magnitude criteria) considering D and E
Commonwealth significant environmental constraints						
Migratory species						
Osprey (*Pandion haliaetus*)	72,174.38	671.49	713.92	0.99	5.94	Low
Oriental cuckoo (*Cuulus optatus*)	34,032.46	604.76	612.35	1.80	1.24	Low
Satin flycatcher (*Myiagra cyanoleuca*)	34,032.46	604.76	612.35	1.80	1.24	Low
Rufous fantail (*Rhipidura rufifrons*)	34,032.46	604.76	612.35	1.80	1.24	Low
Black-faced monarch (*Monarcha melanopsis*)	34,032.46	604.76	612.35	1.80	1.24	Low
Spectacled monarch (*Symposiachrus trivirgatus*)	34,032.46	604.76	612.35	1.80	1.24	Low
Yellow wagtail (*Motacilla flava*)	119,499.11	873.04	918.37	0.77	4.94	Low
Common sandpiper (*Actitis hypoleucos*)	119,499.11	873.04	918.37	0.77	4.94	Low
Sharp-tailed sandpiper (Calidris acuminata)	119,499.11	873.04	918.37	0.77	4.94	Low
Latham's snipe (Gallinago hardwickii)	119,499.11	873.04	918.37	0.77	4.94	Low
Glossy ibis (*Plegadis falcinellus*)	119,499.11	873.04	918.37	0.77	4.94	Low
State significant environmental constraints						
Regulated vegetation (VM Act)						
Category B - Remnant vegetation	153,277.44	3,055.12	3,088.68	2.02	1.09	Low
Category C - High value regrowth	80,331.37	1,578.96	1,696.96	2.11	6.95	Low
MSES wildlife habitat	252,581.68	1,124.91	1,213.88	0.48	7.33	Low
Essential habitat	345,679.69	4,516.47	4,542.36	1.31	0.57	Low
State Significant Environmental Constraint: Nature Conservation (Koala) Conservation Plan 2017 mapping						
Koala Priority Areas	321,377.89	168.61	427.09	0.13	60.52	Low
Koala Habitat Areas	342,281.26	6,023.90	6,169.47	1.80	2.36	Low

Sensitive environmental receptor	A. Extent within cumulative impact study area (50 km extent) (ha) (i.e. 1,280,613 ha)	B. Extent within cumulative impact disturbance footprint (defined projects (Figure 3.4)) (i.e 30,732 ha)	C. Extent within cumulative impact disturbance footprint (defined projects (Figure 3.4)) including the disturbance footprint	D. Percentage (%) total disturbance to sensitive environmental receptors within Cumulative impact study area	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact disturbance footprint	F. Magnitude of contribution to disturbance (refer Table 3.5 for magnitude criteria) considering D and E
Koala Habitat Restoration Areas	203,926.47	2,050.92	2,346.05	1.15	12.58	Low
Locally Refined Koala Habitat Areas	1,662.53	0.00	27.92	1.68	100.00	Low
Threatened flora habitat (NC Act)						
Bailey's cypress (*Callitris baileyi*)	181,747.01	3,579.72	3,591.15	1.98	0.32	Low
Slender milkvine (*Marsdenia coronata*)	47,557.51	64.19	126.04	0.27	49.07	Low
Swamp tea-tree (*Melaleuca irbyana*)	436,561.90	4,849.88	5,087.61	1.17	4.67	Low
Threatened fauna habitat (NC Act)						
Tusked frog (*Adelotus brevis*)	62316.99	512.27	522.48	0.84	1.95	Low
Powerful owl (*Ninox strenua*)	94,169.65	93.57	115.10	0.12	18.71	Low
Glossy-black cockatoo (*Calyptorhynchus lathami*)	127,620.97	31.29	81.92	0.06	61.81	Low
NC Act Least concern and Special least concern species						
Echidna (*Tachyglossus aculeatus*)	515,438.17	6,868.68	6,936.32	1.35	0.98	Low
Least concern flora and fauna	1,280,61	30,732.68	31,709.50	2.48	3.08	Low
Priority Back on Track species (not listed under the EPBC Act or NC Act)	1,280,613.21	30,732.68	31,709.50	2.48	3.08	Low
Biodiversity Planning Assessment (BPA)						
BPA habitat values for EVNT taxa (state)	127,231.32	703.16	820.08	0.64	14.26	Low
BPA habitat values for EVNT taxa (regional)	41,086.07	469.04	470.39	1.14	0.29	Low
Regional Terrestrial corridors	259,694.10	3,692.86	3,780.72	1.46	2.32	Low
State Riparian corridors	59,764.92	1,563.59	1,604.45	2.68	2.55	Low
State Terrestrial corridors	245,359.82	52.20	172.00	0.07	69.65	Low

Table 6.2 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 significant environmental constraints							
Commonwealth Significant Ecological Constraint (Species as migratory under the EPBC Act): ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Oriental cuckoo (*Cuculus optatus*) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Black-faced monarch (*Monarcha melanopsis*) ▪ Spectacled monarch (*Symposiachrus trivirgatus*) ▪ Yellow wagtail (*Motacilla flava*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Osprey (*Pandion haliaetus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Rufous fantail (*Rhipidura rufifrons*)	▪ Habitat loss from vegetation clearing/removal	1	3	1	3	8	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 environmental constraints							
State Significant Environmental Constraint (VM Act): ▪ Remnant vegetation (REs) (Category B).	▪ 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

Sensitive environmental receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
State Significant Environmental Constraint (VM Act): ▪ High value regrowth (HVR) vegetation (Category C).	▪ 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 Environmental Constraint: ▪ MSES wildlife habitat. ▪ Essential habitat mapping	▪ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	2	2	1	3	8	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 Environmental Constraint: Nature Conservation (Koala) Conservation Plan 2017 mapping, including: ▪ Koala Priority Areas ▪ Koala Habitat Areas ▪ Koala Habitat Restoration Areas ▪ Locally Refined Koala Habitat Areas	▪ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	2	2	1	3	8	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 Environmental Constraint (species listed as threatened under the NC Act): **Flora**: ▪ *Callitris baileyi* (Bailey's cypress) ▪ *Marsdenia coronata* (Slender milkvine) ▪ *Melaleuca irbyana* (Swamp tea-tree) **Fauna:** ▪ Tusked frog (*Adelotus brevis*) ▪ Powerful owl (*Ninox strenua*) ▪ Glossy-black cockatoo (*Calyptorhynchus lathami*)	▪ 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 Environmental Constraint: ▪ Special Least concern fauna species: 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 Environmental 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 Environmental 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 Environmental Constraint (BPA): ▪ State habitat for EVNT taxa	▪ Habitat loss from vegetation clearing/removal	1	3	1	3	8	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 Environmental Constraint (BPA): ▪ Regional habitat values for EVNT taxa.	▪ Habitat loss from vegetation clearing/removal	1	3	1	2	7	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 Environmental Constraint (BPA): ▪ State (riparian and terrestrial) ecological corridors.	▪ Habitat loss from vegetation clearing/removal	1	3	1	3	8	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 Environmental Constraint (BPA): ▪ **Regional** ecological corridors.	▪ Habitat loss from vegetation clearing/removal	1	3	1	2	7	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

Table notes:

1 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

7 Conclusion

This report has been prepared in accordance with Sections 11.96 – 11.108 of the Terms of Reference for an environmental impact statement: Inland Rail Calvert to Kagaru Project issued by the Coordinator-General. This document has been prepared to accompany EIS Appendix K: 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 a six NC Act listed conservation significant species (i.e. three plants and three animals) (non-MNES) as well as potential habitat for 11 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 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).

Thirty-one (31) 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 5.2.2. 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 Guidelines, there are **no significant impacts expected** for the following non-threatened EPBC Act listed migratory species:

- Osprey (*Pandion haliaetus*)
- Oriental cuckoo (*Cuculus optatus*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Rufous fantail (*Rhipidura rufifrons*)
- Black-faced monarch (*Monarcha melanopsis*)
- Spectacled monarch (*Symposiachrus trivirgatus*)
- Yellow wagtail (*Motacilla flava*)
- Common sandpiper (*Actitis hypoleucos*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Latham's snipe (*Gallinago hardwickii*)
- Glossy ibis (*Plegadis falcinellus*).

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:

- Endangered or Of concern REs
- Regulated vegetation (Category B (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature)
- Remnant vegetation intersection with a VM Act wetland
- Essential Habitat
- Connectivity areas
- Protected wildlife habitat for the following species:
  - Bailey's cypress (*Callitris baileyi*)
  - Slender milkvine (*Marsdenia coronata*)
  - Swamp tea-tree (*Melaleuca irbyana*)
  - Glossy-black cockatoo (*Calyptorhynchus lathami*)
  - Powerful owl (*Ninox strenua*)

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 K 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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