

UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Planning Alliance

UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Upgrade

Working paper: Biodiversity Assessment

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FINAL

Contents

Executive summary

| | | |
|-----------|---|------------|
| 1. | Introduction | 1 |
| 1.1. | Overview | 1 |
| 1.2. | Project description | 1 |
| 1.2.1. | Definitions | 10 |
| 1.2.2. | Previous development projects | 11 |
| 1.3. | Structure and content of the assessment | 12 |
| 1.4. | Legislative requirements | 12 |
| 1.4.1. | Study objectives and purpose | 12 |
| 1.4.2. | State legislation and assessment requirements | 17 |
| 1.4.3. | Commonwealth legislation | 18 |
| 1.4.4. | Relevant State and Commonwealth guidelines | 19 |
| 2. | Methodology | 20 |
| 2.1. | Assessment approach | 20 |
| 2.1.1. | Potential constraints and limitations | 22 |
| 2.1.2. | Precautionary principle | 24 |
| 2.2. | Landscape context | 24 |
| 2.3. | Preliminary assessment | 25 |
| 2.3.1. | Consulting key stakeholders | 25 |
| 2.3.2. | Collation and review of existing information | 26 |
| 2.3.3. | Previous project development ecological assessments | 27 |
| 2.3.4. | Additional survey requirements | 30 |
| 2.4. | Field surveys | 33 |
| 2.4.1. | Summary of flora survey effort | 34 |
| 2.4.2. | Vegetation and flora survey methods | 37 |
| 2.4.3. | Fauna surveys methods | 49 |
| 2.4.4. | Fauna survey effort | 51 |
| 2.4.5. | Summary of survey effort for threatened fauna | 62 |
| 2.4.6. | Fauna habitat assessment and mapping | 97 |
| 2.4.7. | Emu studies | 98 |
| 2.4.8. | Aquatic survey effort | 101 |
| 2.5. | Important wetlands | 107 |
| 2.6. | Subject species assessment | 107 |
| 2.7. | Significance assessments | 108 |
| 2.8. | Taxonomy and nomenclature | 109 |
| 3. | Existing environment | 110 |
| 3.1. | Bioregional context | 110 |
| 3.1.1. | National parks and nature reserves | 111 |

| | | |
|-----------|---|------------|
| 3.1.2. | State forests | 115 |
| 3.2. | Landscape context | 115 |
| 3.2.1. | Land tenure and land use | 120 |
| 3.2.2. | Key habitats and corridors | 121 |
| 3.3. | Historic and social context | 125 |
| 3.4. | Vegetation communities | 125 |
| 3.5. | Fauna habitats | 186 |
| 3.5.1. | Fauna habitat types | 186 |
| 3.5.2. | Forest habitat condition | 189 |
| 3.6. | Fauna species | 248 |
| 3.6.1. | Vertebrate fauna | 248 |
| 3.6.2. | Invertebrate fauna | 248 |
| 3.7. | Aquatic habitats | 249 |
| 3.7.1. | Watercourses | 251 |
| 3.7.2. | Important wetlands | 253 |
| 3.8. | Fish species | 268 |
| 3.9. | Species, populations and communities of conservation concern | 268 |
| 3.9.1. | Threatened ecological communities | 268 |
| 3.9.2. | Emu populations in the NSW North Coast Bioregion | 272 |
| 3.9.3. | Threatened flora | 276 |
| 3.9.4. | Threatened fauna | 298 |
| 3.9.5. | Migratory species | 309 |
| 3.9.6. | Threatened fish | 312 |
| 3.9.7. | Threatened invertebrates | 315 |
| 3.10. | Other species likely to occur in the study area | 317 |
| 3.10.1. | Threatened flora | 317 |
| 3.10.2. | Threatened fauna and invertebrates | 318 |
| 3.10.3. | Threatened fish | 319 |
| 3.11. | Emu vehicle collision study | 320 |
| 3.11.1. | Temporal patterns in frequency of road-kills | 320 |
| 3.11.2. | Spatial patterns in road-kills | 321 |
| 3.11.3. | Site characteristics and road-kills | 323 |
| 3.11.4. | High risk locations for emu collisions | 324 |
| 4. | Evaluation of impacts | 325 |
| 4.1. | Overview | 325 |
| 4.2. | Avoidance measures | 325 |
| 4.2.1. | Key considerations to avoid and minimise biodiversity impacts | 325 |
| 4.2.2. | Route selection | 326 |
| 4.2.3. | Avoidance during detailed design | 326 |
| 4.2.4. | Ancillary facilities | 327 |
| 4.3. | Potential impacts | 328 |
| 4.3.1. | Loss of native vegetation | 328 |

| | | |
|-------------------|--|------------|
| 4.3.2. | Loss of habitat for fauna | 347 |
| 4.3.3. | Direct mortality of native fauna | 376 |
| 4.3.4. | Loss of habitat connectivity | 377 |
| 4.3.5. | Habitat fragmentation | 379 |
| 4.3.6. | Edge effects, noise and light impacts | 384 |
| 4.3.7. | Impacts to groundwater dependent ecosystems | 386 |
| 4.3.8. | Impacts to aquatic ecosystems | 387 |
| 4.3.9. | Weeds and pests | 398 |
| 4.3.10. | Spread of pathogens | 402 |
| 4.4. | Key threatening processes | 403 |
| 4.5. | Regional scale cumulative impacts | 406 |
| 4.5.1. | State of the environment | 406 |
| 4.5.2. | Historical vegetation loss | 406 |
| 4.5.3. | Past and future activities | 408 |
| 4.5.4. | Mitigation of cumulative impacts | 412 |
| 5. | Mitigation and management | 413 |
| 5.1. | Objectives and framework | 413 |
| 5.2. | Mitigation strategy | 415 |
| 5.2.1. | Biodiversity Connectivity Strategy | 415 |
| 5.2.2. | Flora and Fauna Management Plan | 421 |
| 5.2.3. | Threatened species sub-plans | 430 |
| 5.2.4. | Effectiveness of mitigation measures | 434 |
| 5.3. | Biodiversity monitoring strategy | 438 |
| 5.4. | Biodiversity offset strategy | 439 |
| 6. | Significance assessments | 440 |
| 6.1. | Overview | 440 |
| 6.2. | Methodology | 440 |
| 6.3. | NSW significance assessment | 441 |
| 6.4. | Commonwealth significance assessment | 445 |
| 6.4.1. | Endangered communities and threatened species | 445 |
| 6.4.2. | Migratory species | 447 |
| 7. | Conclusions | 448 |
| 7.1. | Guiding principles for threatened species assessment | 449 |
| 7.1.1. | Key thresholds | 449 |
| 8. | References | 451 |
| Appendix A | Biodiversity Connectivity Strategy | 465 |
| A.1 | Guiding principles | 470 |
| A.2 | Connectivity goals | 472 |
| A.3 | Decision-making framework | 472 |
| A.4 | Monitoring needs | 490 |

| | | |
|-------------------|---|-------------|
| A.5 | Proposed connectivity measures | 490 |
| Appendix B | Biodiversity monitoring strategy | 543 |
| B.1 | Introduction and objectives | 545 |
| B.2 | Structure of the program | 545 |
| B.3 | Content of the program | 546 |
| Appendix C | Biodiversity offset strategy | 552 |
| C.1 | Introduction | 554 |
| C.2 | Potential impacts of the project | 557 |
| C.3 | Management of biodiversity impacts | 566 |
| C.4 | Biodiversity offsetting | 571 |
| C.5 | Conclusions | 601 |
| Appendix D | Likelihood of threatened species occurring in the study area | 603 |
| Appendix E | Significance assessments | 620 |
| E.1 | <i>Environmental Planning & Assessment Act, 1979</i> | 627 |
| E.2 | <i>Environment Protection and Biodiversity Conservation Act, 1999</i> | 808 |
| Appendix F | Vegetation association floristics | 922 |
| Appendix G | Flora | 948 |
| Appendix H | Terrestrial fauna | 986 |
| Appendix I | Aquatic fauna | 999 |
| Appendix J | Summary of stakeholder engagement | 1004 |
| Appendix K | Emu genetics pilot study | 1032 |
| Appendix L | Specialist invertebrate report | 1056 |
| Appendix M | Survey and assessment summary | 1082 |
| Appendix N | Threatened species habitat matrix and survey locations | 1227 |

Table of figures

| | |
|---|-----|
| Figure 1-1 Project Overview | 3 |
| Figure 1-2 The project alignment – Arrawarra to Glenugie | 4 |
| Figure 1-3 The project alignment – Glenugie to Tyndale | 5 |
| Figure 1-4 The project alignment – Tyndale to Devils Pulpit | 6 |
| Figure 1-5 The project alignment – Devils Pulpit to Woodburn | 7 |
| Figure 1-6 The project alignment – Woodburn to Ballina | 8 |
| Figure 3-1: Regional context of the project | 114 |
| Figure 3-2: Landscape context | 117 |
| Figure 3-3: Land tenure and land use within 20 kilometres of the project boundary | 120 |
| Figure 3-4: Key habitats and corridors | 123 |
| Figure 3-5: Climate change corridors | 124 |
| Figure 3-6: Vegetation communities and endangered ecological communities | 134 |
| Figure 3-7: Vegetation communities and endangered ecological communities | 136 |
| Figure 3-8: Vegetation communities and endangered ecological communities | 138 |
| Figure 3-9: Vegetation communities and endangered ecological communities | 140 |
| Figure 3-10: Vegetation communities and endangered ecological communities | 142 |
| Figure 3-11: Vegetation communities and endangered ecological communities | 144 |
| Figure 3-12: Vegetation communities and endangered ecological communities | 146 |
| Figure 3-13: Vegetation communities and endangered ecological communities | 148 |
| Figure 3-14: Vegetation communities and endangered ecological communities | 150 |
| Figure 3-15: Vegetation communities and endangered ecological communities | 152 |
| Figure 3-16: Vegetation communities and endangered ecological communities | 154 |
| Figure 3-17: Vegetation communities and endangered ecological communities | 156 |
| Figure 3-18: Vegetation communities and endangered ecological communities | 158 |
| Figure 3-19: Vegetation communities and endangered ecological communities | 160 |
| Figure 3-20: Vegetation communities and endangered ecological communities | 162 |
| Figure 3-21: Vegetation communities and endangered ecological communities | 164 |
| Figure 3-22: Vegetation communities and endangered ecological communities | 166 |
| Figure 3-23: Vegetation communities and endangered ecological communities | 168 |
| Figure 3-24: Vegetation communities and endangered ecological communities | 170 |
| Figure 3-25: Vegetation communities and endangered ecological communities | 172 |
| Figure 3-26: Vegetation communities and endangered ecological communities | 174 |
| Figure 3-27: Vegetation communities and endangered ecological communities | 176 |

| | |
|--|-----|
| Figure 3-28: Vegetation communities and endangered ecological communities | 178 |
| Figure 3-29: Vegetation communities and endangered ecological communities | 180 |
| Figure 3-30: Vegetation communities and endangered ecological communities | 182 |
| Figure 3-31: Vegetation communities and endangered ecological communities | 184 |
| Figure 3-32: Comparison of successional stage for each broad vegetation community type in the study area | 191 |
| Figure 3-33: Comparison of relative density of Allocasuarina between the broad vegetation communities. | 192 |
| Figure 3-34: Fauna habitats and threatened fauna in the study area | 196 |
| Figure 3-35: Fauna habitats and threatened fauna in the study area | 198 |
| Figure 3-36: Fauna habitats and threatened fauna in the study area | 200 |
| Figure 3-37: Fauna habitats and threatened fauna in the study area | 202 |
| Figure 3-38: Fauna habitats and threatened fauna in the study area | 204 |
| Figure 3-39: Fauna habitats and threatened fauna in the study area | 206 |
| Figure 3-40: Fauna habitats and threatened fauna in the study area | 208 |
| Figure 3-41: Fauna habitats and threatened fauna in the study area | 210 |
| Figure 3-42: Fauna habitats and threatened fauna in the study area | 212 |
| Figure 3-43: Fauna habitats and threatened fauna in the study area | 214 |
| Figure 3-44: Fauna habitats and threatened fauna in the study area | 216 |
| Figure 3-45: Fauna habitats and threatened fauna in the study area | 218 |
| Figure 3-46: Fauna habitats and threatened fauna in the study area | 220 |
| Figure 3-47: Fauna habitats and threatened fauna in the study area | 222 |
| Figure 3-48: Fauna habitats and threatened fauna in the study area | 224 |
| Figure 3-49: Fauna habitats and threatened fauna in the study area | 226 |
| Figure 3-50: Fauna habitats and threatened fauna in the study area | 228 |
| Figure 3-51: Fauna habitats and threatened fauna in the study area | 230 |
| Figure 3-52: Fauna habitats and threatened fauna in the study area | 232 |
| Figure 3-53: Fauna habitats and threatened fauna in the study area | 234 |
| Figure 3-54: Fauna habitats and threatened fauna in the study area | 236 |
| Figure 3-55: Fauna habitats and threatened fauna in the study area | 238 |
| Figure 3-56: Fauna habitats and threatened fauna in the study area | 240 |
| Figure 3-57: Fauna habitats and threatened fauna in the study area | 242 |
| Figure 3-58: Fauna habitats and threatened fauna in the study area | 244 |
| Figure 3-59: Fauna habitats and threatened fauna in the study area | 246 |
| Figure 3-60: Aquatic habitats, wetlands and threatened fish within the study area – Section 1257 | |
| Figure 3-61: Aquatic habitats, wetlands and threatened fish within the study area – Section 2258 | |

| | |
|---|-----|
| Figure 3-62: Aquatic habitats, wetlands and threatened fish within the study area – Section 3259 | |
| Figure 3-63: Aquatic habitats, wetlands and threatened fish within the study area – Section 4260 | |
| Figure 3-64: Aquatic habitats, wetlands and threatened fish within the study area – Section 5261 | |
| Figure 3-65: Aquatic habitats, wetlands and threatened fish within the study area – Section 6262 | |
| Figure 3-66: Aquatic habitats, wetlands and threatened fish within the study area – Section 7263 | |
| Figure 3-67: Aquatic habitats, wetlands and threatened fish within the study area – Section 8264 | |
| Figure 3-68: Aquatic habitats, wetlands and threatened fish within the study area – Section 9265 | |
| Figure 3-69: Aquatic habitats, wetlands and threatened fish within the study area – Section 10266 | |
| Figure 3-70: Aquatic habitats, wetlands and threatened fish within the study area – Section 11267 | |
| Figure 3-71: Threatened flora species –Section 2 | 280 |
| Figure 3-72: Threatened flora species – Section 2 | 281 |
| Figure 3-73: Threatened flora species –Section 3 | 282 |
| Figure 3-74: Threatened flora species – Section 3 | 283 |
| Figure 3-75: Threatened flora species –Section 3 and 4 | 284 |
| Figure 3-76: Threatened flora species–Section 6 | 285 |
| Figure 3-77: Threatened flora species –Devils Pulpit and Section 7 | 286 |
| Figure 3-78: Threatened flora species – Section 7 (New Italy Area) | 287 |
| Figure 3-79: Threatened flora species – Section 10 | 288 |
| Figure 3-80: Regional distribution of <i>Angophora robur</i> and <i>Eucalyptus tetrapleura</i> | 290 |
| Figure 3-81: Oxleyan Pygmy Perch-recorded distribution and critical habitat in conservation areas 316 | |
| Figure 3-82: Number of emu road-kills reported per year during the period 1980-2011. | 320 |
| Figure 3-83: Seasonal variation in reported emu road-kills, during the period 1980-2011. | 321 |
| Figure 3-84: The spatial distribution of emu records in the district during the period 1980-2011. | 322 |
| Figure 3-85: Comparison of emu collision sites according to road surface and size. | 323 |
| Figure 4-1: Map of koala habitat in the project corridor and distribution of koala records | 354 |
| Figure 4-2: Map of koala habitat in the project corridor and distribution of koala records | 355 |
| Figure 4-3: Map of koala habitat in the project corridor and distribution of koala records | 356 |
| Figure 4-4: Map of koala habitat in the project corridor and distribution of koala records | 357 |
| Figure 4-5: Map of koala habitat in the project corridor and distribution of koala records | 358 |
| Figure 5-1: Strategic biodiversity mitigation and offset framework (the blue squares are delivered as part of the EIS). | 414 |
| Figure A-1: The process for managing emu connectivity requirements | 477 |
| Figure A-2: Emu distribution, known movements and habitat use | 480 |
| Figure A-3: Emu collision risk at one kilometre intervals along the project boundary between Glenugie and Maclean. (Station 33.8 is at Glenugie; station 85.8 is just north of Maclean) | 483 |

| | |
|--|-----|
| Figure A-4: The process for deciding if a proposed wildlife connectivity measure is feasible and reasonable. | 484 |
| Figure A-5: Typical cross section of median widening for class M scenario | 489 |
| Figure A-6: Section 1 – Fauna connectivity structures | 530 |
| Figure A-7: Section 2 – Fauna connectivity structures | 531 |
| Figure A-8: Section 3 – Fauna connectivity structures | 532 |
| Figure A-9: Section 4 – Fauna connectivity structures | 533 |
| Figure A-10: Section 5 – Fauna connectivity structures | 534 |
| Figure A-11: Section 6 – Fauna connectivity structures | 535 |
| Figure A-12: Section 7 – Fauna connectivity structures | 536 |
| Figure A-13: Section 8 – Fauna connectivity structures | 537 |
| Figure A-14: Section 9 – Fauna connectivity structures | 538 |
| Figure A-15: Section 10 – Fauna connectivity structures | 539 |
| Figure A-16: Section 11 – Fauna connectivity structures | 540 |

Table index

| | |
|---|----|
| Table 1-1 Project sections and lengths | 1 |
| Table 1-2 Report structure and content | 12 |
| Table 1-3 Director-General’s environmental assessment requirements | 14 |
| Table 1-4 Supplementary Director-General’s requirements | 15 |
| Table 2-1 Assessment phases | 20 |
| Table 2-2: Summary of previous development projects ecological assessments for the preferred route corridor | 28 |
| Table 2-3: Scope of work for additional survey requirements | 31 |
| Table 2-4: Qualifications and role of key personnel | 33 |
| Table 2-5: Summary of flora survey timing, techniques and effort | 34 |
| Table 2-6: Condition thresholds for the federally listed Lowland Rainforest of Subtropical Australia | 38 |
| Table 2-7 Targeted surveys for known threatened flora populations | 40 |
| Table 2-8 Fauna habitat strata and area within the project boundary | 50 |
| Table 2-9: Timing, weather and rainfall conditions for fauna surveys | 50 |
| Table 2-10: Details of fauna survey effort and timing | 52 |
| Table 2-11: Description of the mammal survey techniques and targeted threatened taxa | 56 |
| Table 2-12 Description of the bird survey techniques and targeted threatened taxa | 58 |
| Table 2-13: Description of the herpetofauna survey techniques and target taxa | 60 |

| | |
|--|-----|
| Table 2-14: Targeted threatened invertebrate species targeted in surveys | 61 |
| Table 2-15: Summary of survey method and effort for targeted threatened fauna | 63 |
| Table 2-16: Broad vegetation types used in the habitat assessment | 97 |
| Table 2-17: Description of the site characteristics recorded at emu road-kill and control sites | 98 |
| Table 2-18: Summary of fish survey effort employed within each project section | 102 |
| Table 2-19: Description of the fish survey techniques and targeted fish taxa | 103 |
| Table 2-20: Fish habitat classification criteria for watercourses and recommended crossings types | 106 |
| Table 2-21: Likelihood of species occurrence criteria | 108 |
| Table 3-1: National parks and reserves within 10 kilometres of the project boundary | 111 |
| Table 3-2: State forests within 10 kilometres of the project boundary | 115 |
| Table 3-3: Landscapes in the NSW North Coast Bioregion | 118 |
| Table 3-4 Key regional, sub-regional and climate change corridors in the North Coast Bioregion | 121 |
| Table 3-5 Summary of vegetation associations in each project section | 127 |
| Table 3-6: Comparison of habitat characteristics between broad vegetation types | 190 |
| Table 3-7: Ranking used to create the fauna habitat value index | 193 |
| Table 3-8 Aquatic species and habitats recorded near the project boundary | 249 |
| Table 3-9 Watercourses within the project corridor | 251 |
| Table 3-10 Nationally Important wetlands in the region | 254 |
| Table 3-11 SEPP14 wetlands in the region | 255 |
| Table 3-12 Descriptions and approximate area of Threatened Ecological Communities (TSC Act and EPBC Act) in project boundary | 269 |
| Table 3-13 Details of the three described coastal emu sub-populations in the mid north coast (source NPWS annual survey results 2002-2012; G.Hart pers.comm) | 272 |
| Table 3-14 Summary of landowner interviews | 274 |
| Table 3-15: Threatened flora identified in relation to the project boundary | 277 |
| Table 3-16: Angophora robur population clusters in the study area | 291 |
| Table 3-17: Threatened flora recorded outside of the project boundary | 297 |
| Table 3-18: Threatened fauna species confirmed in the project boundary | 299 |
| Table 3-19: Migratory fauna species (EPBC Act) recorded and expected in the study area | 309 |
| Table 3-20: Summary of potential habitat for threatened fish species in the study area | 312 |
| Table 3-21: Additional threatened flora subject species | 317 |
| Table 3-22: Additional threatened fauna and invertebrate subject species | 318 |
| Table 3-23 Potential threatened fish subject species | 319 |
| Table 3-24: Chi square tests of association between road characteristics and emu road-kills. | 324 |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| | |
|---|-----|
| Table 4-1: Summary of vegetation loss for the project by BioMetric vegetation community and area | 329 |
| Table 4-2 Summary of impact on threatened ecological communities | 330 |
| Table 4-3 Patches of the critically endangered (EPBC Act) Lowland Rainforest of Subtropical Australia potentially impacted by the project | 331 |
| Table 4-4: <i>Angophora robur</i> regional population and comparison with subject population (Section 3) | 333 |
| Table 4-5: <i>Arthraxon hispidus</i> population clusters | 335 |
| Table 4-6: <i>Cyperus aquatilis</i> population clusters | 337 |
| Table 4-7 <i>Eucalyptus tetrapleura</i> population clusters | 338 |
| Table 4-8 <i>Grevillea quadricauda</i> populations and potential impacts | 341 |
| Table 4-9 <i>Lindsaea incisa</i> population clusters | 342 |
| Table 4-10: <i>Maundia triglochmoides</i> population clusters | 344 |
| Table 4-11 Potential impacts to threatened flora species | 346 |
| Table 4-12 Summary of clearing for broad fauna habitat types | 347 |
| Table 4-13 Threatened species in study area impacted by loss of hollow-bearing trees | 348 |
| Table 4-14 Flowering period of dominant trees and shrubs within the project boundary | 350 |
| Table 4-15 Critical habitat containing Koala food tree species to be cleared | 352 |
| Table 4-16 Potential impacts on other threatened fauna known and likely to occur in the project boundary | 370 |
| Table 4-17: Analysis of sensitivity to fragmentation of threatened species | 381 |
| Table 4-18 Proposed loss of vegetation from national parks and reserves | 384 |
| Table 4-19 Waterways and the location of threatened species | 390 |
| Table 4-20 Likely impacts on threatened fish subject species | 397 |
| Table 4-21 Noxious weeds and weeds of national significance | 399 |
| Table 4-22 Pathogens that may impact on flora and fauna during construction | 402 |
| Table 4-23 Key threatening process relevant to the project | 404 |
| Table 4-24 Mitchell Landscapes with historical per cent cleared estimates for the Northern Rivers CMA region | 407 |
| Table 4-25 Estimates historical clearing of threatened ecological communities relevant to the project | 407 |
| Table 4-26: Extent of native vegetation clearing associated with the PHUP | 408 |
| Table 4-27 Extent of native vegetation disturbance from projects within the study area | 410 |
| Table 5-1 Content of RMS Biodiversity Guidelines for developing project CEMPs and FFMP's | 421 |
| Table 5-2 Staged habitat removal process (adapted from RTA 2011) | 424 |
| Table 5-3 Mitigation measures to be incorporated into FFMP for aquatic habitats and riparian zones | 428 |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| | |
|---|-----|
| Table 5-4 Project specific mitigation measures for threatened species | 430 |
| Table 5-5 Common and threatened fauna species recorded using fauna crossing structures. | 435 |
| Table 5-6 Reference guide to effectiveness of fauna crossing structures (source RTA 2011) | 436 |
| Table 5-7 Assessment matrix of mitigation | 438 |
| Table 6-1 Summary of NSW significance assessments | 441 |
| Table 6-2 Summary of Commonwealth significance assessments | 445 |
| Table 6-3 Summary of Commonwealth significance assessment for migratory species | 447 |
| Table 7-1 Key thresholds and biodiversity assessment conclusions | 449 |
| Table A-1 Guiding principles to assist decision-making for biodiversity connectivity | 470 |
| Table A-2 Species specific connectivity goals | 475 |
| Table A-3 Design principles | 491 |
| Table A-4 Overview of the proposed fauna connectivity measures | 500 |
| Table A-5 Proposed fauna connectivity measures for concept design | 503 |

Executive summary

Background

NSW Roads and Maritime Service (RMS) is seeking approval for upgrade of the Pacific Highway from Woolgoolga to Ballina on the mid and far north coast of NSW (the project). The delivery of the project has potential to be staged based on 11 staging sections.

This biodiversity assessment has been prepared to address the NSW Department of Planning and Infrastructure (DP&I) Director General's requirements (DGRs) issued for assessment of the project under Part 5.1 of the NSW *Environmental Planning & Assessment Act 1979* for both terrestrial and aquatic ecology. Matters of National Environmental Significance as protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* have been assessed to address the referral requirements from the Minister for the Department of Sustainability, Environment, Water, Population and Communities.

Desktop and field investigations were undertaken in the planning phase of the project to assist in identifying a preferred route. Biodiversity surveys focused on the preferred route were conducted between 2006 and 2012 and identified threatened communities, populations and species listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), the *Fisheries Management Act 1999* (FM Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that are known, or have the potential to occur in proximity to the project boundary, and which could be potentially impacted.

Existing environment

The study area is wholly located within the NSW North Coast Bioregion. This bioregion is one of the most diverse in NSW, with complex soil and vegetation patterns resulting from complex interactions of substrate, topographic and climatic variation. The project boundary is located in a landscape that has been significantly altered by past land-uses and under continued pressure from population growth and development. Much of the native vegetation in the study area has been cleared or fragmented for agriculture and rural development, with the exception of the Summervale Range and associated foot slopes, Wardell heath, and several adjoining state forests and conservation reserves. The project traverses a number of these key habitats and corridors including the boundaries of eight state forests and six conservation reserves which adjoin the project boundary.

The vegetation and habitat types dominating the landscape around and within the project boundary include:

- Dry sclerophyll open forests and woodlands
- Wet sclerophyll forests
- Swamp forests
- Floodplain forests
- Rainforests
- Freshwater wetlands
- Estuarine wetlands
- Heathlands.

These formations consist of 57 separate vegetation communities including six Threatened Ecological Communities listed as Endangered under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and one Critically Endangered Ecological Community listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These are:

- Sub-tropical coastal floodplain forest of the NSW North Coast Bioregion (TSC Act)
- Swamp sclerophyll forest on coastal floodplains of the NSW North coast, Sydney Basin and south east corner bioregions (TSC Act)
- Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (TSC Act)
- Coastal Cypress Pine shrubby open forest of the North Coast Bioregion (TSC Act)
- Freshwater wetlands on coastal floodplains on the NSW North coast, Sydney Basin and South East Corner bioregions (TSC Act)
- Lowland Rainforest on floodplain in the NSW North Coast Bioregion (TSC Act)
- Lowland Rainforest of sub-tropical Australia (EPBC Act).

A total of 123 threatened flora and fauna species were identified either as known from or potentially occurring in the study area comprising 63 vertebrate fauna species (one an endangered population), 54 plant species, three invertebrate species and three fish species.

The project traverses the major river catchments of the Clarence and Richmond rivers. Eight Nationally Important Wetlands (from the Directory of Important Wetlands in Australia (2001)) and thirteen State listed wetlands (State Environmental Planning Policy No.14) are located in this study area. Many of these wetlands are recharged or fed by the Clarence River catchment and support significant areas of groundwater dependent ecosystems.

Avoidance and mitigation approach

RMS has adopted a policy with regard to road development and associated impacts on biodiversity, which is that the planning and construction of roads should, in order of consideration, endeavour to:

- Avoid impacts on habitat, through the planning process
- Minimise impacts on habitat, through the planning process
- Mitigate impacts on habitat, through a range of mitigation measures
- Offset any residual impacts.

The initial route planning phase focused on avoiding and minimising impacts to biodiversity through examination of a number of route options. Those potential routes that best fit the environmental, social and economic criteria were short-listed which included consideration of biodiversity values and habitat for identified threatened species. Following selection of a preferred route detailed biodiversity surveys within the project boundary sought to refine the alignment and concept design of the footprint to further avoid and minimise the loss of important vegetation communities and habitats and avoid significant species or habitat. Engineering constraints, road design and safety standards were considered during this refinement.

In this regard the selection of the preferred route was influenced by the biodiversity investigations and the data informed both the route selection and the concept design..

Evaluation of impacts

In considering the residual impacts there would be a loss of around 948 hectares of remnant vegetation ranging from low, through moderate and high condition, one third of which (around 337 hectares) consists of the listed threatened ecological communities described. The likely clearing estimates have been quantified based on the concept design construction footprint (the road construction footprint including water quality and sediment basins plus an additional 10 metre allowance for construction buffer). This does not include clearing that may be required for potential ancillary facilities beyond this construction footprint. An additional potential loss of 25 hectares may be required for ancillary facilities. The scale of impact is large and significance assessments indicate that the project is likely to have a significant impact on:

- Five endangered ecological communities including one critically endangered ecological community listed under the EPBC Act, Lowland Rainforest of Subtropical Australia
- Eleven threatened flora species (6 of which are also listed under the EPBC Act)
- Twenty threatened fauna species (7 of which are also listed under the EPBC Act)
- One endangered population listing under the TSC Act: emu population in the NSW North Coast Bioregion and Port Stephens LGA area.

The expected impacts from the project highlight the importance of mitigating and managing long-term indirect impacts to rare and high quality habitats and maintaining existing connectivity in the landscape. Although mitigation and management measures would reduce impacts for these species and communities, there would be residual impacts. Residual impacts would form the focus of an offset strategy.

In general, the types of potential impacts to biodiversity during construction and operation of the project include:

- Loss of native vegetation (including habitat for threatened flora and threatened ecological communities)
- Loss of habitat for fauna (including food resources, shelter and refuge areas during non-breeding and breeding life-cycle events)
- Direct mortality of native fauna
- Loss of connectivity for flora and fauna (including links to national parks and state forests and identified local and regional wildlife corridors)
- Fragmentation of habitat and resulting edge effects from road noise, altered light and wind levels
- Changes to water quality as a result of works in or adjacent to aquatic habitats and alterations to natural hydrological flows
- Invasion and spread of weeds and pest fauna species
- Potential spread of disease pathogens.

Mitigation and management

A biodiversity management framework has been developed to provide a consistent approach to the mitigation and management of biodiversity for the project. The key aspects of the framework include:

- Guidance on significant issues to be addressed in the detailed design
- A Biodiversity Connectivity Strategy including a summary of proposed dedicated and combined fauna crossing underpasses, overpasses and arboreal crossing structures in addition to connectivity design principles for inclusion in the detailed design
- A Flora and Fauna Management Plan consistent with RMS best practice for protecting and managing biodiversity during construction, including several threatened species management sub-plans which address the management of significantly impacted species
- A Biodiversity Monitoring Strategy which outlines the proposed structure and content of a monitoring program for monitoring the effectiveness of mitigation measures and applying adaptive management outcomes based on objectives and performance measures.

Offset strategy

A Biodiversity Offset Strategy is outlined with the objective of delivering a package of offsets to achieve a neutral or net beneficial biodiversity outcome for the region as a result of the project. The strategy would be applied consistently across the project to offset the impacts of the project.

The Biodiversity Offset Strategy meets the NSW Department of Planning and Infrastructure (DoP&I) Director-General's requirements and ensures that the project is consistent with the Office of Environment and Heritage (OEH) *Principles for the use of biodiversity offsets in NSW* and the Commonwealth Government's policy statement with respect to environmental offsets under the EPBC Act. The offset would, as a minimum, be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are 'like for like'. In this respect it will aim to target comparable vegetation and habitat types.

Conclusions

The proposed upgrade of the Pacific Highway from Woolgoolga to Ballina would have a significant impact on aspects of the biodiversity of study area. There would be a loss of around 948 hectares of remnant vegetation from low to high condition, one third of which (337 hectares) consists of listed threatened ecological communities. An additional potential loss of 25 hectares is likely to be required for ancillary facilities. The scale of impact highlights the importance of mitigating and managing long-term indirect impacts to rare and high quality habitats and maintaining existing connectivity in the landscape.

This Biodiversity Working Paper identifies matters which are relevant to the assessment of impacts to threatened species, populations, and ecological communities or their habitats arising from the proposed project being assessed under Part 5.1 of the *Environmental Planning and Assessment Act, 1979*. Significance assessments indicate that the project is likely to have a significant impact on five endangered ecological community (including one critically endangered community), 11 threatened flora species and 14 threatened fauna species or populations. Although mitigation measures would reduce impacts for these species and communities, they are not likely to totally ameliorate the impact.

The assessment address key thresholds identified under the draft *Guidelines for Threatened Species Assessment* under Part 3A (repealed, now Part 5.1) of the *Environmental Planning and Assessment Act 1979*. These key thresholds and the principles in the guidelines were taken into consideration in assessing the impacts on threatened species, populations and communities as a likely result of the project.

As the project would result in clearing of native vegetation including critically endangered ecological communities, threatened species and their habitat, it is unlikely that the objective of maintaining or improving biodiversity values can be met. It would therefore be necessary to offset this impact to fulfil this outcome.

The NSW North Coast Bioregion supports high biodiversity and a considerable number of State and Commonwealth listed threatened species and ecological communities. Measures to avoid and mitigate listed key threatening processes have been duly considered through the route planning process and biodiversity management strategies. This thorough process considered the long-term protection of the majority of the threatened species identified as known or likely to occur in the study area.

There is no conclusive scientific knowledge on the ability of each of the assessed species to sustain a loss of the magnitude expected or resilience to change including adaptation to the proposed mitigation measures. As such, there is a risk that the project could have a significant impact on several threatened flora and fauna, most notably the coastal emu endangered population and the critically endangered Lowland Rainforest of Subtropical Australia present in the study area.

Glossary

| | |
|--------------------|---|
| ANZECC | Australian and New Zealand Environment Conservation Council |
| Arboreal | Adapted for living and moving about in trees |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand. |
| CEMP | Construction Environment Management Plan |
| CRA | Comprehensive Regional Assessment |
| CRAFTI | Comprehensive Regional Assessment Forest Type Inventory |
| DBH | Diameter and Breast Height (refers to measure of tree girth) |
| DECCW | Department of Environment Climate Change – now OEH |
| DEH | Department of Environment and Heritage (Commonwealth) – now DSEWPaC |
| DSEWPaC | Department of Sustainability Environment, Water, Population and Communities (Commonwealth) |
| EPA | Environmental Protection Agency |
| EP&A Act | <i>Environmental Planning and Assessment Act 1979</i> |
| Epiphytic | A plant that grows on another plant but is not parasitic – rather it obtains water and nutrients from the air and rain |
| EPBC Act | <i>Environment Protection and Biodiversity Conservation Act 1999</i> |
| FFMP | Flora and Fauna Management Plan |
| FM Act | <i>Fisheries Management Act 1994</i> |
| Fossorial | An organism that is adapted to digging and life underground or cover |
| Frugivorous | An animal that feeds primarily on fruit |
| ha | Hectare |
| I & I | Industry and Investment NSW. Previously the Department of Primary Industries (DPI) |
| Km | Kilometre |
| Local Area | The area with a 10 kilometres radius of the study area |
| LGA | Local Government Area |
| LNE | Lower North East |
| m | Metre |
| MNES | Matters of National Environmental Significance (Commonwealth) |
| NPWS | National Parks and Wildlife Service (now included under OEH) |
| NRCMA | Northern rivers Catchment Management Authority |
| OEH | Office of Environment and Heritage |
| Planar | Lying on one plane, flat on level ground |
| RAMSAR | List of Wetlands of International Importance |
| Representativeness | Extent to which a site (or its subcomponents) contributes to the conservation of representative samples of the different flora and fauna habitats occurring on a local, regional or national scale. |
| Rhizome | In botany a rhizome is a stem of a plant that is usually found underground, often sending out roots and shoots from its nodes |
| RMS | Roads and Maritime Services |
| Scansorial | Animals with limbs that are adapted for climbing |
| Sedentary | Abiding in one place, not migratory, seldom moving about or attached to a particular habitat |
| Senescent | Growing old, ageing |
| SEPP | State Environmental Planning Policy |
| Stochastic | Sporadic or random |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| | |
|---------|---|
| TEC | Threatened Ecological Community |
| TSC Act | <i>Threatened Species Conservation Act 1995</i> |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

1. Introduction

1.1. Overview

NSW Roads and Maritime Services (RMS) is seeking project approval for the Woolgoolga to Ballina Pacific Highway upgrade project (the project) which is located on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and under the Commonwealth environmental assessment requirements of the *Environment Protection and Biodiversity Conservation Act* (EPBC Act).

The project would upgrade around 155 kilometres of highway, forming a major part of the overall Pacific Highway Upgrade Program. The project would provide a four-lane divided carriageway from around five kilometres north of Woolgoolga to around six kilometres south of Ballina. Figure 1-1 shows the regional location of the project.

This biodiversity assessment has been prepared to assess the ecological impacts of the project.

1.2. Project description

The project has been divided into eleven sections between tie-ins with the existing Pacific Highway to aid description, and the impact assessment for the project is described for each of these sections (refer to Table 1-1).

Table 1-1 Project sections and lengths

| project section | Location | Station | | Length (kilometres) |
|-----------------|--|---------|--------|---------------------|
| | | Start | Finish | |
| 1 | Woolgoolga to Halfway Creek | 0 | 17.0 | 17.0 |
| 2 | Halfway Creek to Glenugie upgrade | 17.0 | 28.7 | 11.7 |
| 3 | Glenugie upgrade to Tyndale | 33.8 | 68.8 | 35.0 |
| 4 | Tyndale to Maclean | 68.8 | 82.0 | 13.2 |
| 5 | Maclean to Iluka Road, Mororo | 82.0 | 96.4 | 14.4 |
| 6 | Iluka Road to Devil's Pulpit upgrade | 96.4 | 105.6 | 9.2 |
| 7 | Devil's Pulpit upgrade to Trustums Hill | 111.1 | 126.4 | 15.3 |
| 8 | Trustums Hill to Broadwater National Park | 126.4 | 137.6 | 11.2 |
| 9 | Broadwater National Park to Richmond River | 137.6 | 145.1 | 7.5 |
| 10 | Richmond River to Coolgardie Road | 145.1 | 158.6 | 13.5 |
| 11 | Coolgardie Road to Ballina bypass | 158.6 | 164.0 | 5.4 |

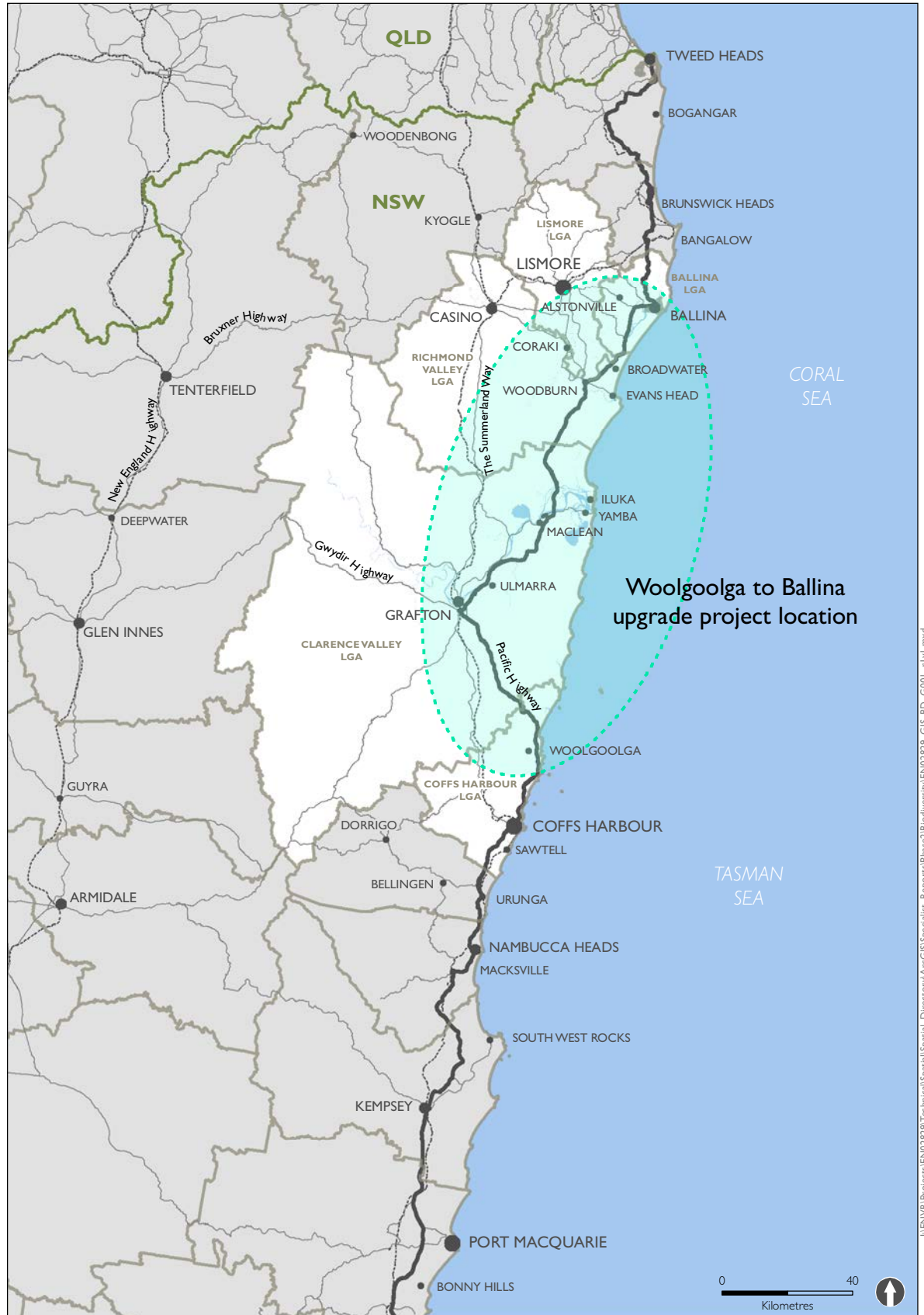
Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

An overview of the project alignment and project sections are shown in Figure 1-2 to Figure 1-6.

While the project is for a four-lane motorway standard upgrade, the construction and opening of the project would be staged. Staging could include some sections being constructed and opened initially as a four-lane arterial standard upgrade.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina, as Glenugie is now complete and Devils Pulpit is under construction. Together with the Glenugie and Devils Pulpit upgrades, the project would complete a total of 164 kilometres of upgraded highway between Woolgoolga and Ballina.

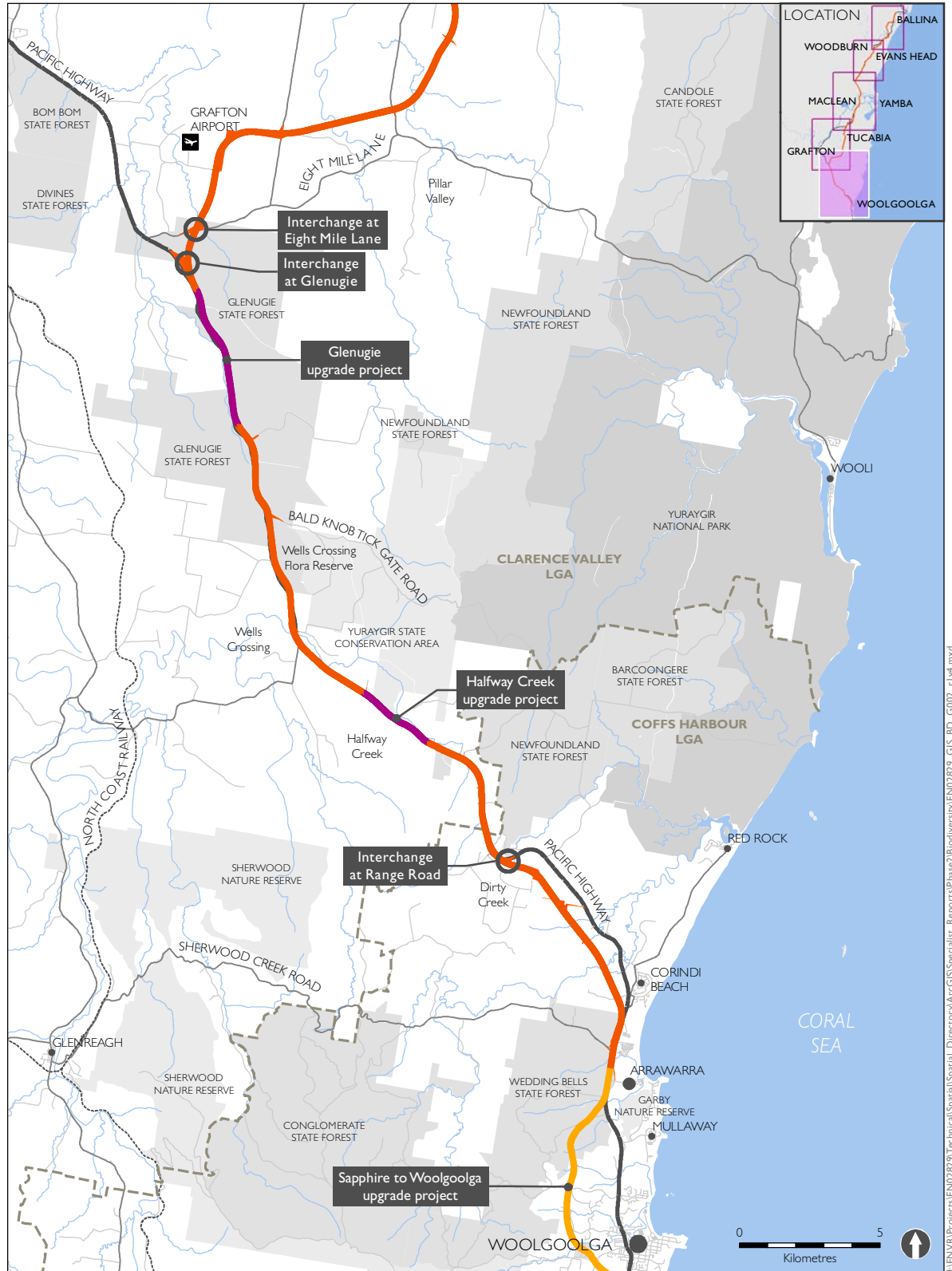
Figure I-1 Project overview



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Upgrading the Pacific Highway - Woolgoolga to Ballina Upgrade

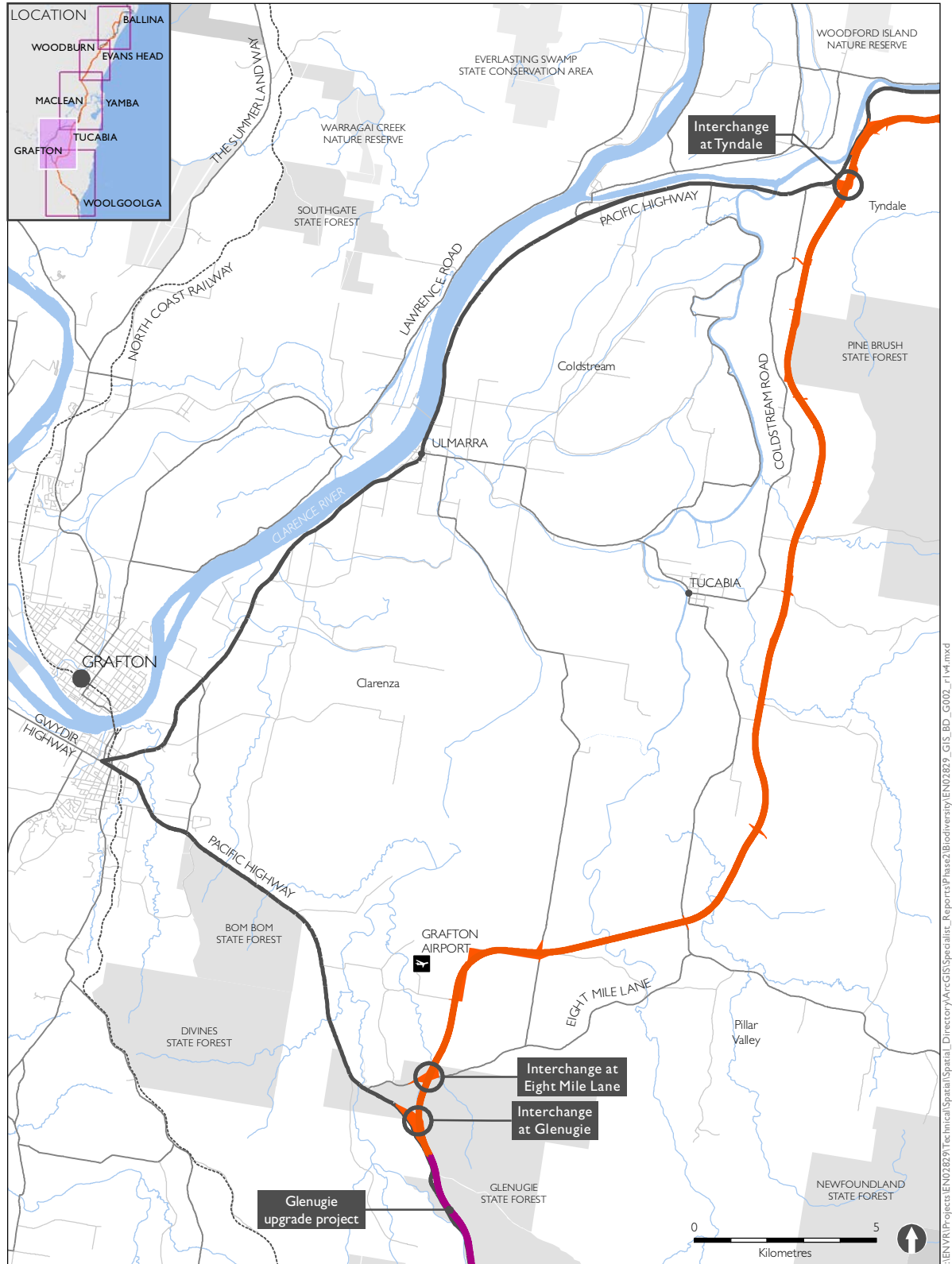
Figure 1-2 The project alignment - Arrawarra to Glenugie



- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

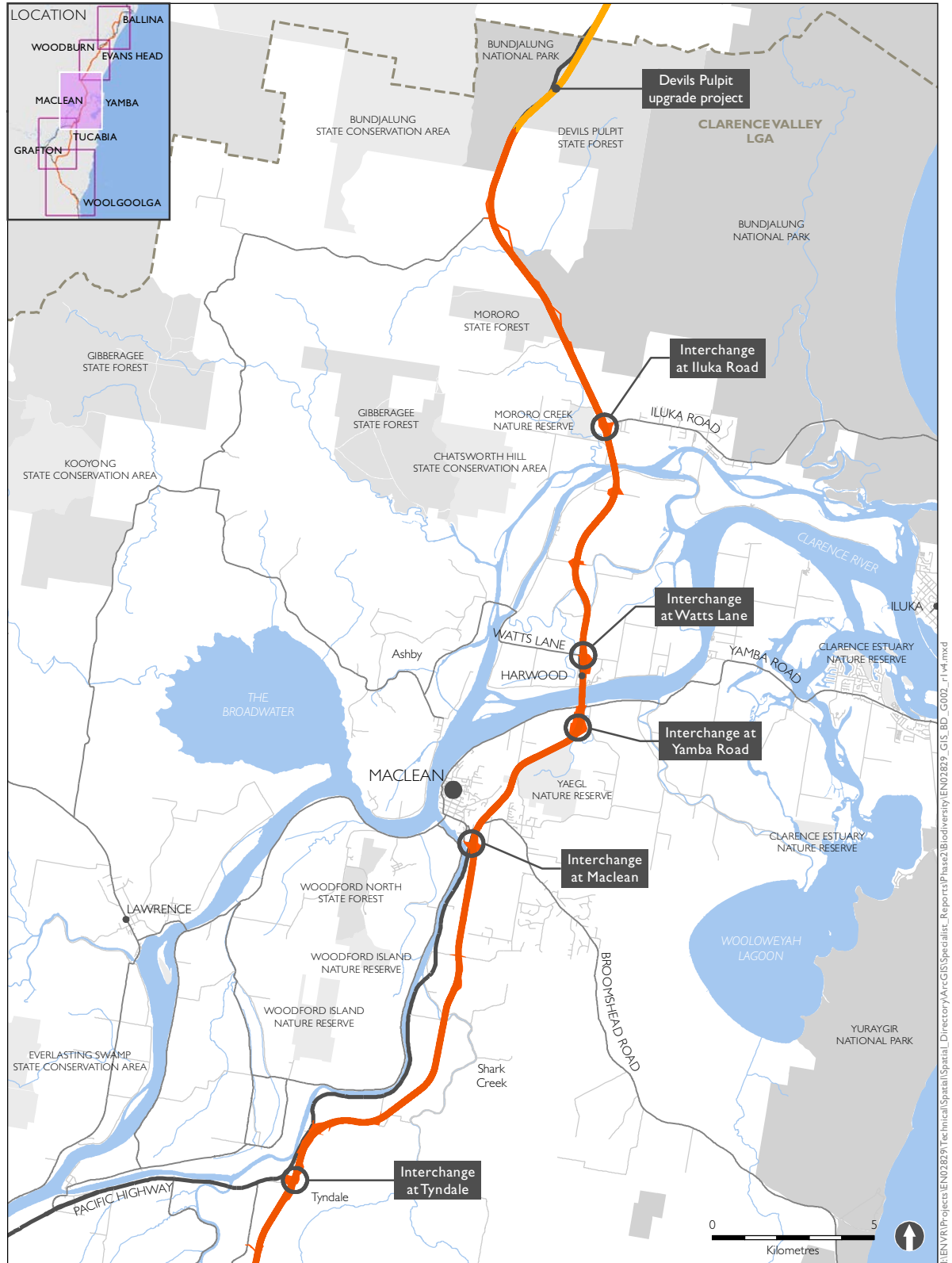
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Figure I-3 The project alignment - Glenugie to Tyndale



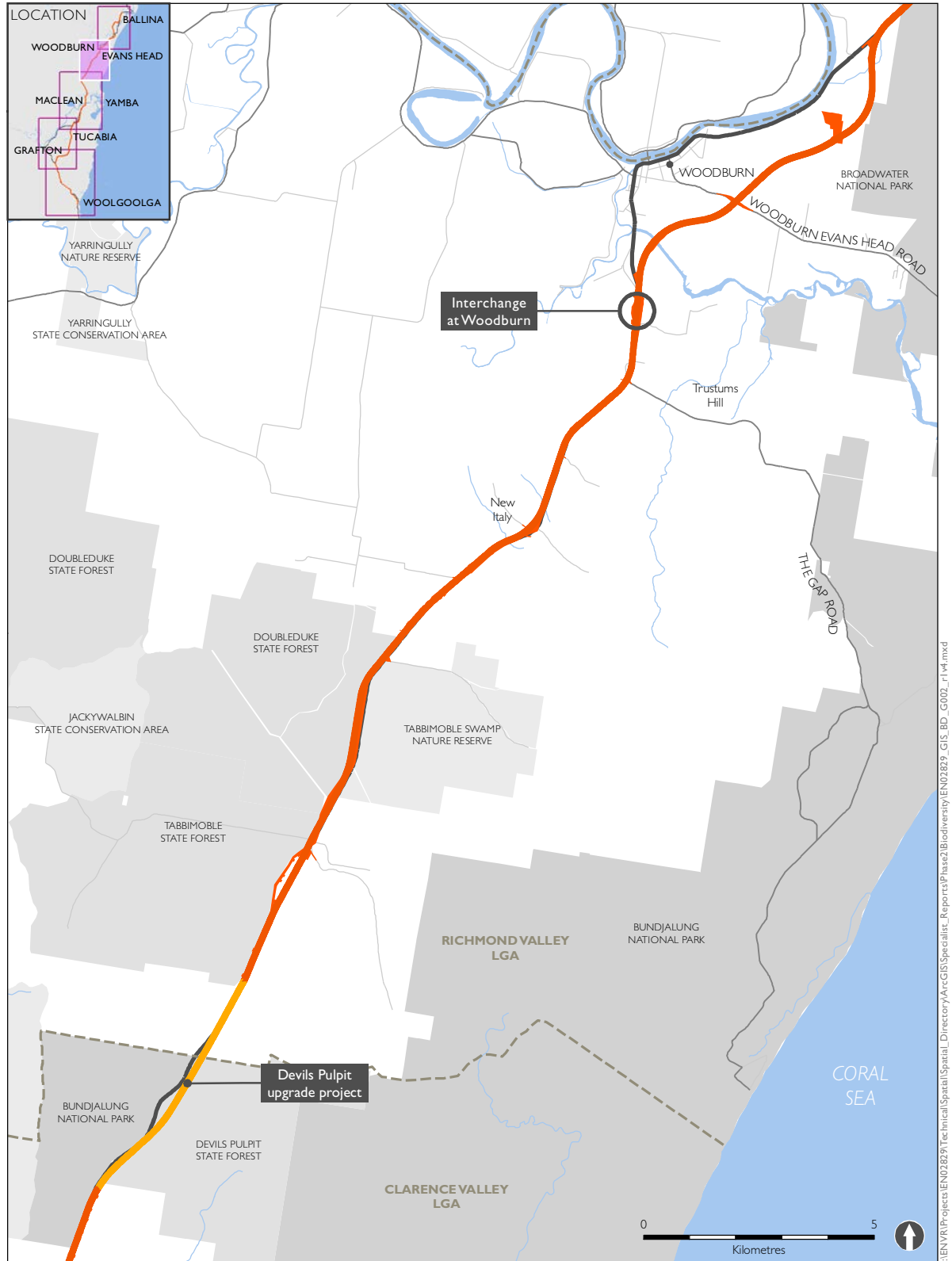
- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

Figure I-4 The project alignment - Tyndale to Devils Pulpit



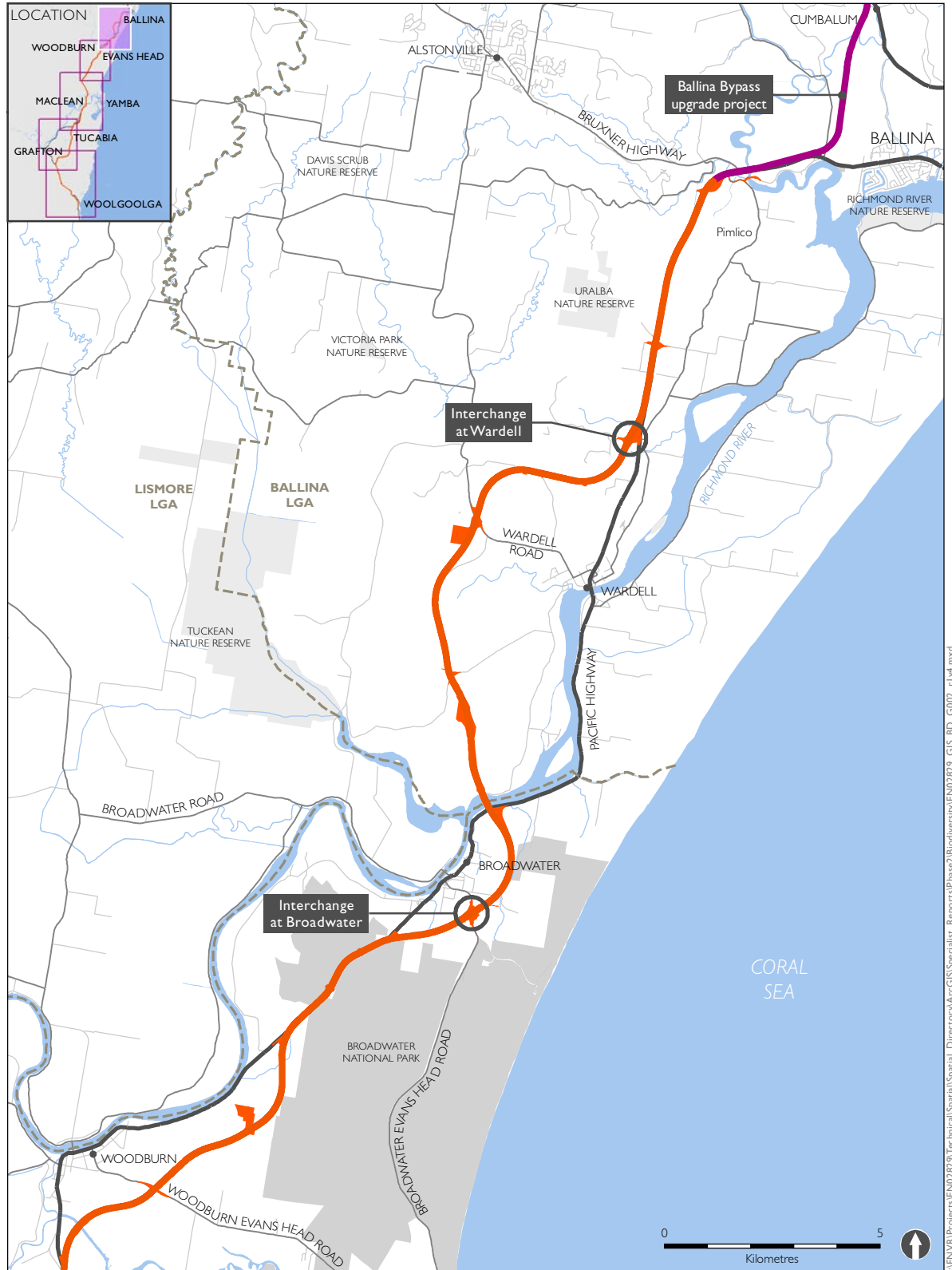
- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

Figure I-5 The project alignment - Devils Pulpit to Woodburn



- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

Figure I-6 The project alignment - Woodburn to Ballina



- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

The key features of the project include:

- Around 155 kilometres of motorway standard highway, comprising a four-lane divided carriageway (two lanes in each direction) that can be upgraded to a six-lane divided carriageway in the future, if required
- Bypasses of Grafton, South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
- Ten interchanges to provide access to and from the upgraded highway at:
 - Range Road (Corindi)
 - Glenugie (Eight Mile Lane)
 - Tyndale (Sheeys Lane)
 - Maclean (Goodwood Street)
 - Yamba Road (Harwood)
 - Watts Lane (Harwood)
 - Iluka Road (Woombah)
 - Woodburn (Trustums Hill Road)
 - Broadwater (Evans Head Road)
 - Wardell (Coolgardie Road)
- About 40 bridge crossings of waterways or floodplains, including bridges over the Clarence and Richmond rivers
- About 55 overbridge and underpasses structures to maintain access along local roads crossed by the project
- Viaducts located where the project would cross low-lying or flood-prone areas
- Service roads and access roads to maintain connections to existing local roads and properties
- Structures to help wildlife cross above or below the project including crossings for tree-dwelling mammals, dedicated culverts under the highway and over-land fauna bridges
- Rest areas located at around 50 kilometre intervals for both northbound and southbound traffic. These are located at:
 - Tucabia (north and southbound)
 - North of Mororo Road (southbound)
 - South of Old Bagotville Road (north and southbound)
- Heavy vehicle weigh station located near Halfway Creek.

In addition to these key features, the project would include construction sedimentation basins, operational water quality basins and construction facilities such as compounds and batching plants.

Construction would be staged from 2013 onwards following project approval, depending on the availability of funding. Construction of the project would generally comprise the conventional techniques employed on most major highway projects, modified for specific environmental or engineering constraints. RMS seeks approval for construction working hours for all day (8am–5pm) on Saturdays and between 6am and 7pm on weekdays.

An indicative outline of construction activities may include:

- Establishment of the construction site and ancillary facilities
- Enabling works, including adjustments to utilities, property adjustments, works to existing drainage and provision of construction access roads
- Clearing and grubbing of vegetation, stripping of topsoil and stockpiling for re-use
- Construction of road cuttings and embankments
- Treating areas of soft soil to stabilise the underlying soil sub-layers
- Installing drainage and bridging structures
- Laying of pavement materials
- Installing pavement markings, signposting, street lighting and progressive landscaping.

The project would not be built in one phase. The project would be delivered in stages as further funding becomes available and to best manage construction and material resources. Stages would be identified that prioritise and target upgrades and works that would best deliver safety and traffic efficiency improvements, and best deliver value for money outcomes.

This working paper assesses the potential impacts of the full motorway standard upgrade for construction and operation. Where there are relevant differences between the full motorway standard upgrade and the initial upgrade to arterial standard, those impacts are also assessed. Impacts are generally identified through the eleven project sections identified above.

Further information on the description of the project and the assessment of other environmental aspects can be found in the main volume of the environmental impact statement.

1.2.1. Definitions

Throughout the report reference is given to the terms project boundary, study area and region. The project boundary is as described in Table 1-1 to the outer width of the design footprint plus a 10 metre construction buffer. The study area encompasses the project boundary and any adjoining or adjacent habitat where potential indirect impacts may occur. Finally, the region is identified in terms of the landscape in the broader bioregional context (NSW North Coast Bioregion) as defined in the *Interim Biogeographic Regionalisation for Australia* (Thackway & Cresswell 1995).

1.2.2. Previous development projects

Planning for the project commenced in 2004 and has involved ongoing community consultation and environmental investigations. Route selection and concept design development was completed in four sections, which are referred to throughout this document as the 'previous development projects'. The four previous development projects were:

- Woolgoolga to Wells Crossing
- Wells Crossing to Iluka Road
- Iluka Road to Woodburn
- Woodburn to Ballina.

The route development process for the previous development projects typically involved the following steps:

- Assessing preliminary information on engineering, environmental, social and economic constraints.
- Identifying and developing potential route options
- Short-listing and refining feasible route options for further investigation
- Comparing short-listed options in terms of functional, environmental, social and economic criteria, with input from the community and stakeholders
- Selecting the preferred route and developing the concept design for the preferred route.

Additional documentation supporting the development of the preferred route and concept design for the project, including methodology, working papers and outcomes of community and stakeholder involvement, is available on the RMS website (click on Woolgoolga to Ballina).

1.3. Structure and content of the assessment

The structure and content of this report follows the *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005), outlined below in Table 1-2.

Table 1-2 Report structure and content

| Chapter | Description |
|---------|--------------------------------|
| 1 | Introduction |
| 2 | Methodology |
| 3 | Existing environment (Results) |
| 4 | Evaluation of impacts |
| 5 | Mitigation and management |
| 6 | Significance assessments |
| 7 | Conclusions |
| 8 | References |
| | Appendices |

1.4. Legislative requirements

1.4.1. Study objectives and purpose

The purpose for this assessment is to consider the:

- NSW Department of Planning and Infrastructure Director-General’s environmental assessment requirements
- Requirements of the Commonwealth Department of Sustainability, Environment, Water, Population and Community for matters of national environmental significance (supplementary Director-General’s environmental assessment requirements).

The assessment structure follows the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005), and the significant impact guidelines 1.1 for matters of national environmental significance

(Department of Environment Heritage and the Arts 2009).

The draft *Guidelines for Threatened Species Assessment* states that the objective of the threatened species assessment process is to provide information to enable decision makers to ensure that developments deliver the following environmental outcomes:

- Maintain or improve biodiversity values (ie there is no net impact on threatened species or native vegetation)
- Conserve biological diversity and promote ecologically sustainable development
- Protect areas of high conservation value (including areas of critical habitat)
- Prevent the extinction of threatened species
- Protect the long-term viability of local populations of a species, population or ecological community
- Protect aspects of the environment that are matters of national environmental significance.

The objectives of this biodiversity assessment are to identify relevant information that demonstrates that the project has been designed to be consistent with the principles outlined above, and where there are impacts, that adequate mitigation measures would be applied. Based on these objectives, and the State and Commonwealth guidelines, the purpose of this biodiversity assessment is to:

- Determine and describe the characteristics and condition of the vegetation communities and terrestrial and aquatic flora and fauna habitats within the project boundary
- Determine the occurrence, or likelihood of occurrence, of Threatened and migratory species, populations and communities listed under the *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the project boundary
- Undertake significance assessments for threatened biodiversity that occur or have potential habitat within the construction boundary under the provisions of the above mentioned legislation
- Propose mitigation strategies to mitigate impacts on the ecological values of the project. This would include a biodiversity connectivity strategy, and a construction mitigation and biodiversity monitoring strategies
- Outline a strategy to offset residual impacts on identified ecological values.

The Director-General's and supplementary Director-General's environmental assessment requirements for the project with respect to biodiversity issues (terrestrial and aquatic flora and fauna) are listed in Table 1-3 and Table 1-4 along with reference to where these issues are addressed in this report.

Table 1-3 Director-General’s environmental assessment requirements

| Reference | Requirements | Where addressed in report |
|--------------------------|--|--------------------------------------|
| Key issues: biodiversity | Impacts on the biodiversity values of the site and adjoining areas, including flora and fauna and their habitat (terrestrial, riparian and aquatic). | Chapters 4 and 6 |
| | Impacts on Endangered Ecological Communities, critical habitat, listed under both State and Commonwealth legislation that have been recorded or considered likely to occur on the site and surrounding land based on the presence of suitable habitat, and whether the project or specific aspects of the project constitute Key Threatening Processes in terms of the <i>Threatened Species Conservation Act, 1995</i> . | Chapters 3, 4 and 6 and Appendix E |
| | Targeted surveys of threatened flora and fauna species and their habitat that are known or likely to occur within the projects study area based on the presence of suitable habitat. The targeted surveys must include but not be limited to the following species: <ul style="list-style-type: none"> • Oxleyan Pygmy Perch (<i>Nannoperca oxleyana</i>), Purple Spotted Gudgeon (<i>Mogurnda adspersa</i>), • Squirrel Glider, Yellow-bellied Glider, Brush-tailed Phascogale, Eastern Pygmy-possum, • Wallum Froglet, Olongburra Frog, Pouched Frog, Giant-barred Frog, Green-thighed Frog, Green and Golden Bell Frog, • White-crowned Snake, Pale Headed Snake, Stephen’s Banded Snake, • Microbats – all threatened species, • Forest Owls – Masked, Sooty, Barking, Powerful and Grass Owl, • Brolga, Black-necked Stork, Comb-crested Jacana, Magpie Goose, Black Bittern, • Bush Stone – curlew, Albert’s Lyrebird, Grey-crowned Babbler, • Koala, Long-nosed Potoroo, Common Planigale, Rufous Bettong, and • Emu (<i>Dromaius novaehollandiae</i>). Details of the survey method employed including survey effort and timing and representativeness for the species targeted, should be identified. | Chapters 2 and 3 |
| | Impacts on wildlife and habitat corridors, and habitat fragmentation and details of mitigation measures, having regard to the range of fauna species and opportunities for connectivity (terrestrial, arboreal and aquatic) across the project; | Section 2, 3 and Appendix A |
| | Impacts on/from vegetation loss, weed infestation (terrestrial and aquatic), edge effects, groundwater dependent ecosystems, wetlands including State Environmental Planning Policy No. 14 – Coastal Wetlands, and aquatic and riparian species and their habitats. | Chapter 4 |
| | Consideration of regional scale cumulative impacts and the significance of the biodiversity impacts of the project in the context of the Pacific Highway Upgrade Program. | Chapter 4 |
| | Details of how impacts would be managed during construction and operation for project components (including ancillary facilities), the suitability of measures and adaptive management and maintenance protocols and monitoring programs. | Chapter 5, Appendix A and Appendix B |
| | The details of available offset measures to compensate the biodiversity impacts of the project where offset measures are proposed to address residual impacts, consistent with the <i>Principles for the use of biodiversity offsets in NSW</i> . | Appendix C |

| Reference | Requirements | Where addressed in report |
|-----------|--|---------------------------|
| | Taking into account the <i>Draft Guidelines for Threatened Species Assessment</i> (Department of Environment and Conservation, 2005); <i>Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians</i> (DECCW, 2009); and <i>Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft</i> (DEC, 2004). | Chapters 2, 4 and 6 |

Table 1-4 Supplementary Director-General’s requirements

| Reference | Supplementary Director-General’s requirements | Where addressed in report |
|---|--|--------------------------------|
| 1 | Impacts on ecological communities and threatened species listed under Section 18 and 18A of the EPBC Act 1999 | Chapter 4 |
| 2 | Impacts on migratory species listed under Section 20 and 20A of the EPBC Act 1999 | Chapter 4 |
| 3 | Any relevant Commonwealth and State Government technical and policy guidelines | Section 1.4.2 |
| 4 | Matters outlined in Schedule 4 of the EPBC Regulation 2000, included in the requirements below and | Chapters 3-6 |
| 5 | The requirements outlined below: | |
| 3 Description of the existing environmental and relevant matters of national environmental significance | <p>A description of the existing environment including:</p> <ul style="list-style-type: none"> • A description of the nature, location and extent of: • All vegetation types occurring on-site and immediately adjacent to the site(s); and • Aquatic and riparian environment that is likely to provide suitable habitat for threatened species. • A description and map of the nature, location and extent of likely suitable habitat, and known records for migratory species, threatened species and ecological communities (including breeding, foraging, roosting habitat, habitat critical to the survival of the relevant species and ecological communities, movement corridors and migration paths) within the site and in surrounding areas that may be impacted by the project; and • A detailed description of the methodology, timing, effort and results of all targeted surveys undertaken for all relevant matters, in accordance with any relevant guidelines and a description of any limitations and constraints of the surveys undertaken; and • Details of relevant baseline conditions to be used to assess the impacts of the action and the performance and effectiveness of proposed mitigation measures, including water quality, road kill data and habitat parameters for relevant areas that support migratory species, listed threatened species and ecological communities; or • Details of the monitoring programs to be implemented before, during and after construction to determine these baseline conditions. | Chapter 3 |
| 4. An assessment of the relevant impacts of the | <p>An assessment of the relevant impacts of the action including:</p> <ul style="list-style-type: none"> • A detailed description and assessment of the nature and extent of all relevant impacts, including direct, indirect and facilitated impacts that the action will have or is likely to have on: • Threatened species and ecological communities listed under | Chapter 4 and 6 and Appendix E |

| Reference | Supplementary Director-General's requirements | Where addressed in report |
|--|--|---|
| action | <p>sections 18 and 18A of the EPBC Act; and</p> <ul style="list-style-type: none"> • Migratory listed under sections 20 and 20A of the EPBC Act. This must include, but not be limited to, an assessment of any habitat loss, degradation, fragmentation as a result of the action, as well as likely impacts from road strike; • Whether any relevant impacts are likely to be unknown, unpredictable or irreversible; and • Any technical data and other information used or needed to make a detailed assessment of the relevant impacts. | |
| 5. Proposed safeguards, mitigation and offset measures | <p>A description of changes to the action and feasible mitigation measures, that are intended to avoid, minimise or compensate for relevant impacts, including:</p> <ul style="list-style-type: none"> • A description of how the action has been designed to avoid impacts to migratory species, threatened species and ecological communities; • A consolidated list of mitigation measures proposed to be undertaken to prevent or minimise the relevant impacts of the action, before, during and after construction and during operation; • A description and an assessment of the expected or predicted effectiveness of, the mitigation measures, including a justification of the location and design of mitigation measures, including a justification of the location and design of mitigation measures to be implemented to ensure their effectiveness. This analysis should be based on best available knowledge and baseline data for the relevant areas; • A description of the objectives of the mitigation measures, thresholds for corrective actions, and the corrective actions to be implemented should these thresholds be exceeded; • Any statutory or policy basis for the mitigation measures; • Details of environmental management plans that set out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including the person or agency responsible for implementing these programs and provisions for independent environmental auditing; • The name of the agency responsible for endorsing or approving each mitigation measure or monitoring program; • In the event that impacts cannot be avoided or mitigated, a description of any offsets to compensate for any predicted or potential residual impacts on migratory species, threatened species and ecological communities. This should be in accordance with the department's draft Offsets Policy and include: <ul style="list-style-type: none"> • An assessment of how any proposed offset compensates for the residual impacts on migratory species, threatened species and ecological communities which remain following avoidance and mitigation measures to be implemented; • The location of any proposed offset; • The timing of the delivery of any offset; and • How the offset will be secured and managed in perpetuity. | Chapter 5, Appendix A, Appendix B, Appendix C |
| 8. Information sources | <p>For information given in the environment assessment, the assessment must state:</p> <ul style="list-style-type: none"> • The source of the information; • How recent the information is; | Section 2.3.3 and section 2.3.4 |

| Reference | Supplementary Director-General’s requirements | Where addressed in report |
|-----------|---|---------------------------|
| | <ul style="list-style-type: none"> • How the reliability of the information was tested; and • What uncertainties (if any) are in the information. | |

1.4.2. State legislation and assessment requirements

Environmental Planning and Assessment Act 1979

The project is being assessed as state significant infrastructure under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). An Environmental Impact Statement is required.

According to the DGRs the environmental impact statement must address the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005). In addressing the guidelines the assessment is to address the important factors and/or heads of consideration with respect to assessing potential impacts on threatened species, populations or ecological communities, or their habitats as listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act).

Threatened Species Conservation Act 1995

Schedules 1, 1A and 2 of the *Threatened Species Conservation Act 1995* (TSC Act) provide for the listing of:

- Species presumed extinct, critically endangered, endangered and vulnerable in NSW
- Populations listed as endangered in NSW
- Ecological communities as critically endangered, endangered and vulnerable in NSW (threatened ecological communities – TEC).

Fisheries Management Act 1994

Schedules 4, 4A, 4 & 5A of the *Fisheries Management Act 1994* (FM Act) provide for the listing of:

- Endangered species, populations and ecological communities
- Critically endangered species and ecological communities
- Vulnerable species and ecological communities.

Draft Guidelines for Threatened Species Assessment

The draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005) state that the biodiversity assessment must include a statement as to whether or not threatened species are likely to occur in the study area. The Guidelines identify study area as the development footprint and any additional areas that are likely to be affected by the project, either directly or indirectly.

If there is a likelihood of threatened species being present, a threatened species

assessment must be prepared. The steps in the assessment process are:

- **Step 1. Preliminary assessment** including a description of the existing environment, vegetation and habitats and list of threatened species known or likely to occur
- **Step 2. Field survey and assessment** to provide a reliable assessment of the presence or absence of threatened species. In some cases, there may be habitat that indicates the possible presence of a species even if the species has not been conclusively found within the survey area. Therefore, consideration must be given to the presence of the known or likely habitat components for the species
- **Step 3. Evaluation of impacts.** Identify the magnitude and extent of impacts and the significance of the impacts on threatened species, populations or ecological communities, or their habitats using the assessment of significance
- **Step 4. Avoid, mitigate and then offset.** Consideration is to be given to measures to avoid or minimise impacts. This step requires the description and justification of measures to mitigate any adverse effects. Where measures to avoid and mitigate are not possible, then offset strategies need to be considered. The extent to which measures avoid, mitigate or offset impacts upon threatened species must reflect the conservation value of the feature including its formal state as a critically endangered, endangered or vulnerable species, population or ecological community
- **Step 5. Key thresholds.** The assessment needs to contain justification of the preferred option based on:
 - whether or not the project, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts would maintain or improve biodiversity values
 - Whether or not the project is likely to reduce the long-term viability of a local population of the species, population or ecological community
 - Whether or not the project is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction
 - Whether or not the project would adversely affect critical habitat.

1.4.3. Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

Under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), any action which has, would have, or is likely to have a significant impact on a matter of national environmental significance or on Commonwealth land, triggers the EPBC Act and requires Commonwealth assessment and approval from the Commonwealth Minister for the Environment. The matters of national environmental significance protected under the EPBC Act and of relevance to this assessment are:

- Listed threatened species and ecological communities (Sections 18 & 18A)
- Migratory species protected under international agreements (Sections 20 & 20A).

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 (DEWHA 2009a). In considering the impacts on listed species, ecological communities and migratory species, the assessment must refer to the significant impact guidelines 1.1 under

the EPBC Act (DEWHA 2009a).

The project was referred to the Department of Sustainability, Environment, Water, Population and Community in May 2012. The project was declared to be a controlled action on 20 June 2012, requiring assessment and approval by the Commonwealth Minister for Sustainability, Environment, Water, Population and Community. The requirements to be addressed for this approval have been incorporated into the NSW Director-General's environmental assessment requirements for the project environmental impact statement. The environmental impact statement is an accredited assessment process for the purpose of decision on whether or not to approve the action by the Commonwealth Minister. The Commonwealth assessment process is also discussed in Chapter 2 of the environmental impact statement, and is explained on the Department of Sustainability, Environment, Water, Population and Community web site <http://www.environment.gov.au/index.html>.

1.4.4. Relevant State and Commonwealth guidelines

The following biodiversity assessment guidelines are of relevance to the environmental impact statement and are referred to in the Biodiversity Working Paper:

- *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries, 2005)
- *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003). These guidelines provide information for waterway classification and ways to minimise impacts to fish and other aquatic wildlife from road projects which may improve the survival rate and protect threatened fish species, populations and their habitat
- *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians* (DECCW, 2009)
- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DEC, 2004)
- *Significant impact guidelines 1.1 – matters of national environmental significance* (DEWHA 2009)
- Commonwealth Policy Statements on survey guidelines for Australia's threatened fauna including bats birds, frogs, fish, mammals and reptiles
- Listing and conservation advices for the Minister of Sustainability, Environment, Water, Population and Communities on listed threatened species and ecological communities of national environmental significance.

2. Methodology

2.1. Assessment approach

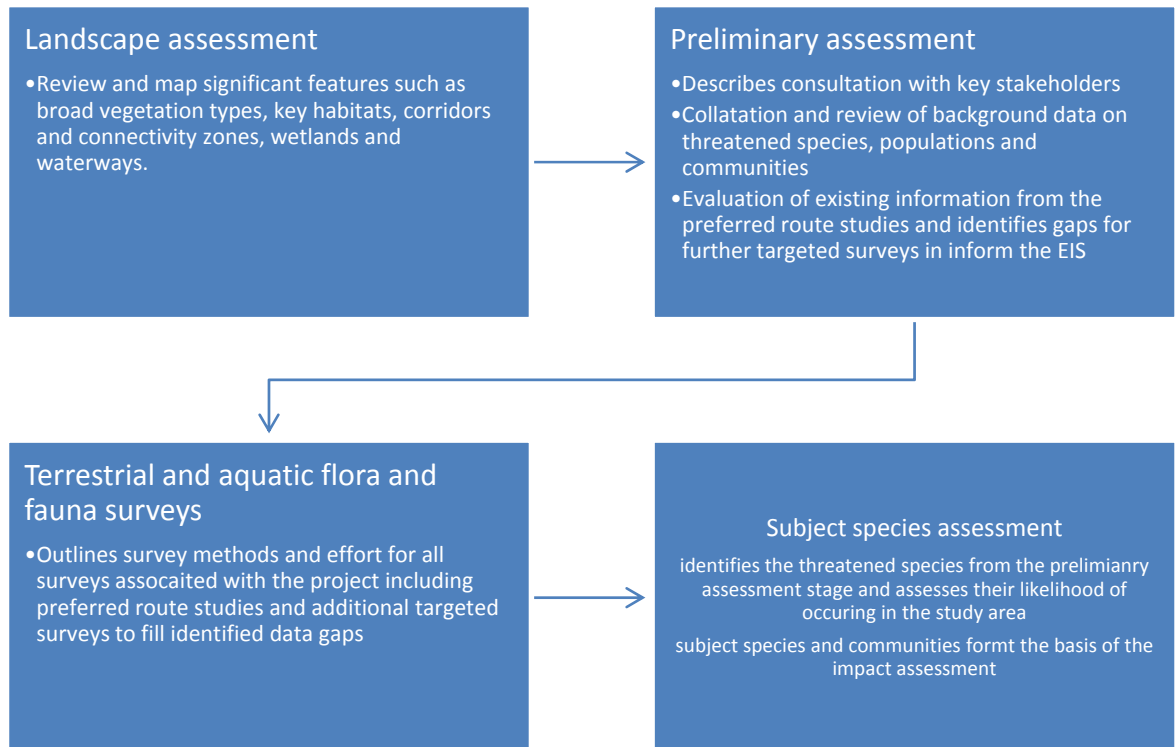
Chapter 2 provides a detailed outline of the biodiversity assessment approach and field survey methods. As discussed the steps in the assessment process follow those outlined in the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005) and draws on the guidance outlined in the various publications discussed in 1.4.4. This biodiversity assessment has been separated out into the following phases shown in Table 2-1.

Table 2-1 Assessment phases

| Phase | Description | Where addressed in report |
|--|--|--------------------------------|
| Preliminary assessment | <ul style="list-style-type: none"> • Outlines the methods for identifying threatened and migratory species, populations and ecological communities known or likely to occur in the project boundary, from a review of background information relevant to the study area. • Outlines the approach taken in consulting key stakeholders. • Collates the methods of all field surveys conducted for the preferred route ecological investigations and critically reviews this data to identify knowledge gaps that would further inform the assessment of impacts. • The critical review focuses on the adequacy of the data for informing this impact assessment with any data gaps identified as a requirement for additional targeted surveys as part of the EA. | Section 2.5 and Appendix D |
| Field surveys and subject species assessment | <ul style="list-style-type: none"> • The field surveys were aimed at providing a reliable assessment of the presence or absence of threatened and migratory species, populations and ecological communities where previous surveys along the route were undertaken at a satisfactory level, these were included. • Field survey methods and results are described in detail which includes firstly an outline of all ecological surveys conducted as part of the project development and secondly a description of any supplementary targeted surveys conducted to fill any gaps identified from the original surveys as part of the EA. • State and nationally listed threatened species and migratory species identified from the preliminary assessment were assessed in detail to identify their likelihood of occurrence in the project boundary based on the survey results and known habitat requirements and compared with the habitats and condition identified across the project boundary. • In some cases, where the habitat present indicated the possible presence of a species even if the species had not been conclusively found within the survey area, the species was assessed as present. | Section 2 and 3 and Appendix D |

| Phase | Description | Where addressed in report |
|---------------------------------|---|-----------------------------|
| Evaluation of impacts | <ul style="list-style-type: none"> • Outlines the general principles of avoidance, mitigation and offsetting and describes the steps taken to avoid potential biodiversity impacts on biodiversity in particular key design measures informed by the detailed field surveys. • Residual impacts are described where avoidance was not possible including direct and indirect impacts. These impacts are then assessed (significance assessment) for threatened and migratory species, populations and ecological communities in the context of Part 5.1 of the EP&A Act, the TSC Act, FM Act and EPBC Act including significance assessments and identification of key threatening processes. | Section 4, 6 and Appendix E |
| Avoid, mitigate and then offset | <ul style="list-style-type: none"> • Where impacts have been identified these form the basis of detailed mitigation strategies. A framework is presented for a consistent mitigation and management approach across the different project sections during construction and operation of the project. • The framework provides a mitigation strategy, including biodiversity connectivity strategy and a monitoring strategy. • An offset strategy is presented for offsetting the residual impacts of the project with a focus on identifying the offset objectives and framework to achieve these objectives so that the project would maintain or improve biodiversity values. | Section 4 and 5 |
| Key thresholds | As a final step in the biodiversity assessment process, an evaluation on whether or not the impacts of the project, including measures to avoid or mitigate impacts or compensation to prevent unavoidable impacts on threatened species, populations and communities would meet the key thresholds identify by the threatened species assessment guideline. | Section 7 |

The structure of the methods chapter is shown in the following diagram.



2.1.1. Potential constraints and limitations

The preferred route biodiversity studies involved a program of detailed ecological surveys conducted between 2006 and 2012 focused along the length of the project boundary. A critical evaluation of all data collected prior to the EIS was conducted and the data found to be adequate for inclusion in the EIS. Additional surveys were conducted to address any data gaps.

Previous studies took a robust approach aimed at providing a level of detail sufficient for inclusion in the EIS and were planned for consistency with survey guidelines outlined in the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation 2004). Details on the general methods and targeted survey methods for threatened species are provided in the following sections, which includes reference to the survey guidelines/

The studies provide a comprehensive inventory of terrestrial and aquatic flora and fauna (biodiversity) including a list of known and potential threatened communities, populations and species as a basis for the biodiversity assessment. Where species populations could be surveyed (for example some threatened plants) this was done, however the majority of the surveys were not designed to estimate populations but simply to indicate presence or absence, noting that you can only confirm presence not absence.

The aim of the preferred route biodiversity surveys was to identify and describe the biodiversity and ecological characteristics potentially impacted by the concept design through systematic surveys using a stratified sampling approach over multiple seasons. The survey design and effort was designed to inform an assessment of significance for species, communities and populations of local, regional, state and national conservation significance (as defined under the EPBC Act, FM Act and TSC Act) and their habitats.

It is recognised that there are some constraints and limitations to the previous work and the objective of the environmental impact statement was to build on this existing dataset and limitations by identifying and addressing additional survey requirements in particular seasonal or property access constraints.

The body of ecological data contributing to this biodiversity assessment has therefore been gathered over a period of six years (2006-2012) covering over 30 weeks of field investigations over four seasons and a diversity of weather conditions. Due to the length of time and diversity of survey techniques, this assessment has been accurate in the identification of many of the flora and fauna and threatened species, communities and populations likely to be present, including those species requiring targeted assessment in the environmental assessment requirements. Despite this, the flora and fauna surveys had some physical and geographical limitations regarding localised weather conditions around each survey period. This can affect fauna activity and flowering times of targeted threatened flora species.

Some surveys occurred in lower condition habitats due to these being positioned in the project boundary compared to higher condition sites which may have occurred outside the boundary and access was not granted. In this case it was assumed that the lower condition areas provide sub-optimal or refuge habitat values for threatened species using offsite habitats. During the site selection and stratification process, every effort was made to select a range of habitat conditions and ensure that high quality habitat was sampled.

Therefore the conclusions of this assessment are based upon available data and ecological surveys undertaken from 2006 to 2012 and are therefore indicative of the environmental conditions of the site at the time of the survey. It should be recognised that site conditions, including the presence of threatened species, can change with time and that some of the original data reports on surveys conducted greater than five years. Where threatened species were not conclusively identified in an area, this was supported by detailed habitat assessment to identify the species potential presence in the study area (or surrounding land) based on known and likely habitat components of the species. This was assisted by referring to Biobanking assessment tools (vegetation types database and threatened species profile database) that predict the presence of threatened species, both State and federally listed. In addition further baseline water quality monitoring is recommended to update these data.

The assessment acknowledges some limitations and has adopted the precautionary principle. The collection of data over an extended survey period allowed the surveys to target seasonal and climatic limitations.

2.1.2. Precautionary principle

The precautionary principle is defined as (*Protection of the Environment Administration Act 1991* s6 (2)): “if there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation”.

The precautionary principle was adopted where properties could not be accessed, detailed ecological population data was not available or where weather conditions were not considered optimal during the survey. This involved assuming that threatened species which are likely to occur in the study area (based on the presence of suitable habitat, recent records and use of the Biobanking assessment tools) are present in the study area. Significance assessments were prepared on this basis for State and federally listed species, populations and communities.

2.2. Landscape context

The landscape features of the region were identified through a review of available biodiversity databases focusing on lands up to 20 kilometres from the project boundary. The objective of the review was to identify and map significant features such as broad vegetation types, key habitats, corridors and connectivity. The list of accessible data included:

- Recent aerial photography obtained for the project was used to examine the network of vegetation and landscape connectivity in the study area
- The NSW Landscapes (Mitchell 2003), a state-wide database and map (1: 250 000 scale) of landscapes, describing land attributes such as geologic, geomorphic and pedologic factors
- The Lower North East (LNE) Forest Ecosystems database (NSW National Parks and Wildlife Service 1999a)
- The Comprehensive Regional Assessment Floristic Types Information (CRAFTI) database (Resource and Conservation Division 2001)
- Key habitats and corridors (NSW National Parks and Wildlife Service 2001), a regional representation of the likelihood of occurrence of fauna key habitats. This is combined with regional and sub regional fauna linking corridors of the Upper North East (UNE) and Lower North East (LNE) NSW Regional Forest Agreement (RFA) regions
- Climate Change Wildlife Corridors for North-east NSW (DECC 2007) conducted on behalf of the Northern Rivers Catchment Management Authority (NRCMA) to help identify land areas for strategic conservation efforts to aid adaptation to the potential adverse effects of climate change for wildlife
- The *Draft Mid-North Coast Regional Conservation Plan* (DECCW, 2010d) which aims to protect and manage the region’s biodiversity assets and uses the Climate Change Wildlife Corridors for North-East NSW (DECC, 2007)
- The *Northern Rivers Regional Biodiversity Management Plan* (DECCW, 2010e), a national regional recovery plan under the EPBC Act for threatened species and ecological communities in the region

- Clarence Valley Council Biodiversity Management Strategy 2010 which uses the DECC (2007) Climate Change Wildlife Corridors and the Northern Rivers Regional Biodiversity Management Plan to inform the Clarence Valley Council Coastal Corridors
- Morgan (2001a) *Landscape health in Australia*. National Land and Water Resources Audit, Canberra, ACT.

While councils hold some additional information about wildlife corridors in their local government area, the scale of this data does not provide additional value to the information already obtained for recognised regional wildlife corridors and connectivity opportunities. Additionally, many councils have simply adopted the existing corridors identified in the Northern Rivers Regional Biodiversity Management Plan and the Climate Change Wildlife Corridors.

2.3. Preliminary assessment

The preliminary background research for the assessment involved a review of biodiversity literature, previous studies and government databases covering the study area and consultation with key agency stakeholders. The review aimed to identify a list of threatened biota relevant to the habitats in the study area and determine their potential presence in the study area to provide a focus for further field investigation and impact assessment.

2.3.1. Consulting key stakeholders

Key stakeholders were consulted throughout the biodiversity assessment through a series of meetings and workshops. A number of issues were raised and clarified throughout through this consultation including:

- The technical objectives of the study
- Identify important factors such as habitats and corridors for the NSW North Coast Bioregion, specifically in relation to biodiversity connectivity workshops
- Any specific survey requirements for targeted species
- The level of reporting and reporting format
- A strategy for identifying knowledge gaps for the endangered emu population
- Issues around biodiversity offsets, monitoring programs and management measures.

Discussions with key stakeholders also provided further ecological context and background to the biodiversity issues in the study area. Key stakeholders relevant to the ecological assessment included:

- Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC)
- NSW Office of Environment and Heritage (OEH) / Environment Protection Authority including the NSW National Parks and Wildlife Service (NPWS)
- NSW Department of Primary Industries (NSW Fishing and Aquaculture)

- Relevant local councils
- National Herbarium
- Forests NSW
- Clarence Valley WIRES
- In addition numerous property owners were consulted during the field investigation to identify local knowledge of flora and fauna, road kill sites and wildlife movements in the study area.

A summary of the key issues relating to biodiversity that were raised through consultation with stakeholder is provided as 0.

2.3.2. Collation and review of existing information

Existing information on the presence and distribution of threatened species and populations in the study area was obtained from a variety of data sources including:

- Atlas of NSW Wildlife Database (OEH 2012b)
- NPWS (2002a and 2002b) Threatened Species of the Upper North Coast of New South Wales: (i) Fauna; and (ii) Flora
- Records published in scientific journals, reports and general flora and fauna distribution texts
- Results of local environmental studies, including studies prepared by consultants, local government authorities, biological organisations, universities and other sources (eg Steenbeeke 1998; 1999)
- Discussions with personnel from the OEH and DPI (Forests NSW and Fisheries) and Coffs Harbour, Clarence Valley, Richmond Valley and Ballina councils
- Anecdotal reports from authorities and local ecologists / naturalists and local landowners
- National Directory of Important Wetlands
- Road kill records provided by Clarence Valley WIRES and RMS
- OEH Threatened Species Profile Search for species population and ecological communities of NSW (accessed online January 2012)
- Protected Matters Search Tool (DSEWPaC)
- Species profile and threats databases (OEH and DSEWPaC) (accessed online January 2012-November 2012)

This list of records of threatened species and populations was critically reviewed for direct relevance to the study area taking into consideration the types of habitats present along the project boundary and their condition relative to the broader NSW North Coast Bioregion. The list of threatened species and populations with the potential to occur on the study area based on database searches is provided at Appendix D.

2.3.3. Previous project development ecological assessments

Existing data on the vegetation, habitats, species and populations including their distribution has been compiled from a series of systematic field-based investigations conducted along the project boundary as part of the previous project development studies, these are described as:

- Section 1-2: Woolgoolga to Wells Crossing
- Section 3-5: Wells Crossing to Iluka Road
- Section 6-8: Iluka Road to Woodburn
- Section 9-11: Woodburn to Ballina.

These project development studies included comprehensive field surveys along the preferred route corridor between 2006 and 2011. These were conducted across all seasons and were designed to a level sufficient to inform an EIS (as detailed in RTA, 2006-2011).

Evaluation of existing information

Due to their comprehensive approach the ecological data from the preferred route corridor studies have been considered a foundation for assessing the impacts on biodiversity. The environmental impact statement therefore aimed specifically at building on this work by identifying knowledge gaps that could be filled by additional surveys. Knowledge gaps refer to inappropriate survey timing and effort and representativeness for the species targeted, taking into account seasonal limitations and lag times. Examples of factors that were considered in determining the reliability of the information are consistent with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DEC 2004) and included:

- date of record, all data for the preferred route were collected during 2006-2011
- survey design, methods and effort
- accuracy of taxonomy, location data and accuracy of identification.

The review focused on both terrestrial and aquatic surveys and looked at preferred route studies only and not earlier route options investigations. In all cases the surveys used a stratified sampling approach and covered a range of seasons in accordance with the survey guidelines *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DEC 2004). The data was designed to inform significance assessments for species, communities and populations of local, regional, state and national conservation significance (as defined under the EPBC Act, FM Act and TSC Act) and their habitats (Table 2-2).

Table 2-2: Summary of previous development projects ecological assessments for the preferred route corridor

| Project sections | Development project and ecological assessments | Summary of ecological surveys conducted | Summary of review findings (limitations with the data) |
|------------------|---|---|---|
| 1-2 | <p>Woolgoolga to Wells Crossing</p> <p>Ecotone Ecological Consultants (2007). Advanced Terrestrial Flora and Fauna Assessment.</p> <p>GHD (2007). Preferred Route Aquatic Ecology Survey.</p> <p>RMS (2012). Detailed design surveys</p> | <p>Fauna surveys – systematic and comprehensive, encompassing a range of seasonal and weather conditions over spring, summer and autumn. Used a full suite of survey methods aimed at identifying a range of threatened fauna species and in accordance with DEC (2004).</p> <p>Flora surveys – systematic and comprehensive, encompassing spring and summer survey including targeted threatened species surveys in accordance with DEC (2004). Vegetation communities were surveyed and mapped to 50 m either side of alignment.</p> <p>Aquatic survey – systematic and comprehensive, including a habitat assessment conducted across all waterways and included targeted surveys for threatened fish including the Oxleyan Pygmy Perch and Purple spotted Gudgeon.</p> | <ul style="list-style-type: none"> • Limited survey of the distribution and abundance of the EPBC Act listed Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) within the project boundary. • Coverage for threatened flora surveys was limited to along the road corridor only and not adjacent areas potentially indirectly impacted by construction and operation. • Coverage of vegetation community survey restricted to 50 m either side of the corridor only. • Some targeted aquatic survey sites, although conditions were dry at the time of survey. • Further surveys were recommended for hollow-bearing trees. |
| 3-5 | <p>Wells Crossing to Iluka Road</p> <p>SKM (2009) Terrestrial ecology Working Paper.</p> <p>Ecology Lab (2009). Aquatic Ecology Working Paper.</p> | <p>Fauna surveys – systematic and comprehensive, encompassing autumn, winter and spring, stratified appropriately and using a full suite of methods aimed at identifying a range of threatened fauna species with potential to occur. In accordance with DEC (2004)</p> <p>Flora surveys – systematic and comprehensive, encompassing autumn, winter and spring, including targeted threatened species surveys in accordance with DEC (2004). Vegetation communities mapped in detail over an area up to 500 m from the project boundary.</p> <p>Aquatic surveys – systematic and comprehensive conducted across all waterways in winter including targeted surveys for threatened fish including the Oxleyan Pygmy Perch and Purple spotted Gudgeon.</p> | <ul style="list-style-type: none"> • Weather conditions were not optimal for detection of bats and frogs during the July-August survey period. Further survey for these taxa was conducted in October 2009 to address the shortfall and further fieldwork in summer was recommended. • Further targeted surveys required for threatened plants in particular the population of Rough-barked Apple (<i>Angophora robur</i>) in the Pillar Valley to Tyndale area to understand the scale of the impact. • Further investigations into the size and impacts on the endangered emu population in the NSW North coast bioregion and Port Stephens LGA including movements around the project boundary and the location and type of proposed mitigation structures. |

| Project sections | Development project and ecological assessments | Summary of ecological surveys conducted | Summary of review findings (limitations with the data) |
|------------------|---|---|---|
| 6- 8 | <p>Iluka Road to Woodburn Connell Wagner (2008). Ecological Assessment.</p> <p>Ecos (2006) <i>Vegetation survey of the investigation area for the upgrade of the Pacific Highway between Iluka Road to Woodburn (incorporating summer survey)</i>.</p> <p>Lewis Ecological Surveys (2006). Targeted Frog Survey.</p> | <p>Fauna surveys – systematic and comprehensive and conducted to sufficient level, seasonal and weather conditions. The initial surveys were conducted during autumn and winter, and further targeted surveys for frogs were conducted in summer under suitable rainfall conditions. In accordance with DEC (2004)</p> <p>Flora surveys – systematic and comprehensive, encompassing autumn and winter including targeted threatened species surveys. Follow-up targeted summer flora survey undertaken to identify spring-summer flowering species. Vegetation communities identified and mapped in detail to 500 m from the project boundary.</p> <p>Aquatic surveys – none conducted.</p> | <ul style="list-style-type: none"> • Recommended further fieldwork for hollow-bearing trees, arboreal and terrestrial mammal surveys for Squirrel Glider, Eastern Chestnut Mouse, Common Planigale and nocturnal birds. • Further surveys recommended for cryptic summer flowering threatened flora species to identify and map the extent of the populations affected by the corridor. • Aquatic fauna surveys were recommended particularly targeted potential habitat that was identified for the Oxleyan Pygmy Perch and Purple Spotted Gudgeon. |
| 9-11 | <p>Woodburn to Ballina Biosis (2007). Terrestrial and Aquatic Ecology Investigations for the Concept Design.</p> <p>Geolyse (2007). Phase Three Fauna Studies Summer Winter and Spring Field Investigations.</p> <p>Ecosense (2008) Independent ecological review of the route options incorporating vegetation community survey and targeted aquatic survey.</p> <p>Hyder (2007). Upgrading the Pacific Highway H10 – Woodburn to Ballina Oxleyan Pygmy Perch Options Report.</p> | <p>Fauna surveys – systematic and comprehensive and conducted to sufficient level, seasonal and weather conditions which included spring, summer and winter and using a full suite of methods aimed at identifying a range of threatened fauna with potential to occur. In accordance with DEC (2004). Additional targeted surveys for Olongburra Frog were conducted to capture a high rainfall event over summer.</p> <p>Flora surveys – systematic and comprehensive and conducted over spring and summer including targeted threatened species surveys. Vegetation communities were surveyed and mapped on two occasions, providing data up to at least 500 m from the project boundary.</p> <p>Aquatic surveys – systematic and comprehensive, conducted across all waterways, including targeted surveys for threatened fish including the Oxleyan Pygmy Perch and Purple spotted Gudgeon.</p> | <ul style="list-style-type: none"> • Recommended further surveys for roosting bats in bridges proposed for demolition • Targeted surveys recommended for threatened invertebrates considered to potentially occur based on presence of suitable habitat. • Threatened flora surveys did not cover disturbed environments which provide potential habitat for the nationally listed Hairy Joint Grass (<i>Arthraxon hispidus</i>). • No surveys were done for the EPBC Act listed community 'Lowland Rainforest' (listed November 2011) using the recommended survey approach provided under the EPBC Act. |

Given the systematic approach of the survey methods and high level of survey effort focused on the project boundary, the data presented from these studies has been considered a strong foundation for the biodiversity assessment and has been used to inform the presence of species in the project boundary.

Each of the ecological assessment reports produced identified the need for further surveys or investigations and these recommendations along with other seasonal data gaps informed the additional targeted surveys conducted in 2011 and 2012.

2.3.4. Additional survey requirements

The approach to mapping vegetation communities for each of the previous development projects varied in quality and scale. Additional desktop assessment was conducted to present a consistent vegetation classification system for the whole project based on the OEH vegetation types database (Office of Environment and Heritage 2012a) used in BioMetric 2.0 (Gibbons *et al.* 2008). Through this assessment some gaps were identified, for example up to 130 hectares of existing vegetation within the project boundary was not mapped or classified sufficiently. As a result the need for further targeted ground-truthing and vegetation mapping was identified. The gaps in vegetation mapping were particularly evident in Sections 1 and 4.

The body of work completed for the preferred route studies were conducted over an extended timeframe which included sampling in different seasons, although some locations were surveyed in cooler months. Additional surveys were deemed to be required to capture warm season flora and fauna particularly cryptic or seasonally dependent flora species. In addition, the review identified some gaps in survey effort in relation to aquatic surveys and targeted surveys for specific taxa.

A list of additional surveys requirements was developed based on the review of previous studies and updated database searches, as well as minor changes to the concept design and in view of the Director-General's environmental assessment requirements. These requirements are outlined in Table 2-3. The scope of work addresses the lag time between the previous surveys, in particular to re-survey identified threatened plant populations to identify if there has been a change in the population or distribution. Some seasonal survey requirements have also been identified.

Table 2-3: Scope of work for additional survey requirements

| Project section | Additional survey requirements | | |
|-----------------|--|---|--|
| | Fauna and habitat | Flora and vegetation | Aquatic surveys |
| 1-2 | <ul style="list-style-type: none"> Record the density of hollow-bearing trees around records for threatened hollow-dependent species, in particular the Yellow-bellied Glider (<i>Petaurus australis</i>) and Squirrel Glider (<i>P. norfolcensis</i>). Glossy Black Cockatoo habitat areas. Surveys and habitat assessment sufficient for determining the potential presence of threatened species. | <ul style="list-style-type: none"> Map any changes to the extent and distribution of previously identified threatened plant locations. Targeted surveys for threatened flora in particular <i>Lindsaea incisa</i> in suitable habitat near Wells Crossing, <i>Olax angulata</i> and <i>Maundia triglochinoidea</i> in Wells Crossing and <i>Marsdenia longiloba</i>. Additional survey of Eucalyptus tetrapleura. Around 130 hectares of vegetation to be ground-truthed including widening the vegetation mapping to be consistent with the other project sections. | Surveys and habitat assessment sufficient for determining the potential presence of threatened species |
| 3-5 | <ul style="list-style-type: none"> Record the density of hollow-bearing trees around records for threatened hollow-dependent species, in particular the Yellow-bellied Glider (<i>Petaurus australis</i>) and Squirrel Glider (<i>P. norfolcensis</i>). Resources for Glossy Black Cockatoo. Any recent Osprey or Black-necked Stork nest sites in the corridor. Targeted summer frogs, bat and reptile surveys. Targeted survey for Common Planigale. Additional forest owl surveys required to meet DEC (2004) survey guidelines Further survey of the Endangered Emu population to identify the distribution, population and any movement corridors. | <ul style="list-style-type: none"> Map any changes to the extent and distribution of previously identified threatened plant locations. Targeted surveys for <i>Lindsaea incisa</i> and <i>Grevillea quadricauda</i> in suitable habitat east of Tucabia along the alignment. Targeted surveys for summer flowering species in areas of identified suitable habitat including <i>Cryptostylis hunteriana</i>, <i>Cyperus aquatilis</i>. More detailed survey of the Angophora robur population between Pillar Valley and Tyndale to identify the size and distribution of the local population and avoidance measures. Vegetation community identification and mapping considered adequate not required. | Surveys and habitat assessment sufficient for determining the potential presence of threatened species |

| Project section | Additional survey requirements | | |
|-----------------|--|---|---|
| | Fauna and habitat | Flora and vegetation | Aquatic surveys |
| 6-8 | <ul style="list-style-type: none"> Record the density extent of hollow-bearing trees around records for threatened hollow-dependent species, in particular the Yellow-bellied Glider (<i>Petaurus australis</i>) and Squirrel Glider (<i>P. norfolcensis</i>). Arboreal surveys in areas of high hollow-bearing tree density where such work has not been previously undertaken, and on opposite side of the highway to existing records to identify potential crossing points. Terrestrial mammal trapping in areas identified as potential habitat for threatened species, such as the Eastern Chestnut Mouse and Common Planigale. | <ul style="list-style-type: none"> Re-visit all previously identified threatened plant locations and map any change in the extent and distribution of the population. Targeted summer surveys for <i>Cyperus aquatilis</i>, <i>Oberonia titania</i>, <i>Lindsaea incisa</i>, <i>Prostanthera cineolifera</i>. | Detailed aquatic assessments, including field surveys targeting threatened fish species where suitable habitat identified, particularly targeting Oxleyan Pygmy Perch and Purple Spotted Gudgeon. |
| 9-11 | <ul style="list-style-type: none"> The extent of hollow-bearing trees around records for threatened hollow-dependent species, in particular the Squirrel Glider (<i>P. norfolcensis</i>). Targeted surveys for roosting colonies of bats on all bridges that are proposed to be removed or modified as part of the project. This specifically applies to Duck Creek and Emigrant Creek bridges which would both be demolished as part of the highway construction. Surveys be conducted for the Atlas Rainforest Ground Beetle, the Shorter Rainforest Ground-beetle, the Australian Fritillary and the Richmond Birdwing Butterfly. These surveys should include targeted surveys for specific habitat characteristics and plant species that these invertebrates may be dependent on. | <ul style="list-style-type: none"> Map any changes to the extent and distribution of previously identified threatened plant locations. Targeted summer survey for cryptic flora species Targeted survey of the newly listed critically endangered Lowland Rainforest (EPBC Act) using the survey methodology and thresholds identified in the listing advice provided under the EPBC Act. | Survey of Duck Creek. |

2.4. Field surveys

The following section describes in detail the field survey methods for surveys conducted between 2006 and 2012 and includes the preferred route surveys and additional targeted surveys (those undertaken as part of the EIS). The surveys were conducted by a number of specialists encompassing multiple field teams. For further detail in relation to project teams and personnel refer to RTA (2005-2011). The personnel involved in the additional work and compilation of the biodiversity assessment working paper for the EIS are shown in Table 2-4.

Table 2-4: Qualifications and role of key personnel

| Personnel | Qualifications | Role |
|---------------------------------------|---------------------------|---|
| Chris Thomson (SKM) | BAppSc; GradCertNatRes | Biodiversity assessment technical lead, fauna surveys |
| Dr Julie-Anne Harty (SKM) | BAppSc; PhD | Biodiversity assessment, fauna and aquatic surveys |
| Andrew Carty (SKM) | BEnvSc; DipBushRegen | Biodiversity assessment report; flora surveys, vegetation mapping |
| Alex Callen (SKM) | BEnvSc; Dip BushRegen | Biodiversity assessment report, flora surveys |
| Jon Carr (SKM) | BEnvScMgt | Biodiversity assessment report, flora and fauna surveys |
| Sarah Douglass (SKM) | BSc; MEnvMgt | Biodiversity assessment report; aquatic surveys |
| Kate Byrnes (SKM) | BSc | Biodiversity assessment report |
| Lui Weber (BAMM) | BSc (Hons) | Flora surveys and mapping |
| Lindsay Pope (BAMM) | BSc; PhD | Invertebrate surveys |
| David Rohweder (Sandpiper Ecological) | BAppSc; PhD | Fauna surveys |

The field surveys aimed to provide a consistent and systematic approach to the survey and assessment of threatened species. The survey techniques and level of survey effort employed was targeted at the range of threatened flora and fauna species expected and as determined by the background review. Surveys were designed for consistency with the *Draft Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation 2004) and reference to these guidelines is made throughout this section.

The majority of the surveys preceded the release of the Commonwealth guidelines for survey of threatened species (ie fish, mammals, reptiles, frogs, bats and birds) which were released in 2010 and 2011. While these guidelines are not mandatory they have been referred to in the latter surveys. The survey techniques across all surveys applied through the course of the study are considered to comply with these surveys in terms of the planning requirements, equipment used, and survey technique. Survey effort per taxa or fauna group is consistent with the DEC (2004) guidelines and may vary with the Commonwealth guidelines.

2.4.1. Summary of flora survey effort

The systematic survey of vegetation used a combination of transects and plot-based surveys to provide information on vegetation boundaries, floristic diversity and the presence of threatened species. Where threatened species were identified, further survey was conducted to identify the extent of the population directly and indirectly impacted by the project.

An overview of the survey methods and total flora survey effort combined for the preferred route ecological studies and the additional targeted surveys is presented in Table 2-5.

Threatened species searches were conducted continuously while traversing all properties and habitats in the study area given a period of 117 days across all seasons. During the survey, all threatened flora species encountered were recorded along with similar common species. Further description of the methods employed during the surveys follows the table. The location of surveys is provided in Appendix N.

Table 2-5: Summary of flora survey timing, techniques and effort

| Project section | Survey date | Overview of survey methods and effort |
|-----------------|---|--|
| 1-2 | 16-21 Oct 2006 18-24 Feb 2007 (13 days) | <ul style="list-style-type: none"> Mapping and detailed descriptions of vegetation communities using ground-truthed data and Aerial Photography Interpretation (API). Comparison with council vegetation mapping between Coffs Harbour and Red Rock (Coffs Harbour City Council 2005) Targeted searches for threatened flora along the entire length of the project using general meanders along project boundary General traverses/transects across the entire project boundary up to 75 m from the project centreline using two observers that collectively surveyed the entire alignment Quadrat sampling (20 x 20 m) to describe the vegetation communities and consistent with DEC (2004). Either one or two quadrats per vegetation stratification unit were sampled. No unit was greater than 50 hectares in size. 22 quadrats were sampled in total and this density exceeded the DEC (2004) survey guidelines General flora species inventory determined from a combination of the quadrat and transect surveys. |
| | 19-24 Aug 2010 (6 days) | <ul style="list-style-type: none"> Targeted survey to map the distribution and abundance of <i>Eucalyptus tetrapleura</i> from Halfway Creek to the Glenugie Upgrade include Wells Crossing Flora Reserve Other threatened flora was also surveyed for opportunistically during the targeted survey. |
| | 5-9 Dec 2011 (5 days) | <ul style="list-style-type: none"> Re-survey previously identified threatened flora populations to identify any change in distribution and abundance since the original survey Targeted searches for threatened flora in areas of suitable habitat as determined by the vegetation mapping data including <i>Lindsaea incisa</i>, <i>Maundia triglochinooides</i> and cryptic summer flowering species Vegetation community mapping and ground-truthing undertaken in areas that were not mapped adequately in 2006-07. |

| Project section | Survey date | Overview of survey methods and effort |
|-----------------|---|--|
| 3-5 | 2-7 July 2007 6-11 Aug 2007 14-19 Oct 2007 (18 days) | <ul style="list-style-type: none"> • Mapping and detailed identification of vegetation communities by ground-truthing up to 500 m from the centre line and Aerial Photography Interpretation (API) • Targeted searches for threatened flora subject species using random meanders, quadrates and transect surveys • General traverses/transects up to 100 m from the project centreline • Quadrat sampling undertaken to describe the vegetation communities • Mapping of regional and local distribution of <i>Eucalyptus tetrapleura</i> from the southern extent of the Glenugie upgrade north to Pillar Valley. Using. Grids and transects in suitable habitat to determine density • Survey to identify the extent and distribution of <i>Angophora robur</i> • Flora species inventory established from random traverses, transects and quadrats. |
| | 23-27 Aug 2010 (5 days) | <ul style="list-style-type: none"> • Fine-scale vegetation mapping including quadrat sampling to describe the vegetation communities and flora species around potential cut and fill locations (early works) • Targeted searches for threatened flora species at potential cut and fill locations along the project boundary • Additional flora species added to the overall section inventory. |
| | 16-19 Nov 2010 (4 days) | <ul style="list-style-type: none"> • Targeted survey to map the regional and local distribution of <i>Angophora robur</i> from Pillar Valley to Tyndale • Opportunistic observations of other threatened flora species during this targeted investigation. |
| | 21-25 Oct 2011 (5 days) | <ul style="list-style-type: none"> • Supplementary surveys of the distribution and abundance of <i>Angophora robur</i> from Pillar Valley to Tyndale. |
| | 12-16 Dec 2011 (5 days) | <ul style="list-style-type: none"> • Re-survey previously identified threatened flora populations to identify any change in distribution and abundance since the original survey • Targeted searches for threatened flora in areas of suitable habitat such as <i>Lindsaea incisa</i> and <i>Maundia triglochinosoides</i> and cryptic summer flowering species. |
| 6-8 | May-June 2005 (15 days) | <ul style="list-style-type: none"> • Vegetation mapping adapted from CRAFTI and Forests NSW data and Aerial Photography Interpretation (API) • Targeted searches for threatened flora • A total of 34 traverses, which varied in length from 1-3 kilometres • Quadrats undertaken where threatened species or EECs observed • Flora species inventory. |
| | 2-7 Dec 2007 (6 days) | <ul style="list-style-type: none"> • Targeted surveys for <i>Melaleuca irbyana</i> population were undertaken at New Italy • Direct counts of individuals undertaken within and surrounding the project boundary and population mapped using GIS. |

| Project section | Survey date | Overview of survey methods and effort |
|-----------------|---|---|
| | 16-20 Jan 2012 (5 days) | <ul style="list-style-type: none"> • Re-survey of previously identified threatened flora populations to identify any change in distribution and abundance since the original survey • Update and validate vegetation mapping across the corridor • Surveys for <i>Melaleuca irbyana</i> at New Italy • Targeted searches for threatened cryptic summer flowering species flora in areas of suitable habitat including <i>Cyperus aquatilis</i>, <i>Oberonia titania</i>, <i>Lindsaea incisa</i>, <i>Arthraxon hispidus</i> and <i>Prostanthera cineolifera</i>. |
| 9-11 | 14-25 March 2005 (12 days) | <ul style="list-style-type: none"> • Mapping and detailed descriptions of vegetation communities using Aerial Photography Interpretation (API) and statistical analysis of quadrat data • Threatened species searches in areas assessed as having potential to support threatened flora species and communities • Flora species inventory. |
| | 15-18 Aug 2006 (4 days) | <ul style="list-style-type: none"> • Mapping and detailed descriptions of vegetation communities using Aerial Photography Interpretation (API) and statistical analysis of quadrat data. |
| | 30-3 Aug-Sept 2010 (5 days) | <ul style="list-style-type: none"> • Fine-scale vegetation mapping including quadrat sampling to describe the vegetation communities at potential cut and fill locations • Targeted searches for threatened flora species at potential cut and fill locations • Added to general flora species inventory established from the project boundary. |
| | 16-20 Jan 2012 13-16 March 2012 (9 days) | <ul style="list-style-type: none"> • Re-survey of previously identified threatened flora populations to identify any change in distribution and abundance since the original survey • Targeted searches for threatened cryptic summer flowering species in areas of suitable habitat including <i>Cyperus aquatilis</i>, <i>Oberonia titania</i>, <i>Lindsaea incisa</i>, <i>Arthraxon hispidus</i> and <i>Prostanthera cineolifera</i> • Targeted survey of the Lowland Rainforest Critically Endangered Ecological Community (EPBC Act) using the suggested methodology provided by DSEWPaC. |

2.4.2. Vegetation and flora survey methods

The flora survey techniques and effort varied across the study area according to the species being targeted and the size of the habitat types in which each species occurs. The following descriptions of the techniques used are therefore described according to the 11 staging sections of the project.

Vegetation community classification and mapping

The previous development projects each classified and mapped the vegetation associations of the project boundary using a combination of transects and plot-based sampling, including a comparison with regional datasets. Any gaps identified in the evaluation of the data were subsequently ground-truthed in 2011 and 2012 including areas of threatened ecological communities. A single Geographic Information System (GIS) dataset was created and aligned with the BioMetric regional dataset (OEH 2012a) for ease of classification and assessment and consistency across the whole project boundary.

The vegetation community classification and mapping aimed to target threatened ecological communities identified from the background review as potentially occurring in the study area, which includes:

- Lowland Rainforest (critically endangered EPBC Act; endangered TSC Act)
- Littoral Rainforest (critically endangered EPBC Act; endangered TSC Act)
- Subtropical coastal floodplain forest (endangered TSC Act)
- Swamp sclerophyll forest (endangered TSC Act)
- Swamp oak floodplain forest (endangered TSC Act)
- Freshwater wetlands (endangered TSC Act)
- Coastal cypress pine forest (endangered TSC Act)

A further gap related to Lowland Rainforest of Subtropical Australia not being targeted in early assessments as it was not listed as Critically Endangered under the EPBC Act until November 2011. Much of the Lowland Rainforest of Subtropical Australia ecological community is listed as endangered in New South Wales as 'Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions' and 'Lowland Rainforest on floodplain in the NSW North Coast Bioregion' under the TSC Act and was targeted during ecological surveys undertaken 2006 to 2012. However, under the Commonwealth listing the listed Lowland Rainforest of Subtropical Australia ecological community comprises those patches that meet the condition thresholds outlined below in Table 2-6. Surveys assessing the below condition thresholds of rainforest patches in the study area were conducted north of the Clarence River to Ballina in Section 6-11 and areas of rainforest which meet these condition thresholds were identified as the federally listed community and mapped.

Table 2-6: Condition thresholds for the federally listed Lowland Rainforest of Subtropical Australia

| Patch Type (evidence of remnant vegetation & regeneration status) | A Natural remnant evident by the persistence of mature residual trees as listed in the listing advice for this community. AND | B Some residual trees from listing advice of this community are present plus evidence of either; natural regeneration ^{*1} AND/OR regeneration with active management ^{*2} AND | C A non-remnant patch that has recovered through a) natural regeneration ^{*1} AND/OR b) supplementary planting that has stature and quality that is reflective of the „Description“ ^{*3} AND |
|---|---|---|--|
| Patch Size (excludes buffer zone) | ≥ 0.1 hectares AND | ≥ 1 hectares AND | ≥ 2 hectares AND |
| Canopy Cover (over entire patch) ^{*4} | Emergent/canopy/subcanopy cover is ≥ 70% AND | | |
| Species Richness (over entire patch) | contains ≥ 40 native woody species ^{*5} from listing advice (for this community) AND | contains ≥ 30 native woody species ^{*5} from listing advice (Appendix A) AND | |
| Percent of total vegetation cover that is native ^{*6} (use sample plot) | ≥ 70% of vegetation ^{*6} is native | ≥ 50% of vegetation ^{*6} is native | |
| Notes: | | | |
| *1 Evidence of natural regeneration is shown by the presence of seedlings of a range of native species that did not originate through deliberate plantings. | | | |
| *2 A patch that is actively managed has regular (eg every 1–2 years) on the ground human regenerative activity such as weed control or supplementary plantings. | | | |
| *3 Closed canopy, 20–30 m tall, of representative species (eg white booyong, hoop pine, figs, brush box, yellow carabeen, red cedar, rosewood, white beech) | | | |
| *4 Canopy cover (projective foliage cover) is estimated over the entire patch. When assessing the ecological community, the canopy includes the emergents and subcanopy (everything above 10 m tall). Canopy/sub-canopy includes all trees and vines (native and non-native). | | | |
| *5 Woody species are trees, shrubs or vines that contain wood or wood fibres that consist mainly of hard lignified tissues. Excluded from woody species are graminoids, other herbs and non-woody vines. | | | |
| *6 Total vegetation cover includes emergents/canopy/subcanopy and understorey and ground layers. | | | |

Threatened flora species

Threatened species searches were conducted continuously while traversing all properties and habitats in the study area. During the survey, all threatened flora species encountered were recorded along with similar common species.

Targeted surveys were conducted for potential threatened flora species known from the region and identified from the background review. The location and abundance of threatened species was recorded using a Global Positioning System or a field computer with inbuilt Global Positioning System and mobile Geographic Information System software. The surveys were conducted along the entire length of the project boundary using general meandering traverses across identified areas of suitable habitat. The location and abundance of threatened flora species was recorded using a Global Positioning System.

Threatened flora populations

Where threatened species were identified further survey of the surrounding locality was conducted to identify the status of the species and identified the population distribution and abundance. The exact method of determining the distribution and abundance of a population depended upon the species being surveyed, in particular its clumping behaviour and its spatial extent based on initial visual abundance.

This technique identified large populations of *Melaleuca irbyana*, *Angophora robur* and *Eucalyptus tetrapleura* in vicinity of the project. Targeted surveys for these species included a traverse throughout the entire population within and adjacent to the project boundary and mapping of the outer extent of the population using a Global Positioning System. For *Melaleuca irbyana* in Section 7, a direct count of the number of trees within the project boundary was undertaken.

Additional targeted surveys

Given the lag time between the earlier surveys and the EIS additional targeted surveys were undertaken over the entire project boundary during the spring-summer season of 2011-12 to revisit locations where threatened flora were known to occur from the previous surveys.

The aim of these surveys was to identify any change in the population size and distribution of the subject species to account for the lag time between the initial surveys and any changes in climatic or general environmental conditions which may have influenced the cover and distribution of the population over time. It was predicted that some flora species may not have been detectable during the initial surveys, due to the drier conditions compared to wetter seasons in 2010-12. This factor was considered when determining the level of survey effort required for the supplementary flora surveys. Details of the additional targeted surveys are summarised in Table 2-7.

Table 2-7 Targeted surveys for known threatened flora populations

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|----------|--|--------------------|------------|
| | TSC / FM Act | EPBC Act | | Impact | Mitigation |
| Sandstone Rough Barked Apple (<i>Angophora robur</i>) | V | V | Confirmed. Section 3-4, Targeted surveys were undertaken to quantify accurate numbers within the project boundary. | 4.3.1. | 5.5 & 6.3 |

Angophora robur survey methods (July-October 2007; November 2010 – October 2011)

The species was first identified in 2009 (reported in SKM (2009)) in the area between Pillar Valley and Tyndale as part of the route selection and preferred route surveys. Targeted surveys were conducted in summer of 2010 and spring-summer 2011 to identify the size and extent of the local population in addition to a wider survey of the regional population.

Mapping occupied habitat

General observations of the distribution of *Angophora robur* in the study area indicated that the species most commonly occurred on the Summervale Range and Richmond Range landscape units (Mitchell 2003). The distribution of the species was initially mapped at a fine scale following extensive ground truthing along the footslopes of the Summervale Range between Pillar Valley and Tyndale near the project boundary. The extent of each of the populations was mapped using a handheld GPS identifying the approximate edge of the distribution of the species, as well as recording point data for individual plants and groups of trees.

Predictive mapping of the extent of the species was undertaken in areas to the west of the study area in the Copmanhurst and Coaldale regions and also to the east in Newfoundland State Forest. Predictive mapping used several GIS layers including Mitchell Landscapes, elevation data, broad-scale vegetation mapping, aerial photography and field observations where access was available.

Rapid habitat assessment

Rapid habitat assessments were undertaken within habitats where *Angophora robur* occurred. A range of environmental variables were recorded including dominant flora species and broad structural vegetation community type, the extent of disturbance including clearing, grazing and fire, the presence of rocky outcrops basic soil attributes, the reproductive health of the population including the population structure and subjective assessments of the health of trees, and potential hybridisation in the population.

Population estimates

The size of the local and regional population was estimated using a combination of several methods including ground-truthed mapping of the distribution of the species and direct counts within these populations, and predictive mapping based on soil landscape data, rapid field observations, direct counts and government-maintained databases. Direct counts were undertaken in each of the populations using belt transects of various lengths in which every tree was counted in a 20 m wide area (10 m either side). A total of 32 transects were undertaken in each of the larger populations and the average number of plants per hectare was extrapolated across the entire extent of the population. Two different estimates have been calculated based on the known extent of *Angophora robur* and the predicted extent.

Survey compliance / limitations

Considering the relatively extensive nature of this species in the project boundary targeted surveys of the species during the detailed design stage are recommended for Section 3 to physically survey and map the specific location of individuals and patches along the edges of the project boundary. The objective of the survey is to further refine the detailed design to avoid and minimise removal of the species.

| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|---|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8 ha), 6 (4.3ha), 7 (22.8ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|----------|--|--------------------|------------|
| | TSC / FM Act | EPBC Act | | Impact | Mitigation |
| Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) | V | V | Confirmed. Section 1-2. Targeted surveys were undertaken to quantify accurate numbers within the project boundary. | 4.3.1. | 5.5 & 6.3 |

Eucalyptus tetrapleura survey methods (July-October 2007; 19-24 Aug 2010)

The species was first identified in Glenugie State Forest as part of the Glenugie Upgrade between Section 2 and 3 (SKM 2010). This data contributed to the assessment of impacts and was built on for the EIS as the southern extent of the species in the study area extends into Section 2 of the project. Within SKM (2009) previously identified populations occurring within State Forests and conservation reserves were surveyed to assess the overall distribution and abundance of the regional population. The approximate extent of each population was mapped using a hand-held GPS to mark the boundaries of the population. Within each extent the density of trees per hectare was identified.

At each locality standardised transects were traversed, recording details on the number of trees 10 m either side of the centreline, with the start and finish of the transect recorded using a hand-held GPS so the exact length of the transect could be calculated. Trees were characterised into size classes based on the Diameter at Breast Height (DBH). The density of trees per hectare was calculated based on the average density from all transects undertaken within that population and extrapolated across the entire distribution of the population cluster.

Follow-up surveys were conducted in 2010 to establish an accurate depiction of the distribution and abundance of the species from Halfway Creek to the start of the Glenugie upgrade including Wells Crossing Flora Reserve and this data was added to the overall knowledge of the local Glenugie population.

Survey compliance / limitations

No further surveys are required for *Eucalyptus tetrapleura* due to survey limitations.

In some circumstances the approximate distribution of *Eucalyptus tetrapleura* was extrapolated based on the particular distribution within that population and identified environmental variables. For example in some populations *Eucalyptus tetrapleura* was restricted to ridge and upper slope areas and faded out below a certain elevation, and so the approximate area of its distribution could be mapped based on contour levels. In other circumstances it was restricted to areas below a certain contour level or was closely associated with a thick shrubby understorey which could be mapped through aerial photography interpretation. However several areas appeared to have complex soil, topography, geology and hydrological interactions making the mapping of *Eucalyptus tetrapleura* more problematic, requiring a larger degree of ground-truthing to determine the limits of the population. Where state forests and conservation reserves adjoin areas of private property, the approximate distribution of *Eucalyptus tetrapleura* on private property was extrapolated from data collected and identified as a predicted occurrence.

| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|--|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8 ha), 6 (4.3ha), 7 (22.8ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Orange Gum (<i>Eucalyptus bancroftii</i>) open forest of the North Coast | 11.5 | 2 (11.5ha) |
| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|--|---------------|----------|--|--------------------|------------|
| | TSC / FM Act | EPBC Act | | Impact | Mitigation |
| Weeping Paperbark (<i>Melaleuca irbyana</i>) | E | - | Confirmed. Section 7. Targeted surveys were undertaken to quantify accurate numbers within the project boundary. | 4.3.1. | 6.3 |

Melaleuca irbyana survey methods (December 2007; January 2012)

A population was first identified in the project boundary for Section 7 in 2006 (Eco 2007). A survey of the population was conducted and spatial data was recorded in GDA data format with a hand-held GPS, which generally displayed an accuracy of 5-10 metres. Point co-ordinates were recorded every 5-10 metres and a tally kept of the number of individuals. Polygons within the population were defined by recording individuals on the edge of the polygon, and then counts made of individuals within the polygon to identify the overall population distribution and abundance.

The population was re-surveyed in summer 2012 to assess any change in distribution and abundance since the original survey and to establish an accurate depiction of the distribution and abundance of the species, direct counts were also undertaken at this time focused on the project boundary.

Survey compliance / limitations

No further surveys are required for *Melaleuca irbyana* due to survey limitations.

The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling.

| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|---|
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| | | |
|---|--------------------------------------|--|
| | | (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Orange Gum (<i>Eucalyptus bancroftii</i>) open forest of the North Coast | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|--|---------------|----------|---|--------------------|------------|
| | TSC / FM Act | EPBC Act | | Impact | Mitigation |
| Slender Screw Fern (<i>Lindsaea incisa</i>) (SF) | E | - | Recorded in Sections 1, 2, 3 and 6. In 2011 targeted surveys determined proportion of habitat within project boundary. | 4.3.1. | 6.3 |
| <i>Maundia triglochinosoides</i> (MT) | V | | Confirmed records in Sections 2, 3 and 7. Targeted surveys were conducted in preferred species habitat (ie drainage lines creeks, rivers) to quantify population densities within project boundary. | 4.3.1. | 6.3 |

Survey methods (May-June 2005; July-October 2007; 5-9 Dec 2011; 16-20 Jan 2012)

Both species were found to be restricted to narrow riparian habitats associated with creeks and drainage swales in varying abundance. Targeted surveys concentrated on these suitable habitat types where crossed by the project using a general traverse approach. These species have been targeted in the initial surveys for each section (2005-2007) and suitable areas of habitat were re-surveyed during 2011 and 2012.

Where encountered the distribution of the species was mapped using a pre-determined abundance scale through the collection of a series of waypoints. For larger distributions an area was attributed to the point data (ie c. 20 m x 10 m area). In some areas where larger populations were observed polygons were mapped onto GIS software using aerial photography interpretation.

Survey compliance / limitations

No further surveys are required for these species due to survey limitations.

The species are readily detectable irrespective of season and reproductive status, but die-off during times of drought and re-grow following rain events particularly *Maundia triglochinosoides*. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling. *Maundia triglochinosoides* was not detectable during drought conditions in 2007 as many of the waterholes/drainage lines were dry, however survey conditions were adequate during 2011/2012 and populations were identified in areas of suitable habitat during these surveys.

These species could not be directly counted in the field as there were a large number of fronds/leaves which emerge from the ground/creek bed along a creeping rhizome making it impossible to delineate individuals without digging up the plants

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-----------------------|-------------------------------|--|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | SF | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | SF | 27.4 | 9 (22.9ha), 10 (3.4ha), 11 (1.1ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | MT | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | SF | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | SF | 2.0 | 4 (2.0ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | SF, MT | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | SF | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | SF, MT | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | SF | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | SF | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | SF, MT | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | SF | 71.9 | 3 (49.6ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | SF | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | SF | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | SF, MT | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | SF, MT | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | MT | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | SF | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | SF, MT | 10 | 6 (10ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|--|---------------|----------|--|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Four-tailed Grevillea (<i>Grevillea quadricauda</i>) (FG) | V | V | Found in Section 3, comprising of two sub-populations. | 4.3.1. | 6.3 |
| Singleton Mint Bush (<i>Prostanthera cineolifera</i>) (SB) | V | V | Recorded in Section 7 at a single location. Population area and abundance was determined during targeted surveys | 4.3.1. | 6.3 |

Survey methods (May-June 2005; July-October 2007; 5-9 Dec 2011; 16-20 Jan 2012)

These species were recorded at two locations in the project boundary in low-moderate abundance, and targeted population surveys involved direct counts of the species in the project boundary. Surveys of the species were also conducted outside the boundary to gain an appreciation of the distribution and abundance of the species and assess the impact on the population. These involved direct counts of plants using a large plot (50 x 50 m) or where large aggregations were encountered population numbers were estimated.

These species have been targeted in the initial surveys for each section (2005-2007) and suitable areas of habitat were re-surveyed during 2011 and 2012.

Survey compliance / limitations

No further surveys are required for these species due to survey limitations.

The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling.

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | FG, SB | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | FG | 2.0 | 4 (2.0ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | FG, SB | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | FG | 44.5 | 3 (44.5ha) |
| Total | | 184.40 hectares | |

| Target species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Water Nutgrass (<i>Cyperus aquatilis</i>) | E | - | Recorded in Section 6 and 7. Targeted surveys were undertaken to estimate the area of suitable habitat within the project boundary. | 4.3.1. | 6.3 |
| Hairy-joint Grass (<i>Arthraxon hispidus</i>) | V | V | Targeted surveys recorded several large populations in Section 10. | 4.3.1. | 6.3 |

Survey methods (May-June 2005; 14-25 March 2005; 16-20 Jan 2012; 13-16 March 2012)

C. aquatilis is an annual species which grows in ephemerally wet situations, and is dependent upon summer rainfall for germination and some level of soil disturbance, with populations being found in roadside drainage swales, deep tyre ruts on disturbed trails and depressions in grazed paddocks. Targeted surveys were conducted in summer (2011-12) by two botanists over period of 20 days. Considering the large area of potential habitat for this species across the project as a whole, representative survey sites were selected focusing on at least one site per 50 hectare in suitable habitat. In addition known locations as determined by the initial preferred route studies and review of the atlas of NSW wildlife were targeted using direct counts of individuals and a general meandering technique.

For *A. hispidus*, two surveys conducted in February-March 2012 in Section 10 and 11 targeted the flowering period of the species by two botanists over a period of 8 days. The survey aimed to record the distribution of the populations within and adjacent to the project boundary by mapping the outer perimeters of the population to develop a series of polygons.

Given the widespread and numerous number of plants counts of abundance used replicated plots of known size to sample the number of plants in a known area and the extent of occupied habitat was recorded to create a polygon. Population estimates were then derived by multiplying the mean number of plants in a known area (plot) by the total area of occupied habitat. The plot size for counts were 50 m x 2 m along fence lines or 5x5 m in other areas. These data were then extrapolated across the entire identified group of polygons to estimate the population size within and adjacent to the project boundary.

Survey compliance / limitations

No further surveys are required for these species due to survey limitations.

Identified populations *C. aquatilis* occurred in low numbers and individual clusters could not always be adequately delineated. Population density estimates and area polygons were used to identify abundance.

A. *hispidus* is a slender inconspicuous tufted annual; it flowers during summer-autumn which represents the optimum time to conduct surveys. The species was in flower during the targeted survey. Targeted surveys were undertaken during the flowering period.

B.

| Vegetation / habitat types linked to <i>C. aquatilis</i> and <i>A. hispidus</i> | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-------------------------------|---|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | 79.7 | 1 (33.6ha), 2 (7.2 ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | 2.0 | 4 (2.0ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to <i>C. aquatilis</i> and <i>A. hispidus</i> | | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|------------|-------------------------------|--|
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | | 10 | 6 (10ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | AL, CF, MT | 44.5 | 3 (44.5ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | AL, CF, MT | 8.6 | 10 (7.9ha), 11 (0.7ha) |

2.4.3. Fauna surveys methods

The fauna survey techniques and effort varied across the study area according to the species being targeted and the habitat types in which each species occurs. The following descriptions of the techniques used are therefore described according to the 11 sections of the project and based on stratification of the habitats present.

Surveys for terrestrial fauna used a range of techniques aimed at identifying the type and distribution of fauna habitats in the project boundary, and fauna species richness, distribution and abundance targeting threatened species as identified as having a moderate to high likelihood of occurring in the study area (Appendix D) and their habitat of conservation significance. The fauna survey techniques and effort varied across the study area according to the habitats present and their size and the species targeted.

Surveys were conducted during all four seasons using a combination of sampling techniques in compliance with or exceeding guidelines in the *Threatened Biodiversity Survey and Assessment: Guidelines for developments and activities - Working draft* (DEC 2004). This included diurnal and nocturnal surveys and opportunistic observations using a stratified sampling approach that aimed to sample the range of habitats present. Surveys were conducted within the project boundary and where possible within adjacent habitats that extended beyond the project boundary and may be indirectly impacted by the project.

Habitat stratification and site selection

The eucalypt-dominated sclerophyll forests are the most widespread fauna habitat across a range of topographies and soil types from the alluvial plains to sandstone coastal ridges and coastal sands. Dry sclerophyll forests are proportionally the most abundant habitats and are represented across the whole project, followed by swamp forest habitats which dominate the Clarence River floodplain habitats from Glenugie to Iluka Road, Mororo (project sections 3-5).

Wet or moist habitats are more restricted to sheltered slopes and gullies and narrow riparian areas, although they are also represented along most sections in particular across the Dirty Creek and Summervale Range (project section 1) and project sections 6-7 between Iluka Road and Woodburn. Portions of the coastal plain in the north of the project around Broadwater and Wardell (project sections 8-9) traverse wallum habitats supporting fire-prone sclerophyllous vegetation on low nutrient sands.

North of the Richmond River on the Richmond alluvial plains are dominated by swamp forests and fragmented examples of lowland rainforest and wet sclerophyll habitats. The different fauna habitats and their area in relation to the project boundary are detailed at Table 2-8.

The stratification of habitats was used to ensure that fauna surveys sampled across the full range of habitat types on the project. Stratification was based on vegetation structure and topography. Soil types were used as a secondary indicator of habitats particularly where dry open forests occurred on alluvial soils and sandy soils. Sampling intensity was guided by vegetation floristics and aerial photographs overlaid with the project boundary and property cadastre to ensure a range of vegetation associations were sampled. Survey effort was distributed across the fauna habitat units as described in Table 2-10. The surveys were conducted across a range of floristic associations within the broader structure types described to provide sufficient confidence in identifying habitat of value for threatened fauna.

Table 2-8 Fauna habitat strata and area within the project boundary

| Fauna habitat | Approximate area (hectares) |
|---|-----------------------------|
| Cleared and modified habitats | 849.9 |
| Dry sclerophyll forests | 437.9 |
| Wet sclerophyll, floodplain forests and rainforests | 332.4 |
| Swamp sclerophyll forests | 149.1 |
| Wet and dry heath | 10.3 |
| Freshwater and estuarine wetlands | 4.5 |

Cleared and modified habitats make up a substantial portion of the study area (47.6 per cent) and these habitats were targeted by random surveys where property access permitted and provided incidental data. A stratified habitat assessment method was used to document the habitat conditions and values across the entire project boundary, details of this method are described in section 2.4.5.

Timing, season and weather conditions

Fauna surveys were conducted over a total of 30 field weeks sampling all months and seasons. Details of the field survey times, average temperature and monthly rainfall conditions experienced during the surveys are provided in Table 2-9.

The range of survey times and conditions were considered suitable for detection of the majority of fauna groups and targeted threatened species. Where the initial preferred route studies were conducted in sub-optimal conditions, this was identified as a gap and supplementary surveys conducted. For example the initial fauna surveys in the project sections 3 to 5 were conducted during autumn and winter with supplementary summer surveys were conducted in 2011-12.

Table 2-9: Timing, weather and rainfall conditions for fauna surveys

| Survey month /year (dates) | Mean temp (°C) | | Total monthly rainfall (mm) |
|----------------------------|----------------|------|-----------------------------|
| | Min | Max | |
| March 2005 (8-24) | 17.4 | 25.9 | 68.2 |
| May 2005 (22-28) | 17.2 | 21.5 | 11.3 |
| July 2005 (18-24) | 11 | 20.3 | 76 |
| February 2006 (20-25) | 19.9 | 28.2 | 90.8 |
| February-March 2006 (20-3) | 21.7 | 27.8 | 109.2 |
| March 2006 (10-16) | 19.6 | 26.1 | 260.2 |
| May 2006 (15-18) | 11.8 | 21.9 | 21.4 |
| July 2006 (10-17) | 10.2 | 20 | 76.8 |
| October 2006 (16-21) | 14.5 | 23.6 | 90.4 |
| November 2006 (6-10) | 16 | 24 | 109 |
| November 2006 (20-25) | 16.9 | 24.3 | 111 |
| January 2007 (4-5) | 20.1 | 26.4 | 75.8 |
| February 2007 (18-24) | 19.1 | 27.2 | 120.8 |
| March 2007 (10-15) | 18.3 | 26.3 | 260 |

| Survey month /year (dates) | Mean temp (°C) | | Total monthly rainfall (mm) |
|----------------------------------|----------------|------|-----------------------------|
| | Min | Max | |
| June 2007 (5-8, 25-29) | 8.2 | 20 | 76 |
| July 2007 (2-7) | 4.9 | 20.8 | 1 |
| August 2007 (6-11) | 8.8 | 23 | 193 |
| October 2007 (14-19) | 14.8 | 28.9 | 123 |
| November -December 2009 (30-9) | 19.8 | 28.9 | 143 |
| August 2010 (23-27) | 11.8 | 20.4 | 41.2 |
| August-Sept 2010 (30-3) | 14.9 | 23 | 61.8 |
| November 2011 (21-25) | 17.5 | 29.1 | 166.4 |
| December 2011 (5-9, 12-16) | 15.9 | 25.9 | 83.6 |
| January 2012 (9-13*, 16-20 & 31) | 18.7 | 28.1 | 388.8 |
| January 2012 (10-13)* | 19.8 | 27.1 | 353 |
| February 2012 (31-4, 16-18) | 18.3 | 29 | 132.8 |

*Same dates with different climate measurements represent different sections in the project boundary.

2.4.4. Fauna survey effort

The total fauna survey effort combined for the preferred route ecological studies and the supplementary surveys has been quantified for each of the survey techniques employed and is presented in Table 2-10 alongside the habitat strata. This description includes a summary of the survey technique, the timing of the different use of this technique and survey effort per habitat unit. The data is presented for each technique and is combined for all project sections however not all habitat types are represented evenly across the project boundary and this accounts for variation in total survey effort. For example greater survey effort was employed in the dry forest and floodplain forest which make up the majority of the project study area. The location of survey sites is provided as Appendix N.

Table 2-10: Details of fauna survey effort and timing

| Survey method & target group | Project section and survey dates | Habitat strata/ survey effort* | | | | | |
|---|---|--|--------------------------------------|------------------------------------|---------------------------|--------------------------|--------------|
| | | Dry forest | Wet forest / floodplain / rainforest | Swamp forest | Wet / dry Heath | Wetlands | Modified |
| | | 437 hectares | 332.4 hectares | 149 hectares | 10.3 hectares | 4.5 hectares | 849 hectares |
| Tree-based Elliott traps (small arboreal mammals) | Section 1-2 (Oct 06, Feb 07) Section 3-5 (July 05, Oct 07) Section 6-8 (May-July 05; Jan 12) Section 9-11 (March 06, Jan 07) | 19 sites (1182 trap nights) = 1 site per 23 hectares | 6 sites (68 trap nights) | 6 sites (234 trap nights) | 3 site (240 trap nights) | | |
| Ground-based Elliott traps (small terrestrial mammals) | Section 1-2 (October 06; Feb 07) Section 3-5 (July-Aug & Oct 05; Oct 07) Section 6-8 (May-July 05; Jan 12) Section 9-11 (Mar 06, Jan 07; Jan 12) | 11 sites (784 trap nights) | 6 sites (300 trap nights) | 5 sites (392 trap nights) | 4 sites (40 trap nights) | | |
| Ground-based cage traps (quolls and bandicoots) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Oct 07) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 11 sites (4 cages) 20 trap nights | 6 sites (14 cages) 80 trap nights | 7 sites (28 cages) 120 trap nights | 2 sites (20 trap nights) | | |
| Ground and tree based hair-tubes (arboreal and terrestrial mammals) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 12 sites (1440 trap nights) | 6 sites (840 trap nights) | 6 sites (1180 trap nights) | 1 site (200 trap nights) | 1 site (400 trap nights) | |
| Dry pitfall traps (small ground active & fossorial reptiles, frogs and mammals) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Jan 12) Section 6-8 (May-Jul 05; Jan 12) Section 9-11 (Mar 06, Jan 07) | 6 sites (80 trap nights) | 1 site (4 pits) 20 trap nights | 2 sites (32 trap nights) | 5 sites (20 traps nights) | | |
| Harp-trapping (microchiropteran bats) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul 05; Oct 07; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 28 sites (50 trap nights) | 10 sites (26 trap nights) | 12 site (32 trap nights) | | | |

| Survey method & target group | Project section and survey dates | Habitat strata/ survey effort* | | | | | |
|--|---|-----------------------------------|--------------------------------------|-----------------------------------|--------------------------|--------------------------|----------------------------------|
| | | Dry forest | Wet forest / floodplain / rainforest | Swamp forest | Wet / dry Heath | Wetlands | Modified |
| | | 437 hectares | 332.4 hectares | 149 hectares | 10.3 hectares | 4.5 hectares | 849 hectares |
| Ultrasonic call recording (microchiropteran bats) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul 05; Oct 07; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 29 sites (236 hours) | 18 sites (163 hours) | 12 sites (140 hours) | 5 sites (60 hours) | | 8 sites (60 hours) |
| Call playback (nocturnal mammals) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 8 sites (34 sessions) | 9 sites (7 sessions) | 7 sites (6 sessions) | 2 sites (2sessions) | | |
| Diurnal census (birds) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Oct 07) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 24 sites (262 person-minutes) | 11 sites (93 person-minutes) | 13 sites (116 person minutes) | 2 sites (4 person hours) | 3 sites (6 person hours) | 2 sites (4 person hours) |
| Call playback (nocturnal birds) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul 05; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 17 sites (36 sessions) | 8 sites (6 sessions) | 8 sites (6 sessions) | 3 sites (3 sessions) | 1 site (1 session) | 1 site (1 session) |
| Timed nocturnal search (nocturnal birds and mammals) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Oct 07) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 24 sites (61 person hours) | 10 sites (24 person hours) | 13 sites (40 person hours) | 2 sites (6 person-hours) | 6 sites (6 person hours) | 1 site (1 session) |
| Timed and area based nocturnal searches (frogs) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul 05; Oct 07; Dec 11) Section 6-8 (May-Jul 05; Jan 12) Section 9-11 (Mar 06, Jan 07) | 25 sites (approx 21 person hours) | 22 sites (approx 20 person hours) | 14 sites (approx 12 person hours) | 3 sites (3 person-hour) | 6 sites (6 person hours) | 10 sites (approx 7 person hours) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Survey method & target group | Project section and survey dates | Habitat strata/ survey effort* | | | | | |
|---|--|-----------------------------------|--------------------------------------|------------------------------------|-----------------------------------|--------------|-----------------------------------|
| | | Dry forest | Wet forest / floodplain / rainforest | Swamp forest | Wet / dry Heath | Wetlands | Modified |
| | | 437 hectares | 332.4 hectares | 149 hectares | 10.3 hectares | 4.5 hectares | 849 hectares |
| Call playback (frogs) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Dec 11; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 4 sites (8 person hours) | 4 sites (8 person hours) | | | 8 sites | |
| Timed diurnal active searches (reptiles) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Oct 07; Dec 11; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 56 sites (approx 22 person hours) | 23 sites (approx 7.5 person hours) | 28 sites (approx 9.5 person hours) | 7 sites (approx 2.5 person hours) | | 8 sites (approx 2.5 person hours) |
| Area searches (Spot Assessment Technique for koala) | Section 1-2 (Oct 06; Feb 07) Section 3-5 (Jul-Aug, Oct 05; Dec 11; Jan 12) Section 6-8 (May-Jul 05) Section 9-11 (Mar 06, Jan 07) | 76 sites | 34 sites | 42 sites | 7 sites | | |
| Invertebrate surveys | Section 9-11 (Mar 06; Feb 12) | | 17 sites | | | | |
| Habitat surveys | Section 1-2 (Nov 2011) Section 3-5 (Dec 2011; Jan 2012) Section 6-8 (March 2005) Section 9-11 (March 2006, Jan 2007) | 85 sites | 23 sites | 29 sites | 6 sites | | |

Vertebrate fauna groups

Mammals

Live trapping was used to target small to medium sized terrestrial mammals and small arboreal mammals. Ground-based trapping used a combination of aluminium folding traps (Elliott type A, 33 x 10 x 9 cm, and Elliott type B, 15 x 16 x 45 cm) and cage traps (30 x 30 x 60 cm) using different trap densities and transect configurations. The numbers of traps at each site varied between 10 and 25, for a period around three to four nights.

Trapping for arboreal mammals used Elliott type B traps attached to tree trunks 3 - 3.5 metres above ground and also used a combination of trap numbers and transect configurations.

Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and *Antechinus* spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7.

Standard two-bank 4.2 m² harp traps were used to sample for microchiropteran bats. Harp traps were placed in forested areas along narrow gaps such as vehicle and walking tracks. Such locations are generally associated with natural flyways for microchiropteran bats. Harp traps were placed at each location generally for two to three nights with captured bats collected early the following morning and identified. Stationary and hand-held ultrasonic bat call detectors (Anabat II, Titley Electronics) were used with storage ZCAIM units to record bat calls. Calls were recorded using two techniques, 1) hand-held during spotlighting surveys, or 2) continuously between dusk and dawn using a timer switch. Calls were identified to genus or species level where possible using computer frequency analysis software (Analog v.4.0-5.0). Details of the personnel used to analyse bat call data are provided in the previous ecological assessments (RTA 2005-11).

Both the Duck Creek and Emigrant Creek bridges (project section 10 and 11) were inspected for roosting bats on 2 February 2012 as these bridges would be removed as part of the project.

Spotlighting and dusk census for arboreal mammals was conducted during the trapping periods. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares. All fauna heard or observed were recorded to species level. Observations of fauna were aided by the use of binoculars. Counts were taken on the number of fauna heard and observed.

Area searches for koala scats were conducted during the habitat assessment method in 2011 and 2012 as part of the additional gap surveys and involved a traverse across the entire habitat plot (50 x 20 metres) and searching the base of all larger trees (>20 centimetres DBH) with particular focus paid to any known koala feed trees species for the north coast region as identified in the Recovery Plan for the Koala (DECC 2008c). This included primary, secondary and supplementary trees species. The locations of any scats found were recorded with a Global Positioning System. A total of 120 plots were searched using this method across the entire project corridor. An additional 12 plots were sampled

using with same plot size and method in 2008 between Wells Crossing and Iluka Road (SKM 2009) and 27 plots of 20 x 20 metres in area were searched over the remainder of the project (Geolyse 2007; Ecotone 2007, Connell Wagner 2008). The total number of koala scat search plots surveyed was 159.

A description of each mammal survey technique including baits used, trap density and target species is provided in Table 2-11.

Table 2-11: Description of the mammal survey techniques and targeted threatened taxa

| Survey technique | Target group | Threatened species | Description |
|----------------------------------|------------------------------------|---|---|
| Tree-based Elliott traps | Small arboreal /scansorial mammals | Squirrel Glider, Brush-tailed Phascogale, Eastern Pygmy Possum | Size B 'Elliott' traps baited with peanut butter/rolled oats and honey set on brackets on tree trunks 3-3.5 m above ground and set for 3-4 consecutive nights. Number of traps at each site varied from 6-24 |
| Ground-based Elliott traps | Small terrestrial mammals | Eastern Chestnut Mouse, Common Planigale, Eastern Pygmy-possum | Size A and Size B traps baited with peanut butter/rolled oats and honey set at ground level and set for 3-4 consecutive nights. Number of traps per site varied from 10-25 |
| Ground-based cage traps | Medium-sized mammals | Spotted-tailed Quoll, Long-nosed Potoroo | 30 x 30 x 60 cm cage trap baited with meat, set at ground level and set for 3-4 consecutive nights. |
| Ground and tree based hair-tubes | Arboreal and terrestrial mammals | Squirrel Glider, Yellow-bellied Glider, Brush-tailed Phascogale, Eastern Pygmy Possum, Eastern Chestnut Mouse, Spotted-tailed Quoll, Long-nosed Potoroo, Rufous Bettong | Small hair-tubes attached to tree trunk and medium hair-tubes placed on the ground near logs and cover. Baited with peanut butter / rolled oats / honey. Honey-water mixture sprayed near tree tubes. Set for 3-4 consecutive nights. |
| Dry pitfall traps | Small terrestrial mammals | Common Planigale, Eastern Chestnut Mouse | Pits consisted of either metal or plastic buckets with drainage holes. Trap lines of 4-5 traps (400-500 mm deep) linked by a 10 m drift fence for 3-5 consecutive nights. |
| Harp-trapping | Microchiroptera n bats | All threatened species | Harp –trap set across likely flyway for 1-2 consecutive nights, done in all four seasons |
| Ultrasonic call recording | Microchiroptera n bats | All threatened species | Bat calls recorded over all night survey (Anabat: Titley Electronics). Done between dusk and sunrise on dry calm nights for 1-2 consecutive nights. |
| Call playback | Nocturnal mammals | Koala, Yellow-bellied Glider, Squirrel Glider | Taped calls of Squirrel Glider, Yellow-bellied Glider, and Koala broadcast through a loudspeaker for 5 minute periods, followed by periods of listening and spotlighting. Done on 1-2 consecutive nights. |
| Scat area searches | Large mammals | Koala, Spotted-tailed Quoll | Area search over a 50 x 20 m plot searching for scats. Concentrated around the base of all trees over 20 cm diameter at breast height. |

| Survey technique | Target group | Threatened species | Description |
|---|------------------|--|--|
| Foot-based and vehicle based spotlighting | All fauna groups | Koala, Spotted-tailed Quoll, Brush-tailed Phascogale, Squirrel Glider, Yellow-bellied Glider, Rufous Bettong, Long-nosed Potoroo, Grey-headed Flying-fox | Foot-based spotlighting at trapping sites and supplementary sites. Involved two or three observers at each site for between 30-60 minutes over a 2 hectares search area. Vehicle-based spotlighting was routinely conducted in all sections, although time and area searched was not recorded. |

Birds

Systematic bird surveys were conducted at a total of 55 sites across the range of habitat types present from swamp forests to dry and moist forest types. These surveys were generally time-based and consisted of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility (refer to Table 2-12). In general, these surveys covered an average two hectares search area. Birds were also recorded opportunistically during all fauna survey activity with binoculars carried in the field at all times to assist in identification.

Stationary bird surveys were conducted at wetlands near the project boundary. This involved a point census from wetland edge or vantage point along nearby road during early morning and dusk census. The survey period varied from 5-20 minutes. Surveys were conducted where the project boundary intersects wetland habitat such as the Coldstream River at Wants Lane north of Sandy Crossing, Chaffin Swamp, and floodplain wetlands surrounding lower Shark Creek for a total of one hour per site.

The method of listening, call-playback, stationary spotlighting, and waiting for vocal responses is an established technique for detecting the threatened species Powerful Owl, Barking Owl, Masked Owl, Grass Owl, Sooty Owl and Bush Stone Curlew (Kavanagh & Peake 1993; Kavanagh *et al.* 1995; Kavanagh & Bamkin 1995; Debus 1995, 1997; Maciejewski 1997; Debus *et al.* 1998, 2001; Debus 2001).

The call playback survey technique was used consistently across the project boundary surveys. The species played at each site was dependent on the habitat present and the suitability for target species such that not all species calls were played.

Pre-recorded calls were broadcast over 15 – 20 Watts loudspeaker for a period of five minutes for each species, followed by a five minute listening period. Spotlighting was conducted briefly between calls and then following completion of the call playback series for a period of 10 minutes. Quiet listening for dusk calls of species was also undertaken whilst conducting other field activities such as spotlight searches.

Table 2-12 Description of the bird survey techniques and targeted threatened taxa

| Survey technique | Target group | Threatened species | Description |
|-------------------------------|--------------------------------------|--|---|
| Time-based area search | Diurnal birds | Grey-crowned Babbler, Brown Treecreeper (<i>Climacteris picumnus</i>), Black-chinned Honeyeater (<i>Melithreptus gularis</i>), Alberts Lyrebird | Duration varied between 20-60 minutes over 2 hectares search area listing all species seen or heard. Done on days with minimal wind within 4 hours of sunrise in all four seasons |
| Wetland surveys | Waterfowl, wetland dependent species | Black-necked Stork, Brolga, Comb-crested Jacana, Magpie Goose, Black Bittern (<i>Ixobrychus flavicollis</i>), Australasian Bittern (<i>Botaurus poiciloptilus</i>) | Stationary surveys at vantage points during early morning and dusk, listening for call and direct observation at all accessible wetlands. |
| Call playback | Nocturnal birds | Masked Owl, Powerful Owl, Sooty Owl, Barking Owl, Grass Owl, Bush Stone-Curlew | Calls of target species broadcast through a 15-20W loudspeaker for 5 minute periods, followed by periods of listening and spotlighting. Bush-stone curlew, Sooty Owl, and Grass Owl were only played at sites with suitable habitat. Playback sessions were repeated in all sections and varied from 2 nights per site in Sections 1-2, 4 nights per site in Section 3-5, 8 nights per site in Section 6-7. In section 9-11, 5 nights per site were repeated for Powerful Owl, Barking Owl and Grass Owl, 6 nights for Sooty Owl and 7 nights for Masked Owl. Surveys were conducted all year round and were widely spaced. |
| Day habitat search | Nocturnal birds | Masked Owl, Powerful Owl, Sooty Owl, Barking Owl, Grass Owl, Bush Stone-Curlew | Search habitat for pellets and hollows. Area searches over 50 x 20 m plot concentrated around large hollows when encountered to search for pellets and white wash. |
| Stagwatching and spotlighting | Nocturnal birds | Masked Owl, Powerful Owl, Sooty Owl, Barking Owl, Grass Owl, Bush Stone-Curlew, Australasian Bittern | Foot-based spotlighting at trapping sites and supplementary sites. Involved two or three observers at each site for between 30-60 minutes over a 2 hectares search area. Vehicle-based spotlighting was routinely conducted in all sections, although time and area searched was not recorded. |

Reptiles and Frogs

Pitfall trapping, nocturnal and diurnal hand searches, and call playback techniques were employed to survey frogs and reptiles (refer to Table 2-13). Pit trap sites consisted of burying four or five metal or plastic buckets (400-500 millimetres deep) and connected with drift fencing for a total of between three to five consecutive nights at each site. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pit trap sites were correlated with sandy soil locations for ease of installation and were used in project sections 1-7.

Targeted frogs surveys included spotlighting in suitable habitats and call playback for target species. Surveys were conducted in a range of wet habitats to sample the habitat requirements of the expected frog assemblage. This included stream habitats, dam and lagoon habitats, wetland habitats and ephemeral drainage areas.

Surveys were both time-based and area-based and varied in duration according to the length of habitat investigated at each site. The surveys timing varied between 20-60 minutes and involved a minimum of two people using head torches and spotlights searching for adult frogs and tadpoles in the water column. Streams were surveyed using this time interval or alternatively traversing a 500 metre transect depending on the length of waterway and ease of traversing. Wetland surveys tended to be time-based and involved general traverse around wetland edges, shallow fringes or along artificial embankments in flooded paddocks or densely vegetated wetlands. Dams and lagoons were targeted by perimeter searches and listening for calls. Ephemeral habitats were typically targeted following rainfall events when encountered during the survey period. The survey method at all sites used active search techniques by a minimum of two people using 50 watt handheld spotlights, call imitation at regular intervals and illumination of the water column to identify and capture tadpoles.

Call playback surveys were conducted in accordance with standard methods. After an initial five-minute listening period, calls of the species were broadcast for a period of around five minutes, followed by a five minute listening period. After completion of the call playback surveys, the immediate area was searched by spotlight for any species that approached the broadcast site without eliciting calls.

Potential habitat was identified at a number of locations for three threatened frog species the Olongburra Frog, Green-thighed Frog and Wallum Froglet. The presence or absence of these species could not be confirmed during surveys done in autumn-winter or dry conditions during spring-summer. Where this occurred, further surveys were conducted in spring-summer (eg February 2006 Lewis Ecological Surveys) and supplementary surveys in January-February 2011. These surveys were designed to coincide with the breeding biology of these species, particularly the Green-thighed Frog which breeds during heavy rainfall and associated flood events.

On three occasions during the summer survey program, high rainfall periods were experienced in January and February 2006, January 2007 and January 2011. This prompted additional targeted frog surveys for Green-thighed Frog. The objective of this timing was to coincide with the breeding biology of the Green-thighed Frog which breeds during heavy rainfall and associated flood events. These rainfall events were also viewed as an optimal survey period for other target species including the Giant Barred Frog, Wallum Froglet, Olongburra Frog and Boorolong Frog (*Litoria boorolongensis*).

Frogs were predominantly identified by call, and occasional capture. Captured frogs were identified and immediately released. As the majority of the frog surveys were conducted prior to the release of the DECC (2008b) hygiene protocol for the control of disease in frogs, protocols outlining in this guideline were not used. Suitable hygiene procedures were adopted for the summer 2011/2012 surveys.

The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. The surveys were both time-based and area-based and varied in duration according to the size of the habitat, wetland. Reptile surveys were conducted at all trap sites and involved a 30-minute general traverse. Systematic reptile searches were conducted at the habitat assessment sites. This involved an active area-search across the habitat plot (20 x 50 metres). A total of 129 habitat plots were sampled (see Section 2.4.5), of these reptile searches were conducted at 83 plots.

Opportunistic observations of all herpetofauna were recorded during the carrying out of other survey activities, in particular spotlighting surveys which aimed to target threatened frog and reptile species.

Table 2-13: Description of the herpetofauna survey techniques and target taxa

| Survey technique | Target group | Target Species | Description |
|--|--|--|---|
| Dry pitfall traps | Small ground active and fossorial reptiles and frogs | Wallum Froglet, Green-thighed Frog, Olongburra Frog, Giant Barred Frog, Stuttering Frog, Pouched Frog, Fleays Barred Frog, Green and Golden Bell Frog, Stephen's Banded Snake, Pale-headed Snake, White-crowned Snake. | Pits consisted of either metal or plastic buckets with drainage holes. Trap lines of 4-5 traps (400-500 mm deep) linked by a 10 m drift fence for 3-5 consecutive nights. |
| Timed and area based nocturnal searches | Frogs | Boorolong Frog, Wallum Froglet, Olongburra Frog, Giant Barred Frog, Stuttering Frog, Fleays Barred Frog, Green-thighed Frog, Pouched Frog, Green and Golden Bell Frog. | Searches varied between 20-90 minutes and up to 500 m length of stream depending on the size of the habitat and involved listening for calls and searching by torch or spotlight for active animals. Surveys in October-March during or following rain and conducted over 1-2 separate nights. Call playback used for target species at appropriate habitat. Also included spotlighting at trap sites. |
| Timed and area based active diurnal searches | Reptiles | Stephen's Banded Snake, Pale-headed Snake, White-crowned Snake, Three-toed Snake-tooth Skink (<i>Coeranoscincus reticulatus</i>). | Searches varied between 30-60 person minutes search over 20 x 50 m plots on mid-morning and afternoon sessions October-March using direct observation and investigation of potential shelter sites. |
| Call playback | Frogs | Wallum Froglet, Green-thighed Frog, Olongburra Frog, Giant Barred Frog, Stuttering Frog, Fleays Barred Frog, Green and Golden Bell Frog, Pouched Frog. | Call playback surveys were conducted in accordance with standard methods. After an initial listening period, calls of the species were broadcast for a period of around five minutes, followed by a five minute listening period. After completion of the call playback surveys, the immediate area was searched by spotlight for any species that approached the broadcast site without eliciting calls. Calls were also imitated by observers during targeted frog surveys. |

| Survey technique | Target group | Target Species | Description |
|------------------|--------------|---|---|
| Spotlighting | All species | Pale-headed Snake, Stephen's Banded Snake | General spotlighting conducted for mammal surveys also aimed to target active frogs and reptiles, in particular the semi arboreal Pale-headed Snake and Stephen's Banded Snake. |

Invertebrates

Methods and results of targeted surveys for threatened Mitchells Rainforest Snail (*Thersites mitchellae*) are reported in Geolyse (2007) and were conducted from 10-11 March 2006. A meandering transect method was used to search for live animals and empty shells in preferred habitat being lowland rainforest and riparian habitat. A total of seven transects were searched over 11.5 hours, each transect having a 20 metre search area in the same vegetation type.

Additional surveys were conducted in the summer season of 2012 (6-10 February) to target conservation significant invertebrate species listed under the *Threatened Species Conservation Act* and the *Environment Protection and Biodiversity Conservation Act* and regionally significant species identified as potentially occurring in the study area (Table 2-14). The methods and results of the survey are documented in BAAM (2012a). Targeted surveys were conducted in project sections 9-11 as the distribution of these species occurs mostly over south-eastern Queensland with the southern limit extending into northern NSW to the Richmond River associated with lowland rainforest habitats. Suitable habitats were found at 10 sites and survey methods were based on the threatened species survey and assessment guidelines (DEC 2004).

Table 2-14: Targeted threatened invertebrate species targeted in surveys

| Common name | Species | EPBC Act | TSC Act | Survey techniques |
|----------------------------------|--|------------|-----------------------|--|
| Mitchells Rainforest Snail | <i>Thersites mitchellae</i> | Endangered | Critically Endangered | Transect meander searches |
| Laced Fritillary | <i>Argyreus hyperbius</i> subsp. <i>inconstans</i> | - | Endangered | Random meander searches and opportunistic observations |
| Pink Underwing Moth | <i>Phyllodes imperialis</i> sthn ssp. | Endangered | Endangered | Random meander searches |
| Atlas Rainforest Ground Beetle | <i>Nurus atlas</i> | - | Endangered | Active ground searches |
| Shorter Rainforest Ground Beetle | <i>Nurus brevis</i> | - | Endangered | Active ground searches |
| Coastal Petaltail | <i>Petalura litorea</i> | - | Endangered | Opportunistic observations |
| Richmond Birdwing | <i>Ornithoptera richmondia</i> | - | - | Random meander |

A wide representation of potential habitat was surveyed using a variety of techniques including random meander searches, active ground searches and opportunistic observations. A random meander search was carried out to find host plants in a 30 minute meander through each hectare of suitable habitat. An active ground search was also used to intensely observe the ground layer at each site for 30 minutes per hectare depending on the complexity of ground debris. Opportunistic observations were undertaken in 20 minute searches at suitable habitats in wetlands and swamps to find invertebrates in transit. Host plants were also searched and used as indicators for suitable habitat. A second stage survey was undertaken at previously missed sites in section 10 to search for the Pink Underwing Moth (*Phyllodes imperialis*).

2.4.5. Summary of survey effort for threatened fauna

The description of survey methods and effort provided in section 2.4.3 and 2.4.4 outline general methods for all fauna including threatened fauna species as shown. Further details in relation to targeted threatened fauna species, and survey effort relative to the area of habitat represented on the project in Table 2-15, and the timing and survey effort for each of these surveys is provided for each section in Table 2-10.

Table 2-15: Summary of survey method and effort for targeted threatened fauna

| Target species | Listed status | | Status on project and additional species methods | Further report reference | |
|---|---------------|----------|--|--------------------------|------------|
| | TSC / FM Act | EPBC Act | | Impact | Mitigation |
| Wetland and migratory bird species | | | | | |
| Australasian Bittern <i>Botaurus poiciloptilus</i> (AB) | E1 | E1 | Confirmed. Section 3. This species was also targeted in spotlighting surveys around wetlands and riparian sites (16 sites) | 4.3.2. | 6.3 |
| Australian Painted Snipe <i>Rostratula australis</i> (AS) | E | V, Mi | Predicted all sections | 4.3.2. | 6.3 |
| Black-necked Stork <i>Ephippiorhynchus asiaticus</i> (BS) | E1 | - | Confirmed: Sections 1-5. Known breeding habitat. Targeted searches for nest sites across the project particularly in Sections 3-5) | 4.3.2. | 5.3.2 |
| Pale-vented Bush Hen <i>Amaurornis molucanna</i> (PH) | V | - | Predicted | 3.11.2 | 6.3 |
| Magpie Goose <i>Anseranas semipalmata</i> (MG) | V | - | Confirmed: Section 3. Wants Lane, Coldstream wetland | 4.3.2. | 6.3 |
| Comb-crested Jacana <i>Irediparra gallinacea</i> (CJ) | V | - | Predicted | 4.3.2. | 6.3 |
| Black Bittern <i>Ixobrychus flavicollis</i> (BB) | V | - | Predicted | 4.3.2. | 5.6 & 6.3 |
| Brolga <i>Grus rubicundus</i> (B) | V | - | Confirmed, Clarence River floodplain | 4.3.2. | 6.3 |
| Freckled Duck <i>Stictonetta naevosa</i> (FD) | V | - | Predicted | 3.11.2. | 6.3 |
| Pied Oystercatcher (<i>Haematopus longirostris</i>) | | | | | |
| Migratory listed wetland species including but not limited to Latham's Snipe, Cattle Egret, Great Egret | | Mi | Predicted all sections | 4.3.2 | 5.2 |
| Wetland birds targeted survey methods and effort | | | | | |
| <p>Area and time-based bird surveys were conducted in representative wetlands, wet forest, swamp forests, wet heaths and riparian habitats. The survey periods varied from 5-20 minutes at each site depending on the condition and size of the site, location and noise of traffic. Surveys were conducted across swamp forests, wet heaths, wetland habitat and modified lands covering a total of 20 sites and 130 person hours over four seasons.</p> <p>Systematic bird surveys were also conducted at the small areas of floodplain wetlands near the project boundary. This involved a point census from wetland edge or vantage point along nearby road during early morning and dusk census for a total of 1 person hour at each site including at Chaffin Swamp, the Coldstream wetland near Tucabia and north of Sandy Crossing (Wants Lane) in Section 3.</p> | | | | | |
| Survey compliance / limitations | | | | | |
| <p>No further surveys are required for wetland and migratory species due to survey limitations.</p> <p>Direct impacts on the majority of wetland areas are avoided with many of the larger wetlands in the study area occur upstream or downstream of the project boundary and beyond the limit of the property access. For example large portions of the Coldstream wetlands are not within the project boundary. The surveys covered a broad range of potential habitats for wetland birds, including wetlands (6 person hours), modified floodplains (4 person hours), swamp forests (1.93 person hours) and creek and riparian habitats (appx. 1 person hour).</p> | | | | | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to wetland birds | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------------------|-------------------------------|--|
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | PH | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) |
| Coastal floodplain sedgelands, rushlands, and forblands | AB, AS, BS, PH, MG, CJ, BB, B, FD | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | PH | 2.0 | 4 (2.0ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | AB, BS, MG, BB, FD | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | AB, BS, PH, BB | 1.5 | 5 (1.3ha), 10 (0.2ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | AB, BS, MG, BB, FD | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | AB, BS, PH, CJ, BB | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | AB, BS, BB | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | AB, BS, PH, CJ, BB | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | AB, AS, BS, PH, MG, CJ, BB, B, FD | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | PH | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | PH | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | AB, BS, PH, MG, CJ, BB, B | 10 | 6 (10ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | PH | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| Total | | 455.8 hectares | |

| Target species | Listed status | | Status on project and additional species methods | Further report ref* | |
|--|---------------|------------------------------|--|--|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Large forest owls and other nocturnal birds | | | | | |
| Barking Owl <i>Ninox connivens</i> (BO) | V | | Predicted across a range of habitats | 4.3.2. | 6.3 |
| Powerful Owl <i>Ninox strenua</i> (PO) | V | | Confirmed at a number of locations | 4.3.2. | 6.3 |
| Grass Owl <i>Tyto longimembris</i> (GO) | V | | Confirmed and predicted in restricted habitats | 4.3.2. | 6.3 |
| Masked Owl <i>Tyto novaehollandiae</i> (MO) | V | | Confirmed | 4.3.2. | 6.3 |
| Sooty Owl <i>Tyto tenebricosa</i> (SO) | V | | Confirmed in restricted habitats | 4.3.2. | 6.3 |
| Large forest owls and nocturnal birds survey methods and effort | | | | | |
| <p>Targeted surveys were conducted at 38 individual sites over a total of 53 survey nights. Calls of target species were broadcast through a 15-20W loudspeaker for 5 minute periods, followed by periods of listening and spotlighting. Sooty Owl and Grass Owl were only played at sites with suitable habitat. Playback sessions were repeated at each site in all sections and varied from 2 nights per site in Sections 1-2, 4 nights per site in Section 3-5, 8 nights per site in Section 6-7. In section 9-11, 5 nights per site were repeated for Powerful Owl, Barking Owl and Grass Owl, 6 nights for Sooty Owl and 7 nights for Masked Owl. Surveys were conducted all year round and were widely spaced to account for different home range areas.</p> <p>Searches for owl pellets were conducted at all 129 habitat assessment sites. Spotlighting searches were conducted at 56 sites for a total of 138 person hours, covering all habitat strata. The spotlighting searches targeted nocturnal birds.</p> | | | | | |
| Survey compliance / limitations | | | | | |
| No further surveys are required for large forest owls and other nocturnal birds due to survey limitations. | | | | | |
| <p>The method of listening, call-playback, stationary spotlighting, and waiting for vocal responses is an established technique for detecting the five owls species concerned (Kavanagh & Peake 1993; Kavanagh & Bamkin 1995; Kavanagh et al. 1995; Debus 1995, 1997; Maciejewski 1997; Debus et al. 1998, 2001; Debus 2001). These surveys were conducted in accordance with the DEC survey guidelines for threatened owls by incorporating call-playback on different nights once per site per night in dry, calm conditions. The minimum number of surveys for each species was exceeded during the surveys.</p> | | | | | |
| Vegetation / habitat types linked to large forest owls | | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) | |
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | | BO, PO, MO, SO. | 1.4 | 3 (1.4ha) | |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | | BO, PO, MO. | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) | |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | | BO, PO, MO, SO. | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) | |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | | BO,PO, GO,MO. | 27.4 | 9 (22.9ha), 10 (3.4ha), 11 (1.1ha) | |
| Coastal floodplain sedgeland, rushlands, and forblands | | BO, PO, GO, MO, SO. | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) | |
| Coastal heath on sands of the North Coast | | BO, GO. | 0.2 | 9 (0.2 ha) | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to large forest owls | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | PO, MO, SO. | 2.0 | 4 (2.0ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | BO, PO, GO, MO, SO. | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | BO, MO. | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | BO, PO, MO, SO. | 0.5 | 10 (0.5ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | BO, PO, GO, MO, SO. | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | BO, PO MO. | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | BO, PO, MO. | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | BO, PO, MO, SO. | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | BO, PO, MO, SO. | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | BO, PO, GO, MO. | 71.9 | 3 (49.6ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | BO, PO, MO. | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | BO, PO, MO. | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | BO, PO, MO, SO. | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | BO, PO, MO, SO. | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | BO, PO, GO, MO, SO. | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | BO, PO, SO | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | PO, MO, SO | 44.5 | 3 (44.5ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | PO, MO, SO | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| | Total | 936.4 hectares | |

| Target Species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Swift Parrot <i>Lathamus discolor</i> | E | E, Mi | Predicted, suitable foraging habitat but outside the breeding range. | 4.3.2. | 6.4 |
| Regent Honeyeater <i>Xanthomyza phrygia</i> | E1 | E, Mi | Predicted, suitable seasonal foraging habitat but no known breeding areas | 4.3.2. | 6.4 |

Survey methods and effort for target birds

As both the Regent Honeyeater and Swift Parrot are semi-nomadic species that move large distances in search of flowering resources, their presence in a particular area of coastal NSW is unpredictable. This makes targeted surveys difficult without previous knowledge of known sites. The primary focus of this study was to identify the distribution and quality of potential foraging habitat for both species within the study area. As a secondary aim, targeted searches were conducted for both species where flowering trees were noted. Aggregations of other nectivorous birds, particularly Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*) and Rainbow Lorikeet (*T.haematodus*), which could often be heard from a distance, were also used as a guide to locate flowering trees and search for the target species, as Swift Parrot are found with these species.

Systematic bird surveys were conducted at a total of 55 sites stratified by broad habitat types where this intersects with the project boundary. Dry forest (24 sites), wet forest/floodplain rainforests (11 sites), swamp forest (13 sites), heath (2 sites). Surveys in section 3-11 included autumn and winter surveys which coincide with the peak presence of these migratory species in the study area.

These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility. A total of 485 person hours were spent surveying birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.

Survey compliance / limitations

No further surveys are required for Swift Parrot and Regent Honeyeater due to survey limitations.

Bird surveys were conducted in the optimum season in all project sections. Analysis of atlas records for both species indicates peaks in detection around the months from May to September. This is to be expected and coincides with the autumn-winter season and the flowering period of several tree species predominantly Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E.tereticornis*) and Spotted Gum (*Corymbia henryii*).

| Vegetation / habitat types linked to Swift Parrot and Regent Honeyeater | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-------------------------------|--|
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | 27.4 | 9 (22.9ha), 10 (3.4ha), 11 (1.1ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | 2.0 | 4 (2.0ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to Swift Parrot and Regent Honeyeater | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|--|
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | 71.9 | 3 (49.6ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | 44.5 | 3 (44.5ha) |
| Total | 925.7 hectares | |

| Target Species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Woodland birds | | | | | |
| Brown Treecreeper <i>Climacteris picumnus</i> (BT) | V | | Confirmed. Section 2 | 4.3.2. | 6.3 |
| Diamond Firetail <i>Stagonopleura guttata</i> (DF) | V | | Not detected, habitat not characteristic for this species. | - | - |
| Speckled Warbler <i>Pyrrholaemus sagittatus</i> (SW) | V | | Not detected, low likelihood | 4.3.2. | - |
| Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i> (BH) | V | | Confirmed. Section 2 | 4.3.2. | 6.3 |
| Hooded Robin <i>Melanodryas cucullata</i> (HR) | V | | Not detected, habitat not characteristic for this species. | - | - |
| Painted Honeyeater <i>Grantiella picta</i> (PH) | V | | Not detected, habitat not characteristic for this species. | - | - |
| Bush Stone-curlew <i>Burhinus grallarius</i> (BC) | E1 | | Confirmed. Section 2. This species was also targeted in the call playback program for surveys conducted in Sections 1-9 where this coincided with suitable dry sclerophyll forest habitats. | 4.3.2. | 6.3 |

Survey methods

Suitable habitat includes a range of dry sclerophyll forest types, predominantly with open or grassy understorey. Systematic bird surveys targeting these habitats were conducted at a total of 24 sites. These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.

A total of 226 person hours were spent surveying woodland birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.

Survey compliance / limitations

No further surveys are required for woodland birds due to survey limitations.

Survey effort per stratification unit was not resolved in the DEC guidelines. These surveys were conducted based on a species time curve approach whereby the searches at each site were ceased when no additional species were detected over the given time period.

| Vegetation / habitat types linked to woodland birds | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-------------------------|-------------------------------|---|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | BT, DF, SW, HR, PH. | 1.4 | 3 (1.4ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | BT, SW, BH, HR, PH, BC. | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3 ha), 7 (22.8ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | BT, DF, SW. | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | BT, SW, BH, HR, PH, BC. | 27.4 | 9 (22.9ha), 10 (3.4ha), 11 (1.1ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | BT, BC. | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to woodland birds | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------------|-------------------------------|--|
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | BC | 2.0 | 4 (2.0ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | BT, DF, SW, HR, PH. | 0.5 | 10 (0.5ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | BT, SW, BH, HR, PH, BC. | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | BT, BC. | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | BT, DF, BC. | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | BT, BH, HR, PH, BC. | 71.9 | 3 (49.6ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | BT, DF, SW, BH, HR, PH, BC. | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | BT, BC. | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | BT, BC. | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | BT, BC. | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | BT, DF, BC. | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | BC | 44.5 | 3 (44.5ha) |
| Total | | 936.4 hectares | |

| Target Species | Listed status | | Status on project and additional species methods | Further reference* | |
|---|---------------|------------------------------|---|--|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Rainforest birds | | | | | |
| Double-Eyed Fig-Parrot <i>Cyclopsitta diophthalma coxeni</i> (DP) | CE | E1 | Potential foraging, although outside range of breeding populations. | 4.3.2. | 6.3 |
| Alberts Lyrebird <i>Menura albertii</i> (AL) | V | | Not detected and low likelihood in the project boundary | 2.4.4. | - |
| Wompoo Fruit-dove <i>Ptilinopus magnificus</i> (WD) | V | | Potential foraging range | 4.3.2. | 6.3 |
| Rose-crowned Fruit Dove <i>Ptilinopus regina</i> (RD) | V | | Recorded in Section 10 with potential foraging range in other sections. | 4.3.2. | 6.3 |
| Superb Fruit-dove <i>Ptilinopus superbus</i> (SD) | V | | Potential foraging range | 4.3.2. | 6.3 |
| Rufous Scrub-Bird <i>Atrichornis rufescens</i> (RB) | V | | Not detected and low likelihood in the project boundary. | - | - |
| White-eared Monarch <i>Monarcha leucotis</i> (WM) | V | | Not detected and low likelihood in the project boundary | - | - |
| Black-breasted Button-quail <i>Turnip melano aster</i> (BQ) | CE | V | Not detected and low likelihood in the project boundary | - | - |
| Survey methods | | | | | |
| Systematic bird surveys for rainforest species were conducted at 31 sites stratified by broad habitat types where this intersects with the project boundary. These include wet forest/floodplain rainforests (11 sites), swamp forest (13 sites). These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility. A total of 485 person hours were spent surveying all birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities. | | | | | |
| Survey compliance / limitations | | | | | |
| No further surveys are required for rainforest birds due to survey limitations. | | | | | |
| In spite of intensive survey effort and range of techniques applied within all habitat types during multiple seasons, it is likely that some species that would be expected to occur may not have been detected. Nomadic species such as the threatened Wompoo Fruit-dove, Superb Fruit-dove, and Rose-crowned Fruit dove may only visit the study area on a sporadic basis depending on the availability of food resources which varies between years, and thus may not have been detected. | | | | | |
| Vegetation / habitat types linked to rainforest birds | | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) | |
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | | DP, AL, WD, RD, SD, BQ | 1.4 | 3 (1.4ha) | |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | | DP, AL, WD, RD, SD, RB | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) | |
| Coastal floodplain sedgeland, rushlands, and forblands | | SD | 27.4 | 3 (0.9ha), 4 (0.1ha), 8 (1.1ha), 9 (0.9ha) | |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | | DP, AL, WD, RD, SD, RB | 2.0 | 4 (2.0ha) | |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | | SD | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to rainforest birds | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|----------------------------|-------------------------------|--|
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | DP, AL, WD, RD, SD, BQ | 0.5 | 10 (0.5ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | SD | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | SD | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | DP, AL, WD, RD, SD, RB | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | SD | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | SD | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | SD | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha), 10 (5.8 ha), 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | DP, AL, WD, RD, RB, SD | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | DP, AL, WD, RD, SD, RB | 44.5 | 3 (44.5ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | DP, AL, WD, RD, SD, RB, BQ | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| Total | | 516.8 hectares | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Target Species | Listed status | | Status on project and additional methods | Further reference* | |
|--|---------------|----------|---|--------------------|--------------|
| | TSC / FM Act | EPBC Act | | A | B |
| Forest birds | | | | | |
| Little Eagle <i>Hieraaetus morphnoides</i> (LE) | V | | Predicted. General searches for nest sites within the project boundary | 4.3.2. | 6.3 |
| Square-tailed Kite <i>Lophoictinia isura</i> (SK) | V | | Predicted. General searches for nest sites within the project boundary | 4.3.2. | 6.3 |
| Eastern Osprey <i>Pandion haliaetus</i> (EO) | V | Mi | Present. General searches for nest sites within the project boundary | 4.3.2. | 6.3 |
| Red Goshawk <i>Erythrorchis radiatus</i> (RG) | CE | V | Predicted, no known breeding populations but habitat suitable. | 4.3.2. | 6.3 |
| Glossy Black-cockatoo <i>Calyptorhynchus lathami</i> (GC) | V | | Confirmed: Section 1, 3, 7 and 10. Survey of Allocasuarina species (feeding resources) and density at 129 sites as part of the habitat assessment survey. | 4.3.2. | 6.3 |
| Little Lorikeet <i>Glossopsitta pusilla</i> (LL) | V | | Predicted | 4.3.2. | 6.3 |
| Mangrove Honeyeater <i>Lichenostomus fasciolaris</i> (MH) | V | | Confirmed and predicted restricted to small localised habitats crossed by the project. | 4.3.2. | 6.3 |
| Turquoise Parrot <i>Neophema pulchella</i> (TP) | V | | No known populations, low likelihood of occurring in the actual project boundary | - | - |
| Olive Whistler <i>Pachycephala olivacea</i> (OW) | V | | Low likelihood of occurring in the actual project boundary | - | - |
| Ground Parrot (eastern subsp.) <i>Pezoporus wallicus wallicus</i> (GP) | V | | Not detected with suitable habitat in section 8-10, known populations in conservation reserves. | 4.3.2. | 6.3 |
| Barred Cuckoo-shrike <i>Coracina lineata</i> (BCS) | V | | Predicted, foraging habitat identified. | 4.3.2. | 6.3 |
| Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i> (GB) | V | | Confirmed. General searches for dormitories near bird and mammal survey sites | 4.3.2. | 6.3 |
| Collared Kingfisher <i>Todiramphus chloris</i> (CK) | V | | Absent and unlikely | - | - |
| Coastal Emu <i>Dromaius novaehollandiae</i> (CE) | E2 | | Confirmed. Sections 3-4. Population surveys, landowner interviews, scat and feather collections, genetic study and road kill investigation | 4.3.2. - 4.3.5. | 5.5 & 6.3 |

Diurnal birds survey methods

Systematic bird surveys were conducted at a total of 55 sites stratified by broad habitat types where this intersects with the project boundary. Dry forest (24 sites), wet forest/floodplain rainforests (11 sites), swamp forest (13 sites), and heath (2 sites). These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.

A total of 485 person hours were spent surveying birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.

Survey compliance / limitations

No further surveys are required for forest birds due to survey limitations.

Survey effort per stratification unit was not resolved in the DEC guidelines. These surveys were conducted based on a species time curve approach whereby the searches at each site were ceased when no additional species were detected over the given time period.

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|--|--------------------------------------|--|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | BCS, LE, SK, GB. | 1.4 | 3 (1.4ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE. | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | LE, EO, RG, GC, LL, TP, GB, CE. | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | BCS, LE, SK, EO, RG, GC, LL, MH, GP, CK, GB, CE. | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | LE, SK, EO, GC, OW | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | BCS, LE, SK, EO, RG, GC, LL, OW | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE. | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | BCS, LE, SK, RG, GC, LL, TP, GB, CE. | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | BCS, LE, SK, GB | 0.5 | 10 (0.5 ha) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | LE, SK, EO, MH, CK | 1.5 | 5 (1.3 ha), 10 (0.2 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE. | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE. | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | BCS, LE, SK, RG, GC, LL, TP, GB, CE. | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, CK, GB, CE. | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|--|-------------------------------|--|
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE. | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | BCS, LE, SK, RG, GC, LL, TP, GB, CE. | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | BCS, LE, SK, RG, GC, LL, TP, GB, CE. | 144.8 | 1 (17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, CK, CE. | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, CK, CE. | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | BCS, LE, SK, EO, RG, GC, LL, MH, GP, CK, CE. | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | BCS, LE, SK, EO, RG, GC, LL, OW, GB | 44.5 | 3 (44.5 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | LE, SK, EO, RG, MH, GP, CE. | 10 | 6 (10 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | BCS, LE, SK, EO, OW | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| | Total | 947.9 hectares | |

| Species | Status | | Status on project | Further reference* | |
|--|--------------|----------|--|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Microchiropteran bats | | | | | |
| Large-eared Pied Bat <i>Chalinolobus dwyeri</i> (LPB) | V | V | Predicted, foraging habitat identified. | 4.3.2. | 6.3 |
| Hoary Wattled Bat <i>Chalinolobus nigrogriseus</i> (HB) | V | - | Confirmed in Sections 1-3 & 6-8 | 4.3.2. | 6.3 |
| Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i> (EP) | V | - | Confirmed in Sections 1-3 | 4.3.2. | 6.3 |
| Golden-tipped Bat <i>Kerivoula papuensis</i> (GTB) | V | - | Confirmed in Sections 9-11 | 4.3.2. | 6.3 |
| Little Bent-wing Bat <i>Miniopterus australis</i> (LBB) | V | - | Confirmed in Sections 1-11 | 4.3.2. | 6.3 |
| Eastern Bent-wing Bat <i>Miniopterus schreibersii oceanensis</i> (EBB) | V | - | Confirmed in Sections 1-2 & 6-11 | 4.3.2. | 6.3 |
| Beccari's Freetail-Bat <i>Mormopterus beccarii</i> (BB) | V | - | Likely and predicted to occur, potential habitat | 4.3.2. | 6.3 |
| Eastern Freetail-Bat <i>Mormopterus norfolkensis</i> (EFB) | V | - | Confirmed in Sections 6-11 | 4.3.2. | 6.3 |
| Southern Myotis <i>Myotis macropus</i> (LM) | V | - | Confirmed in Sections 1-2 and 6-11 | 4.3.2. | 6.3 |
| Eastern Long-Eared Bat <i>Nyctophilus bifax</i> (ELB) | V | - | Confirmed in Sections 6-11 | 4.3.2. | 6.3 |
| Yellow-bellied Sheath-tail-bat <i>Saccolaimus flaviventris</i> (YSB) | V | - | Confirmed in Sections 9-11 | 4.3.2. | 6.3 |
| Greater Broad-nosed Bat <i>Scoteanax rueppellii</i> (GBB) | V | - | Confirmed in Sections 9-11 | 4.3.2. | 6.3 |
| Eastern Cave Bat <i>Vespadelus troughtoni</i> (ECB) | V | - | Confirmed in Sections 6-11 | 4.3.2. | 6.3 |

Survey methods

Three methods were used including harp trapping, call surveys and roost surveys. Standard two-bank 4.2 m² harp traps were used to sample for microchiropteran bats at 50 sites stratified by dry (28), moist (10) and swamp forest (12) for a total of 108 trap nights. This resulted in a total of one site per 15 hectares in dry forest, 1 site per 33 hectares in moist forest and one site per 12 hectares in swamp forest. Trapping sessions were conducted over a minimum of two consecutive nights. This resulted in 11 trap nights per 100 hectares in dry forest, eight trap nights per 100 hectares in moist forests, and 21 trap nights per 100 hectares in swamp forest.

The surveys aimed to sample representative vegetation associations. Ultrasonic call recording was conducted at 72 sites for a total of 552 recording hours. Roost surveys were conducted for the Duck Creek and Emigrant Creek bridges (project sections 10 and 11) during the summer season.

Survey compliance / limitations

No further surveys are required for microchiropteran bats due to survey limitations.

The survey methods used for bats were consistent with or exceeded the DEC survey guidelines in terms of survey effort and survey period. For example the guidelines recommend four trap nights per 100 hectares of each stratification unit. On the basis of the broad habitat stratification units this survey effort is exceeded. The limitation with the trapping and bat call detection related to optimum survey locations in order to trap bats. Ideal locations represent narrow tracks through forest where bats can be funnelled into traps.

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|---|-------------------------------|--|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | LPB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB, GBB ECB | 1.4 | 3 (1.4 ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | LPB, HB, EP, GTB, LBB, EBB, EFB, LM, ELB, YSB GBB | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | HB, EP, EBB, BB, EFB, LM, YSB | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | LPB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 0.5 | 10 (0.5 ha) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | LPB, LBB, EBB, EFB, LM, YSB GBB | 1.5 | 5 (1.3 ha), 10 (0.2 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 11.5 | 2 (11.5 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|---|-------------------------------|--|
| Paperbark swamp forest of the coastal lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB, GBB | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB | 144.8 | 1(17.9ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 28.5 | 1 (23.3 ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB | 44.5 | 3 (44.5 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | LPB, EP, LBB, EBB, EFB, LM, YSB GBB | 10 | 6 (10 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | LPB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| Total | | 947.90 hectares | |

| Species | Status | | Status on project and additional species methods | Further reference* | |
|---|------------------------------|--------------------------------------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Arboreal mammals | | | | | |
| Eastern Pygmy-possum <i>Cercartetus nanus</i> (EP) | V | - | Predicted. This species also was targeted using small terrestrial mammal survey methods (pitfalls and ground traps). Refer below. | 4.3.2. | 6.3 |
| Yellow-bellied Glider <i>Petaurus australis</i> (TG) | V | - | Confirmed. Call playback was used in suitable habitat during the forest owl playback sessions | 4.3.2. | 6.3 |
| Squirrel Glider <i>Petaurus norfolcensis</i> (SG) | V | - | Confirmed. Call playback was used in suitable habitat during the forest owl playback sessions. | 4.3.2. | 6.3 |
| Brush-tailed Phascogale <i>Phascogale tapoatafa</i> (BP) | V | - | Confirmed. | 4.3.2. | 6.3 |
| Survey methods | | | | | |
| <p>Trapping for arboreal mammals used Elliott type B traps attached to tree trunks 3 - 3.5 metres above ground and also used a combination of trap numbers and transect configurations. Trapping was conducted at 34 sites stratified by dry forests (19 sites), wet forests (6 sites), swamp forests (6 sites) and heath (3 sites), resulting in a total of one site per 23 hectares in dry forest, one site per 55 hectares for wet forests, one site per 24 hectares for swamp forest, and one site per 3 hectares in heath. Trapping sessions were conducted over 3-4 consecutive nights and the resulting in a total of 1182 trap nights in dry forest or 135 trap nights per 50 hectares. Wet forests equate to 68 traps nights or 10 trap nights per 50 hectares and swamp forest was 234 trap nights or 78 trap nights per 50 hectares and heath was 240 trap nights over 10 hectares. Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7.</p> <p>Spotlighting and dusk census for arboreal mammals was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.</p> <p>Call playback was used for Yellow-bellied Glider, Squirrel Glider and Koala during the forest owl playback sessions.</p> | | | | | |
| Survey compliance / limitations | | | | | |
| No further surveys are required for arboreal mammals due to survey limitations. | | | | | |
| The DEC guidelines specify a survey effort per 50 hectares of a stratification unit of 24 trap nights over 3-4 consecutive nights, this was exceeded in most habitat types | | | | | |
| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) | | |
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | EP | 1.4 | 3 (1.4ha) | | |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | EP, TG, SG, BP | 79.7 | 1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha) | | |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | EP, TG, SG BP | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) | | |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | EP, TG, SG BP | 27.4 | 9 (22.9ha), 10 (3.4ha), 11 (1.1ha) | | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Coastal floodplain sedgeland, rushlands, and forblands | EP, TG, SG BP | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | EP, SG | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | EP, TG, SG BP | 2.0 | 4 (2.0ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | EP, TG, SG BP | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | EP, TG, SG BP | 48.2 | 3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | EP | 0.5 | 10 (0.5ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | EP, TG, SG BP | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | EP, TG, SG BP | 58.2 | 1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | EP, TG, SG BP | 11.5 | 2 (11.5ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | EP, TG, SG BP | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | EP, TG, SG BP | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | EP, TG, SG BP | 71.9 | 3 (49.6ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | EP, TG, SG BP | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | EP, TG, SG BP | 144.8 | 1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | EP, TG, SG BP | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | EP, TG, SG BP | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | EP, TG, SG BP | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | EP, TG, SG BP | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | EP, TG, SG BP | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | EP BP | 10 | 6 (10ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | EP | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| | Total | 946.40 hectares | |

| Species | Status | | Status on project and additional species methods | Further reference* | |
|--|--------------|------------------------------|---|---|-----------|
| | TSC / FM Act | EPBC Act | | A | B |
| Ground-dwelling mammals | | | | | |
| Rufous Bettong <i>Aepyprymnus rufescens</i> (RB) | V | - | Confirmed in Section 1-3 | 4.3.2. | 6.3 |
| Common Planigale <i>Planigale maculata</i> (CP) | V | - | Confirmed in Section 1-2 | 4.3.2. | 6.3 |
| Long-nosed Potoroo <i>Potorous tridactylus tridactylis</i> (LP) | V | V | Not confirmed in project corridor | 4.3.2. | 6.3 |
| Eastern Chestnut Mouse <i>Pseudomys gracilicaudatus</i> (EM) | V | - | Not recorded, low likelihood | 4.3.5. | - |
| Hastings River Mouse <i>Pseudomys oralis</i> (HM) | E1 | E1 | Not detected , low likelihood | - | - |
| Spotted-tailed Quoll <i>Dasyurus maculatus maculatus</i> (SE population) (SQ) | V | E1 | Not detected, but suitable habitat occurs in all sections | 4.3.2. - 4.3.5. | 5.5 & 6.3 |
| Survey methods | | | | | |
| <p>Ground-based trapping was used to target small and medium sized ground-dwelling mammals. The technique used a combination of aluminium folding traps (Elliott type A, 33 x 10 x 9 cm, and Elliott type B, 15 x 16 x 45 cm), and cage traps (30 x 30 x 60 cm) and hair-tubes using different trap densities and transect configurations. The numbers of traps at each site varied between 10 and 25, for a period of between three to four consecutive nights.</p> <p>Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7.</p> <p>Searches for scats and signs of mammals were conducted over 129 habitat assessment sites.</p> <p>Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.</p> | | | | | |
| Survey compliance / limitations | | | | | |
| No further surveys are required for ground-dwelling mammals due to survey limitations. | | | | | |
| The survey methods used in this study are consistent with the DEC (2004) suggested techniques for non-flying mammals. Survey effort per stratification unit is shown in Table 2-9 and exceeded the suggested survey effort outlined in the guidelines. | | | | | |
| Vegetation / habitat types linked to target species | | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) | |
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | | RB, CP, LP, SQ | 1.4 | 3 (1.4 ha) | |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | | RB, CP, LP, EM, HM, SQ | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) | |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|------------------------|-------------------------------|--|
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | RB, CP, LP, EM, HM, SQ | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | RB, CP, LP, EM, HM, SQ | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | RB, CP, LP, EM, SQ | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | CP, LP, EM, SQ | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | RB, CP, LP, EM, HM, SQ | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | RB, CP, LP, EM, HM, SQ | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | RB, CP, LP, EM, SQ | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | RB, CP, LP, SQ | 0.5 | 10 (0.5 ha) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | SQ | 1.5 | 5 (1.3 ha), 10 (0.2 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | RB, CP, LP, EM, HM, SQ | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | RB, CP, LP, EM, HM, SQ | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | RB, CP, LP, EM, SQ | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | CP, LP, EM, SQ | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | RB, CP, LP, EM, HM, SQ | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | RB, CP, LP, EM, HM, SQ | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | RB, CP, LP, EM, SQ | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | RB, CP, LP, EM, SQ | 144.8 | 1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | CP, LP, EM, SQ | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | CP, LP, EM, SQ | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | RB, CP, LP, EM, SQ | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|------------------------|-------------------------------|---|
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | RB, CP, LP, EM, HM, SQ | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | RB, CP, LP, EM, HM, SQ | 44.5 | 3 (44.5 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | CP, LP, EM, SQ | 10 | 6 (10 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | CP, LP, SQ | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| Total | | 947.90 hectares | |

| Species | Status | | Status on project and additional species methods | Further reference* | |
|---|--------------|----------|--|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Megachiropteran bats | | | | | |
| Grey-headed Flying-fox <i>Pteropus poliocephalus</i> (GF) | V | V | Confirmed in Sections 1-2, 4-6, & 8-11 | 4.3.2. | 6.3 |
| Common Blossom-bat <i>Syconycteris australis</i> (CB) | V | - | Confirmed in Section 10 | 4.3.2. | 6.3 |

Survey methods

The primary focus of this study was to identify the distribution and quality of potential foraging habitat for these species within the study area and in the case of the Grey-headed Flying-fox identify the location of known roost camps for the species from the EPA Grey-headed flying-fox database. The assessment used vegetation mapping for the project and region to identify the distribution and extent of critical foraging habitat for the species with reference to DECCW (2009).

Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised of a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares. Concentrated searches were conducted for this species where flowering trees were noted.

Survey compliance / limitations

No further surveys are required for megachiropteran bats due to survey limitations.

Survey comply with DEC (2004) in terms of technique and effort. The species presence is dependent on seasonal nectar productivity of the dominant tree species in the habitat and this varies from year to year.

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-----------------------|-------------------------------|---|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | GF | 1.4 | 3 (1.4 ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | GF | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | GF, CB | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | GF | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| | | | |
|---|------------------------------|--------------------------------------|--|
| Coastal floodplain sedgeland, rushland, and forblands | GF, CB | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | GF, CB | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | GF, CB | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | GF | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | GF, CB | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | GF | 0.5 | 10 (0.5 ha) |
| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | GF | 1.5 | 5 (1.3 ha), 10 (0.2 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | GF | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | GF | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | GF, CB | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | GF, CB | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | GF, CB | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | GF | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | GF, CB | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | GF, CB | 144.8 | 1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | GF, CB | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | GF, CB | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | GF, CB | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | GF, CB | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | GF, CB | 44.5 | 3 (44.5 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | GF, CB | 10 | 6 (10 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | GF, CB | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| | Total | 947.90 hectares | |

| Species | Status | | Status on project and additional species methods | Further reference* | |
|-------------------------------------|--------------|----------|--|--------------------|-----------|
| | TSC / FM Act | EPBC Act | | A | B |
| <i>Koala Phascolarctos cinereus</i> | V | V | Recorded in Section 3 from scats, potential to occur in all sections | 4.3.2. - 4.3.5. | 5.5 & 6.3 |

Survey methods

Surveys for koala were conducted between 2006 and 2012 (February) and preceded the listing of the species on the EPBC Act and subsequent release of the Interim Koala Referral Advice for Proponents released in June 2012 (DSEWPaC 2012b). However the method for assessing potential impacts of the project on the Koala was consistent with the interim Koala referral advice. In summary the approach used was to:

- **Establish that a Koala population occurs in the study area.** This was conducted using a search and background review of the following: (1) Atlas of NSW wildlife (2) The Richmond Valley Koala Habitat Atlas. Report prepared for the Richmond Valley Council. Clarence Valley Council (2010). (3) Comprehensive Koala Plan of management for the Ashby, Woombah and Iluka localities of the Clarence Valley LGA. Coffs Harbour City Council (1999). (4) Coffs Harbour City Council Koala Plan of Management. Reported prepared by the NSW National Parks and Wildlife Service and Coffs Harbour City Council.
- **Gather adequate information on the characteristics of the Koala populations and the quality of potential habitat within the study area.** This involved a review of the documents listed above, followed by Koala surveys and comparison of the habitat of the species as listed in the Koala Recovery Plan (DECC 2008c) against the habitats identified in the project boundary.

Koala surveys

Koala surveys involved a combination of the Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011) to provide an indication of how much or frequently the area of habitat is being used by Koalas and identify the relative importance of the habitat, In addition to call playback surveys and spotlighting, area searches for koala scats were conducted during the habitat assessment method in 2011 and 2012 as part of the additional surveys and involved a traverse across the entire habitat plot (50 x 20 metres) and searching the base of all larger trees (>20 centimetres DBH) with particular focus paid to any known koala feed trees species for the north coast region as identified in the Recovery Plan for the Koala (DECC 2008c). This included primary, secondary and supplementary trees species. The locations of any scats found were recorded with a Global Positioning System. A total of 120 plots were searched using this method across the entire project corridor. An additional 12 plots were sampled using with same plot size and method in 2008 between Wells Crossing and Iluka Road (SKM 2009) and 27 plots of 20 x 20 metres in area were searched over the remainder of the project (Geolyse 2007; Ecotone 2007, Connell Wagner 2008). The total number of koala scat search plots surveyed over the entire project boundary was 159.

Spotlighting and dusk census for koala was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.

Call playback was used for Koala during the forest owl playback sessions.

Survey compliance / limitations

No further surveys are required for koala due to survey limitations.

This approach is reflective of the DSEWPaC advice but follows the NSW assessment methodology rather than the QLD approach suggested in the advice. The QLD approach is not as relevant to the study area as the NSW methodology in relation to the extent of information known about the koala population in the study region.

Application of the NSW methodology does not undermine or alter the outcome with regard to the interim referral advice. The survey methods comply with the DEC (2004) guidelines and exceed the recommended survey effort.

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to the Koala | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|---|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | 1.4 | 3 (1.4 ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha), 6 (18.8 ha), 7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | 0.5 | 10 (0.5 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | 144.8 | 1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | 44.5 | 3 (44.5 ha) |
| Total | 927.60 ha | |

| Species | Status | | Status on project | Further reference* | |
|---|--------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Wetland and swamp dwelling frogs | | | | | |
| Wallum Froglet <i>Crinia tinnula</i> (WF) | V | - | Confirmed records in Sections 1, 2 and between 6-11. | 4.3.2. | 6.3 |
| Green and Golden Bell Frog <i>Litoria aurea</i> (GBF) | E1 | V | Not recorded in the project boundary. Low likelihood. | - | - |
| Booroolong Frog <i>Litoria booroolongensis</i> (BF) | E1 | E1 | Not recorded in the project boundary. Low likelihood of occurring in the actual project corridor. | - | - |
| Green-thighed Frog <i>Litoria brevipalmata</i> (GF) | V | | Recorded in Sections 2, 6 and 7. | 4.3.2. | 6.3 |
| Olongburra Frog <i>Litoria olongburensis</i> (OF) | V | V | Not recorded in the project corridor, but known from the locality in Sections 9-11 in particular | 4.3.2. | 6.3 |

Survey methods

Potential habitats were identified from stratification and during the initial field survey design. Targeted frog surveys conducted between 2006-2012 included spotlighting in suitable habitats, pitfall traps, diurnal and nocturnal searches and call playback.

Spotlighting targeted timed based wetland surveys depending on the size of the area and were conducted across spring and summer seasons. Survey timing varied between 20-60 minutes and involved a minimum of two people using head torches and spotlights searching for adult frogs and tadpoles in the water column. A total of 80 sites were surveyed using this technique for 69 person hours.

Call playback involved an initial five-minute listening period, after which calls of the species were broadcast for a period of around five minutes, followed by a five minute listening period for a response. After completion of the call playback surveys, the immediate area was searched by spotlight for any species that approached the broadcast site without eliciting calls. Frog were searched under rocks, by the edge of the water, on floating vegetation, in fringing grass or other vegetation, under logs and other debris. Call playback was used at 16 sites.

Pit traps were deployed to target a range of fauna including frogs and were used at 14 sites in total, seven of which were within suitable habitat for the target species. On three occasions during the summer survey programs, high rainfall periods were experienced in 2006, 2007 and 2011. This prompted additional targeted frog surveys for Green-thighed Frog in particular to coincide with the breeding biology of the species which breeds during heavy rainfall and associated flood events. These rainfall events were also viewed as an optimal survey period for other target species including the Giant Barred Frog, Wallum Froglet, Olongburra Frog and Booroolong Frog.

Survey compliance / limitations

No further surveys are required for wetland and swamp dwelling frogs due to survey limitations.

Survey methods and effort were conducted in accordance with the guidance of DEC (2004). Surveys were conducted in a range of wet habitats to sample the habitat requirements of the expected frog assemblage. The presence or absence of threatened frog species could not be confirmed during surveys done in autumn-winter or dry conditions during spring-summer. Where this occurred, additional targeted surveys were conducted in spring-summer (eg February 2006 Lewis Ecological Surveys) and additional surveys in January-February 2011 to cover this gap. These surveys were designed to coincide with the breeding biology of these species, particularly the Green-thighed Frog which breeds during heavy rainfall and associated flood events (typically in ephemeral habitats).

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | GBF, GF | 1.4 | 3 (1.4 ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | GBF, GF | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | BF, GF | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | GF | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgelands, rushlands, and forblands | WF, GBF, GF, OF | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | GF | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | GBF, GF | 2.0 | 4 (2.0 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | GBF, GF | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | GF | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | GBF, GF | 0.5 | 10 (0.5 ha) |
| Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions | GBF | 1.5 | 5 (1.3 ha), 10 (0.2 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | GBF, GF | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | GBF, GF | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | GF | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | WF, GBF, GF, OF | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | BF, GF | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | GF | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | GF | 2.1 | 2 (2.11ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | GF | 144.8 | 1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | WF, GBF, GF, OF | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | WF, GBF, GF, OF | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | WF, GBF, GF, OF | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|---|
| Tallowood dry grassy forest of the far northern ranges of the North Coast | BF, GF | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | GBF, GF | 44.5 | 3 (44.5 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | WF, GBF, BF, GF, OF | 10 | 6 (10 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | GF | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| Total | | 947.90 hectares | |

| Species | Status | | Status on project | Further reference* | |
|--|--------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Stream dwelling frogs | | | | | |
| Stuttering Frog <i>Mixophyes balbus</i> (SF) | E1 | V | Not recorded, low likelihood | - | - |
| Fleay's Barred Frog <i>Mixophyes fleayi</i> (FF) | E1 | E1 | Not recorded, low likelihood. | - | - |
| Giant Barred Frog <i>Mixophyes iterates</i> (GF) | E1 | E1 | Recorded in Section 1 and 7. Also recorded outside of Sections 2 and 9. | 4.3.2. | 6.3 |
| Pouched Frog <i>Assa darlingtoni</i> (PF) | V | - | Not recorded, low likelihood. | - | - |

Survey methods

Survey methods and effort were conducted in accordance with the guidance of DEC (2004). Targeted field surveys for stream-dwelling frogs were typically the same as wetland and swamp-dwelling frogs with the use of spotlighting, diurnal and nocturnal searches and call playback in different but suitable habitat. However in addition streams were also surveyed using a combination of the time interval search or alternatively traversing a 500 metre transect along the targeted creek depending on the length of waterway and ease of traversing. A total of 22 sites and over 20 person hours were spent searching in suitable habitat using this technique.

Creeks targeted using this methods included Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek , Black Snake Hole (Pillar Valley Creek); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek). In addition to this, numerous wetlands, drains and unnamed watercourses were sampled.

The high rainfall events in January and February 2006, January 2007 and January 2011 resulted in optimal survey conditions for the Giant Barred Frog and Stuttering Frog which breeding occurs in summer usually after flood events.

Survey compliance / limitations

No further surveys are required for stream dwelling frogs due to survey limitations.

Variable weather (temperature and rainfall) conditions and seasonal survey periods, especially flood events in summer allowed for the greatest opportunity to observe frogs. With a wide range of survey techniques undertaken, lack of threatened frog observations is possibly due to limited suitable habitat and behaviour/life cycle of targeted frogs.

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|------------------------------|--------------------------------------|--|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | SF, FF, GF | 1.4 | 3 (1.4ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | SF, FF, GF, PF | 46.2 | 1 (22.2ha), 9 (1.3ha), 10 (22.7ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | GF | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast | SF, FF, GF | 2.0 | 4 (2.0ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | GF | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | SF, FF, GF | 0.5 | 10 (0.5ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | GF | 34.7 | 6 (9.6ha), 7 (14.7ha), 8 (10.4ha) |
| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | GF | 49.5 | 1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | SF, FF, GF, PF | 46.2 | 6 (8.9ha), 7 (35.7ha), 8 (1.6ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | GF | 28.5 | 1 (23.3ha), 2(5.2ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | GF | 44.2 | 1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | GF | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowwood dry grassy forest of the far northern ranges of the North Coast | SF, FF, GF, PF | 53 | 3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | SF, FF, GF | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | SF | 10 | 6 (10ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | SF, FF, GF, PF | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| Total | | 502.40 | |

| Species | Status | | Status on project | Further reference* | |
|---|--------------|----------|---|--------------------|-----|
| | TSC / FM Act | EPBC Act | | A | B |
| Reptiles | | | | | |
| White-crowned Snake <i>Cacophis harriettae</i> (WS) | V | | Not recorded. Possible habitat in the project boundary | - | - |
| Three-toed Snake-tooth Skink <i>Coeranoscincus reticulatus</i> (TS) | V | V | Not recorded. Low likelihood | - | - |
| Pale-headed Snake <i>Hoplocephalus bitorquatus</i> (PS) | V | - | Not recorded. Potential habitat in Sections 1, 2, 3 and between 6-8. | 4.3.2. | 6.3 |
| Stephens' banded snake <i>Hoplocephalus stephensii</i> (SS) | V | - | Confirmed in Section 3. Potential habitat in Sections 1, 2 and between 6-8. | 4.3.2. | 6.3 |

Survey methods

Targeted surveys consisted of dry pitfall traps, spotlighting diurnal and nocturnal searches during the same periods of frog surveys. The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. The surveys were both time-based and area-based and varied in duration according to the size of the habitat, wetland. Systematic reptiles searches were conducted at a total of 122 sites stratified by habitat types (56 dry sclerophyll habitats; 27 wet/moist sclerophyll habitats; 28 swamp forest; 7 heathland and 8 in modified landscapes. The total survey effort equated to 44 person hours. In addition to this, a total of 14 pitfall traps sites were employed and nocturnal reptiles were also targeted during the spotlighting surveys.

Systematic reptile searches were also conducted at the habitat assessment sites. This involved an active area search across the habitat plot (20 x 50 metres). A total of 129 habitat plots were sampled of these reptile searches were conducted at 83 plots.

Survey compliance / limitations

No further surveys are required for reptiles due to survey limitations.

Survey methods and effort were conducted in accordance with the guidance of DEC (2004). In particular a range of seasons were targeted and additional supplementary summer surveys were conducted in 2011 and 2012 to target locations where inappropriate seasons were missed previously such as sections 3 and 4.

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-----------------------|-------------------------------|---|
| Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast | TS, PS, SS | 1.4 | 3 (1.4ha) |
| Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast | WS, PS | 79.7 | 1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha) |
| Blackbutt grassy open forest of the lower Clarence Valley of the North Coast | WS, TS, PS, SS | 46.2 | 1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha) |
| Coast Cypress Pine shrubby open forest of the North Coast Bioregion | WS, PS | 27.4 | 9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | WS, PS, SS | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Coastal heath on sands of the North Coast | WS, PS | 0.2 | 9 (0.2 ha) |
| Flooded Gum - Tallowood - Brush Box moist open forest of the coastal ranges of the North Coast | WS, TS, PS, SS | 2.0 | 4 (2.0 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | WS, PS, SS | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast | WS, PS | 48.2 | 3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha) |
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | TS, PS, SS | 0.5 | 10 (0.5 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | WS, PS, SS | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast | WS, PS | 58.2 | 1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha) |
| Orange Gum (Eucalyptus bancroftii) open forest of the North Coast | WS, PS | 11.5 | 2 (11.5 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | WS, PS, SS | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha),7 (20.6 ha),8 (11.2 ha),10 (0.3 ha) |
| Red Mahogany open forest of the coastal lowlands of the North Coast | WS, TS, PS, SS | 46.2 | 6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha) |
| Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast | WS, PS | 71.9 | 3 (49.6 ha), 7 (22.3 ha) |
| Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast | WS, PS | 2.1 | 2 (2.11 ha) |
| Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast | WS, PS | 144.8 | 1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | WS, PS, SS | 28.5 | 1 (23.3 ha), 2(5.2 ha) |
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | WS, PS, SS | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | WS, PS, SS | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Tallowood dry grassy forest of the far northern ranges of the North Coast | WS, TS, PS, SS | 53 | 3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha) |
| Turpentine moist open forest of the coastal hills and ranges of the North Coast | WS, TS, PS, SS | 44.5 | 3 (44.5ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | WS | 10 | 6 (10ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | TS, PS, SS | 8.6 | 10 (7.9ha), 11 (0.7ha) |
| | Total | 946.40 hectares | |

| Species | Status | | Status on project | Further reference* | |
|--|--------------|----------|--|--|-----------|
| | TSC / FM Act | EPBC Act | | A | B |
| Fish | | | | | |
| Oxleyan Pygmy Perch <i>Nannoperca oxleyana</i> (OPP) | E | E | Confirmed in Section 7-9 | 4.3.2. & 4.3.7. | 5.5 & 6.3 |
| Purple-spotted Gudgeon <i>Mogurnda adspersa</i> (PSG) | E | | Not detected, but potential habitat is present | 4.3.7 | 6.3 |
| Eastern Freshwater Cod <i>Maccullochella ikei</i> (EC) | E | E | Not detected, but potential habitat is present | 4.3.7 | 6.3 |
| Survey methods | | | | | |
| <p>Investigations were done at 67 different sites covering 36 different waterways (named and unnamed), this includes 43 sites surveyed for the preferred route studies and an additional 24 sites surveyed to address gaps in the data particularly to target the Oxleyan Pygmy Perch and Purple spotted Gudgeon.</p> <p>The named creeks surveys were: Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek, Black Snake Hole (Pillar Valley Creek), Coldstream River, Pheasants Creek); Section 4 (Edwards Creek, Shark Creek); Section 5 (Clarence River - at two locations); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek, Richmond River at two locations); Section 9 (Richmond River at two locations), Section 9 (Evan's River, Rocky Mouth River, Tuckean Broadwater, Bingil Creek); Section 10 (Garretts Creek); Section 11 (Duck Creek and Emigrant Creek).</p> <p>In addition to this, numerous wetlands, drains and unnamed watercourses were sampled.</p> <p>The additional targeted surveys were aimed at addressing gaps from the preferred route studies and were undertaken in September 2011 in consultation with the Department of Fisheries, and in accordance with the Survey Guidelines for Australia's Threatened Fish (DSEWPac 2011). This ensured the optimum survey period for the Oxleyan Pygmy Perch. Targeted surveys were undertaken, before the onset of the Oxleyan Pygmy Perch breeding season, to prevent disturbance to breeding populations and breeding habitats. Fish sampling methods involved the use of electrofishing, bait traps and dip netting. Where habitat and site access allowed, backpack electrofishing was undertaken with an electrical output of 500b, 60Hz pulsed DC to allow capture but without causing muscle rigidity. Unbaited bait traps were set for a period of 30-60 minutes (as baiting does not improve the probability of attracting fish (Knight et al. 2007). Up to 40 nets were deployed at each site, set around 1.5-2 metres apart. Dip-netting was undertaken in areas where it was too shallow to trap.</p> | | | | | |
| Survey compliance / limitations | | | | | |
| <p>Surveys in Sections 1 and 2 were completed in a dry period which would have affected the results of the survey. The presence of Oxleyan Pygmy Perch and Purple-spotted Gudgeon has been assumed in these sections where suitable habitat was identified.</p> <p>No further surveys are necessary for these fish species considering their presence has been assumed and additional surveys are unlikely to result in an expansion of this assumed area of occupancy in Section 1 and 2.</p> | | | | | |
| Vegetation / habitat types linked to target species | | | Species (Abbreviated) | Project Section (confirmed and potential habitat) | |
| <p>Prefers slow-moving or still waters with dense aquatic vegetation (eg sedges) or undercut, root-filled banks. The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 4.5-6.5) with low conductivity (90 to 830µS/cm). Potential habitat observed in a number of Class 1 waterways throughout the project boundary.</p> | | | OPP | 1, 2, 3, 6, 7, 8 & 9 | |

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Project Section (confirmed and potential habitat) |
|--|-----------------------|---|
| Are found in slow moving or still waters of rivers, creeks and billabongs, often among weeds, rocks or large woody debris. The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically waters with a pH ranging from 5.6 to 8.8, conductivity of 72 to 4,295µS/cm, dissolved oxygen between 0.6 and 12.8mg/L and low turbidity. | PSG | 1, 2, 3, 5, 6, 8, 9 |
| They are generally associated with areas that have plenty of boulders or large woody debris (snags) and intact riparian vegetation. Potential habitat was observed in the middle section of Coldstream River, Chaffin Creek and Pillar Valley Creek. | EC | 3, 5, 8, 10 & 11 |

| Species | Status | | Status on project | Further reference* | |
|--|--------------|----------|---|--------------------|---|
| | TSC / FM Act | EPBC Act | | A | B |
| Mitchells Rainforest Snail <i>Thersites mitchellae</i> | E1 | CE | Absent and unlikely. The ground surveys revealed that the vegetation was not key habitat preferred by the species (Geolyse 2007). The absence of a known co-habitant, the Large Camaenid (<i>Sphaerospira fraseri</i>) also led to the conclusion that the species was unlikely to occur in the study area (Stanisic 2006). | 3.7.2 | - |

Survey methods

Geolyse (2007) and Stanisic (2006) undertook surveys 10-11 March 2006. A meandering transect method was used to search for live animals and empty shells in preferred habitat being lowland rainforest and riparian habitat. A total of seven transects were searched over 11.5 hours, each transect having a 20 metre search area in the same vegetation type. Weather and moisture conditions were excellent for snail collecting. Rain had fallen before the survey and on one of the survey days frequent rainstorms (high humidity) occurred.

Survey compliance / limitations

A number of sites were unable to be surveyed due to limitations to property access. Notwithstanding this access problem, surveys were undertaken at sites which represented all major habitat types occurring within the project boundary and as such the limitations to survey sites as a result of property access were not considered as significant to the thoroughness of the surveys.

| Vegetation / habitat types linked to target species | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-------------------------------|--------------------------------------|
| White Booyong - Fig subtropical rainforest of the North Coast | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |

| Species | Status | | Status on project | Further reference* | |
|--|--------------|----------|--|--------------------|-----------|
| | TSC / FM Act | EPBC Act | | A | B |
| Invertebrates | | | | | |
| Pink Underwing Moth <i>Phyllodes imperialis southern subsp.</i> (PM) | E | E | Confirmed in Section 10 | - | 5.5 & 6.3 |
| Coastal Petaltail <i>Petalura litorea</i> (CP) | E | - | Predicted. Suitable habitat occurs section 8-9 | - | 5.5 & 6.3 |
| Atlas Rainforest Ground Beetle <i>Nurus atlas</i> (AB) | E | - | Confirmed in Section 10 | - | 5.5 & 6.3 |
| Shorter Rainforest Ground Beetle <i>Nurus brevis</i> (SB) | E | - | Not detected and unlikely to occur | - | - |

Survey methods

Suitable habitat was identified at 10 sites in Sections 9-11. A wide representation of potential habitat was surveyed using a variety of techniques including random meander searches, active ground searches and opportunistic observations. A random meander search was carried out to find host plants in a 30 minute meander through each hectare of suitable habitat. An active ground search was also used to intensely observe the ground layer at each site for 30 minutes per hectare depending on the complexity of ground debris.

Opportunistic observations were undertaken in 20 minute searches at suitable habitats in wetlands and swamps to find invertebrates in transit. Host plants were also searched and used as indicators for suitable habitat. A second stage survey was undertaken at previously missed sites in section 10 to search for the Pink Underwing Moth (*Phyllodes imperialis*).

Survey compliance / limitations

Additional field investigations are recommended for the Atlas Rainforest Ground Beetle and Pink Underwing Moth within and surrounding the project boundary in section 10 and 11 during detailed design with the aim of accurately identifying the distribution and abundance of the species so that avoidance and mitigation measures can be adequately implemented.

The extent of survey locations was limited to where property access was available. Each area was surveyed using the method described in the threatened species survey and assessment guidelines (DEC, 2004). High suitability breeding habitat for Coastal Petaltail occurs in wallum swamp heathland with permanent wetlands in sections 8 and 9.

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|---|-----------------------|-------------------------------|--|
| Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast | PUM, AB, SB | 0.5 | 10 (0.5 ha) |
| White Booyong - Fig subtropical rainforest of the North Coast | PM, AB, SB | 8.6 | 10 (7.9 ha), 11 (0.7 ha) |
| Coastal floodplain sedgeland, rushlands, and forblands | CP | 3.0 | 3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha) |
| Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast | CP | 73.9 | 1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha) |
| Narrow-leaved Red Gum woodlands of the lowlands of the North Coast | CP | 34.7 | 6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha) |
| Paperbark swamp forest of the coastal lowlands of the North Coast | CP | 49.5 | 1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha) |
| Swamp Box swamp forest of the coastal lowlands of the North Coast | CP | 28.5 | 1 (23.3 ha), 2(5.2 ha) |

Upgrading the Pacific Highway – Woolgoolga to Ballina Upgrade

| Vegetation / habitat types linked to target species | Species (Abbreviated) | Area in project boundary (ha) | Project Section (extent in hectares) |
|--|-----------------------|-------------------------------|--|
| Swamp Mahogany swamp forest of the coastal lowlands of the North Coast | CP | 44.2 | 1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha) |
| Swamp Oak swamp forest of the coastal lowlands of the North Coast | CP | 56.2 | 1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha) |
| Wet heathland and shrubland of coastal lowlands of the North Coast | CP | 10 | 6 (10ha) |
| Total | | 309.10 hectares | |

Further reference: A – impact assessment; B – management and mitigation

2.4.6. Fauna habitat assessment and mapping

The habitat assessment and mapping was conducted over November and December 2011 and January 2012 and was aimed at re-visiting the habitat along all sections of the project boundary that were sampled during the preferred route studies to gather data in relation to density of habitat trees and other important fauna microhabitat features for forest fauna and thereby validate the previous habitat mapping.

This information contributes to understanding the likelihood of threatened fauna species based on the habitat present as well as the potential impacts of habitat modification on forest fauna. The data in relation to habitat tree density was also used to formulate management measures such as the positioning and design of arboreal crossing locations.

A stratified survey technique was used to representatively sample habitats according to broad vegetation community type. There are around 32 vegetation associations in the study area. These were consolidated into six broad vegetation community types and their overall area determined. The number of habitat assessment sites in each broad community type was then determined using a ratio of one site per 75 hectares of vegetation association. A total of 129 sites were assessed across the entire project area (Table 2-16). Habitat assessment were not conducted in wetland areas or modified agricultural habitats where trees were absent.

Table 2-16: Broad vegetation types used in the habitat assessment

| Habitat type | Number of survey sites |
|--|------------------------|
| Dry forest habitat (sandy soils) | 44 |
| Dry forest habitat (clay soils) | 34 |
| Swamp forest habitat | 26 |
| Wet forests and riparian habitats | 15 |
| Rainforest and moist floodplain forest | 6 |
| Heath | 5 |
| Total | 129 |

A number of site characteristics were recorded in the field in a 50 x 20 metre plot at each survey site using a proforma. The number of hollow-bearing trees, total length of logs greater than 10 centimetre DBH, presence and density of *Allocasuarina*, average overstorey height, percent overstorey foliage cover, dominant tree species, and forest successional stage were each described. A GPS was used to record the site location, and a photograph of the transect taken.

The habitat assessment data were used in combination with field survey results to identify potential habitats for threatened species. The surveys identified and mapped the distribution of broad habitat types in relation to the predicted presence of threatened fauna species. This included identifying important habitat characteristics required for each species (ie keystone food plants, locations with abundant tree hollows or logs, or preferences for a particular habitat type and structure). This information, in conjunction with targeted fauna surveys and a review of regional records, was used to assess the extent and magnitude of potential impacts on threatened species habitat.

2.4.7. Emu studies

Emu-vehicle collision study

Collision with vehicles is listed as a primary threat to the endangered emu population, particularly in the Clarence Valley area. As there is little data on the frequency and cause of emu-vehicle collisions, a study into the causal factors was conducted within the study area. The objectives of the study were to:

- Identify temporal and spatial patterns in the frequency of road-kills in terms of the characteristics of road kills sites and potential causal factors
- Identify features that might attract emus to the vicinity of the road (vegetation, natural and artificial water sources) or hinder their movements (road cuttings, fences)
- Use the data to predict which locations along the project present a high probability of emu road-strike and hence inform the mitigation strategy for this species.

The study design consisted of a combination of desktop assessment using aerial imagery and topographic map interrogation, and fieldwork to describe the physical characteristics of road-kill sites and controls. Records of emu road-kills from the Atlas of NSW Wildlife (OEH) were combined with anecdotal evidence to create a list of emu road-kill sites. These sites were then visited between the 5th and 9th of December 2011 to document the roadside vegetation characteristics, road characteristics and the site landscape context. The same data was taken from a set of randomly positioned control sites along roads in the study area.

A total of 26 emu road-kill sites and 15 control sites were surveyed. Sites where multiple emu-vehicle collisions were reported along a 5 kilometres stretch of road, or at a particular site, were assessed as a single site if the site characteristics were uniform.

Field data at each site was collected using four replicate 20 metre transects, two on each side of the road, positioned around 25 metres apart. For each transect, a measuring tape was positioned perpendicular to the road running into the roadside vegetation. Data on the type and species composition of roadside vegetation (overstorey, midstorey and understorey), type and condition of the road, and the site context was collected (Table 2-17).

Table 2-17: Description of the site characteristics recorded at emu road-kill and control sites

| Descriptor | Characteristic |
|---------------------|--|
| Roadside vegetation | <i>Tree Layer (overstorey):</i> |
| | Top height of average representative (m) |
| | Canopy cover (%) |
| | Three dominant species |
| | Status (regenerating, mature, senescent) |
| | <i>Shrub Layer (midstorey):</i> |
| | Top height of average representative (m) |
| | Overall shrub cover (%) |
| | Three dominant species |
| | <i>Ground Layer (understorey):</i> |
| | Overall groundcover (%) |
| | Dominant groundcover species |
| | Road |

| Descriptor | Characteristic |
|------------|---|
| | Distance from road edge to vegetation >2 m tall (m) |
| | Slope of the roadside verge (cut, fill, flat) |
| | Speed limit (kilometres/hr) |
| | Adjacent speed limit (kilometres/hr) |
| | Planar character (straight, gentle curve, tight curve, other) |
| | Vertical character (steep, gentle, flat, other) |
| | Road surface (dirt, concrete, tarred, other) |
| | Road size (1.5 lanes, 2 lanes (highway & country road), 4 lanes, other) |
| | Road condition (good, moderate, poor, other) |
| | Site context |
| | Fence condition (good, moderate, poor, other) |
| | Adjacent land use (cleared field, same as roadside, other) |
| | Adjacent waterbodies (none, farm dam, wetland, stream) |
| | Distance to waterbodies (m) |

The field data was analysed using a chi-square goodness of fit test because there were typically between two and six frequency categories and 25-200 observations (Dytham 2005). A chi-square goodness of fit, tests whether the data fits a random pattern (ie a Poisson distribution) or not. The test determines whether there are significant differences between control and road-kill sites in terms of their site context, road characteristics, and roadside vegetation characteristics. Prior to conducting the goodness of fit tests, the field data was subjected to correlation analysis. The following highly correlated parameters were excluded from the goodness of fit tests:

- Status (senescent)
- Distance to fence
- Planar road character
- Road condition.

Significant chi-square goodness of fit test results were used to describe the key characteristics of an emu collision site. This information was then used to predict the level of emu collision risk at one kilometre increments (stations) along the project boundary between Glenugie and Maclean (generating a total of 53 data points along the boundary) using an index. The index included consideration of all significant predictors of an emu collision site, plus weighted scores for proximity to a known emu kill site (eg within one kilometres of an emu kill site was given a score of three; within three kilometres of an emu kill site was given a score two, and within five kilometres of an emu kill site was given a score of one). The overall score for each of the data points was summed, and categories of low, medium and high risk assigned to groups of scores.

The resulting information was mapped to depict those sections of the project boundary between Glenugie and Maclean which pose high, medium and low risk to emus, and to inform mitigation measures to avoid emu collisions.

Genetic study pilot

The pilot study was conducted to trial the efficacy of collecting genetic material to identify the population size and structure and the range of group territories in relation to the project and wider distribution of the population. Recent studies on cassowaries in northern Queensland have successfully used a technique that identifies DNA from the birds' dung, the technique relies on skin cells being removed from the animals gut and transported via the dung (Dr. Michael Weston, CSIRO, *pers.comm*). The pilot aimed to collect emu dung to trial a similar analysis and was conducted in conjunction with researchers at Macquarie University (Shannon Smith and Adam Stow) who extracted and tested DNA from field samples.

The objectives of the pilot was to investigate the efficacy of DNA extraction from faecal and feather samples and subsequent DNA amplification at mitochondrial and microsatellite loci and examine the utility of these molecular markers for investigating patterns of population genetic structure of emus in the study area.

Emu feathers and scat material was collected from three broad areas including Brooms Head-Taloumbi, Tucabia-Pillar Valley and Woolli-Minnie Waters. Records of emus from the community survey and atlas database were used to establish 31 transects. Transects were positioned along dirt roads, walking trails and power easements to target clearings in bushland. A methodology was developed to ensure replication for future surveys, this involved:

- A minimum of two observers walking 500 metres in around 20 minutes along each transect
- Record the start and finish location of transect using global positioning system
- Record transect code
- Walk along the centre of the transect and collect all scats or feathers seen within 5 metres of the transect
- Record each scat or feather found separately and place in a separate bag
- Record all details about the scat or feather on a pro-forma.

Samples were dried prior to the DNA extraction process.

Landowner interviews

A series of interviews were conducted over two days (3-4 April 2012) with seven landowners from properties located along the project boundary from Pillar Valley to lower Shark Creek (Section 3-4). The aim of the survey was to gather further insight that may assist in planning for targeted mitigation measures. The discussion including the following topics:

- Any observed seasonal movements of emus in relation to the wetlands and habitats adjoining the project
- Identify any known nesting habitats or locations
- Identify observed food plants
- Identify emu behaviour in relation to stock fences and any other general observations on emu behaviour.

2.4.8. Aquatic survey effort

The study area incorporates the eleven proposed staging sections located principally in the Corindi River, Clarence River and Richmond River catchments, and includes major watercourses located along the preferred route.

Investigations were done at 67 different sites covering 36 different waterways (named and unnamed). The total aquatic survey effort across the preferred route ecological studies and the supplementary surveys is presented in Table 2-18.

The description includes details on the timing of surveys and the different survey techniques employed and rely on information documented from the preferred route studies. The named creeks surveyed are included below, in addition to this, numerous wetlands, drains and unnamed watercourses were also sampled:

- Arrawarra Gully - Section 1
- Corindi River – Section 1
- Blackadder Gully – Section 2
- Redbank Creek – Section 2
- Champion Creek – Section 3
- Black Snake Hole (Pillar Valley Creek) – Section 3
- Coldstream River – Section 3
- Pheasants Creek – Section 3
- Edwards Creek – Section 4
- Shark Creek (Clarence River) – Section 4
- Clarence River - Section 5 at two locations
- Mororo Creek – Section 6
- Tabbimoble Creek – Section 6
- Oakey Creek – Section 7
- Macdonalds Creek – Section 8
- Richmond River – Section 8 and 9 at four locations
- Evans River – Section 9
- Rocky Mouth River –Section 9
- Tuckean Broadwater – Section 9
- Bingil Creek- Section 9
- Garretts Creek – Section 10
- Duck Creek - Section 11
- Emigrant Creek - Section 11.

Table 2-18: Summary of fish survey effort employed within each project section

| project section and survey dates | Survey technique | | | |
|--|---|----------------------|-----------------------------------|---|
| | Fish survey methods | Macro-invertebrates | Water quality | Habitat |
| Section 1-2 10-15 March 2007 5 Sites | Electrofishing Seine Netting Fyke Nets Bait Traps | | Physico-chemical | Waterway Classification (Fairfull & Witheridge 2003) Also conducted assessment of marine vegetation (mangroves and seagrasses) |
| Section 3-5 5-8 June 2007 25-29 June 2007 8 Sites | Fish Surveys Electrofishing Bait Trapping Gill Netting | AUSRIVAS assessment | Physico-chemical Water Quality | Waterway Classification (Fairfull & Witheridge 2003) Also conducted Habitat Assessments (Riparian, Channel and Environmental Inventory) |
| Section 6-8 13-15 September 2011 24 Sites | Targeted surveys for Oxleyan Pygmy Perch Electrofishing Dip Net Bait Traps | | Physico-chemical Water Quality | Lewis Ecological Surveys (2006) assessed aquatic habitats for targeted frog searches. Waterway Classification (Fairfull & Witheridge 2003) Also conducted Habitat Assessments (Riparian, Channel and Environmental Inventory) |
| Section 9-11 11-16 March 2006 15 - 18 May 2006 12-14 September 2006 16 - 20 August 2010 30 Sites | Electrofishing Bait Traps Seine Nets Fyke Nets Dip Net | AUSRIVAS assessment | Physico-chemical Water Quality | Waterway Classification (Fairfull & Witheridge 2003) Also conducted Habitat Assessment (modified AUSRIVAS) |
| | Bait Traps Seine Nets Dip Net Line Fishing Plankton Tows Crab Nets Scuba Dive | Benthic Invertebrate | N/A | N/A |

Aquatic survey methods

The following information describes the whole of project aquatic field surveys. Aquatic surveys were conducted using a variety of different methods depending upon the identified aquatic values within each section. Aquatic survey methods included fish surveys, macroinvertebrates, water quality, habitat assessments, and targeted surveys for threatened species.

A total of 67 aquatic field sites were sampled in the study area using a range of techniques as described below, this includes 43 sites surveyed for the preferred route studies and an additional 24 sites were surveyed to address spatial gaps in the data particularly to target the Oxleyan Pygmy Perch and Purple spotted Gudgeon. A description of the techniques employed is provided below in addition to details of survey effort across the study area (Table 2-19).

Fish Surveys

Estuarine and freshwater fish communities were sampled at each site using a combination of bait traps, fyke nets, seine nets, dip nets, gill nets, crab traps, line fishing, scuba diving, and electrofishing. The sampling methodology varied between watercourses, depending upon a number of site characteristics including:

- Freshwater or Estuarine
- Channel depth
- Provision of woody snags
- Provision of submerged vegetation
- Accessibility
- Property access.

Table 2-19: Description of the fish survey techniques and targeted fish taxa

| Survey technique | Target group | Threatened species | Description |
|------------------|---------------------------|---|---|
| Bait traps | Small bodied fish | Oxleyan Pygmy Perch, Purple-spotted Gudgeon | Both baited and unbaited traps were used depending upon the target species and were deployed in within watercourses of a variety of depths amongst stands of emergent vegetation, submerged vegetation, or snag piles, as these areas are likely to have a greater diversity and abundance of small bodied fish. Typically bait traps were deployed for a minimum of 2 hours. |
| Fyke nets | Mobile, large bodied fish | | Large single-wing fyke nets with either a 4m or 6m leaders were set with the cod-end on one bank with the wind attacked mid stream. The cod-end of each fyke net was always suspended above the water to avoid the mortality of captured air breathing vertebrates. Fyke nets were not deployed at sites with an identified risk of cattle becoming entangled in the net. Typically fyke nets were deployed for a minimum of 2 hours. |

| Survey technique | Target group | Threatened species | Description |
|-------------------------|---|---|---|
| Seine nets | Fish species of a variety of size classes | | Seine nets were used at sites where sections of the river or creek were wadeable (<1m) and where the presence of instream habitat did not impeded the passage of the net through the water. The net was deployed from the bank and dragged through the river/creek in a loop by two of the researchers. The net was then dragged into the bank to record the catch. |
| Dip nets | Small bodied fish | Oxleyan Pygmy Perch, Purple-spotted Gudgeon | Dip nets (200µm mesh size) were used in shallow creeks and ephemeral pools or locations dense with aquatic snags where the use of other netting methods was unfeasible |
| Gill nets | Large fish species | | Gill nets were deployed in major rivers and tributaries where other netting methodologies such as electrofishing and fyke nets were unfeasible. Nets were left for around 30 minutes. Fish swim into the net becoming entangled by their gills or spines. Great care was taken in handling and untangling the fish. |
| Crab traps | Small crabs | | Crab Traps (40 cm x 40 cm x 67 cm) with wire openings of 5 x 7.5 cm were used during surveys undertaken in Sections 8-11. Traps were set in the afternoon, and collected the following morning. |
| Line fishing | Large bait fish. | | Line fishing was undertaken at one location (Geolyse 2005). The line was rigged with a lure. |
| Scuba diving | Benthic environment | | Scuba diving was undertaken with the aim to assess benthic habitat in Section 8-11 (Geolyse 2005) however it also provided an opportunity for sightings of pelagic fish species. |
| Backpack electrofishing | Fish species of a variety of size classes | Oxleyan Pygmy Perch, Purple-spotted Gudgeon | Electrofishing was undertaken at sites with wadeable habitats, appropriate access and conductivity levels less than 1500 µS/cm. Electrofishing is a commonly used, non-destructive technique for sampling smaller watercourses, the technique temporarily stuns the fish, whereupon they float to the surface and can be identified and counted. |

All fish captured were identified to species and the following information recorded:

- Relative abundance
- Size of fish (total length in millimetres)
- Sampling technique.

The supplementary targeted surveys were aimed at sampling gaps from the preferred route studies and were undertaken in September 2011 in consultation with the Department of Fisheries, and in accordance with the *Survey Guidelines for Australia's Threatened Fish* (DSEWPaC 2011). This ensured the optimum survey period for the Oxleyan Pygmy Perch and minimised impacts to breeding life-cycle events. Hence targeted surveys were undertaken, before the onset of the Oxleyan Pygmy Perch breeding season, to prevent disturbance to breeding populations and breeding habitats. Fish sampling methods involved the use of electrofishing, bait traps and dip netting. Where habitat and site access allowed, backpack electrofishing was undertaken with an electrical output of 500b, 60Hz pulsed DC

to allow capture but without causing muscle rigidity. Unbaited bait traps were set for a period of 30-60 minutes (as baiting does not improve the probability of attracting fish (Knight *et al.* 2007). Up to 40 nets were deployed at each site, set around 1.5-2 metres apart. Dip-netting was undertaken in areas where it was too shallow to trap.

Macroinvertebrate assessment

Macroinvertebrates were assessed in project sections 3-5 and 8-11. Sampling was conducted in accordance with the AUSRIVAS (Australian Rivers Assessment System) sampling technique. AUSRIVAS is a rapid prediction system used to assess the biological health of Australian rivers. AUSRIVAS protocols for sampling ensure the temporally and spatial analyses are comparable amongst sites through repeatable and consistent sampling techniques. The AUSRIVAS model compares collected fauna to fauna predicted to occur at the site in the absence of environmental impacts such as pollution.

Water quality

Physico-chemical water quality parameters were measured using multi-parameter water quality probes. The number of survey sites is detailed in Table 2-16, with waterways sampled identified in section 0. Measurements were generally collected between 15 and 30 centimetres below the surface depending on the depth of water with the sampling depth recorded in the field. A range of parameters were measured including:

- Turbidity (NTU) – a measure of the 'muddiness' of the water. It is important as an indication of the amount of suspended colloidal and particulate matter in the water and how much light can penetrate for important biochemical processes such as photosynthesis. Elevated levels of particulate matter can also impact on dissolved oxygen concentrations and pH
- Conductivity (mS/cm, uS/cm) – a measure of the amount of dissolved salts in the water and its ability to conduct an electrical current. It is important as some plant and animal species are salt sensitive whilst others require higher salt concentrations
- Salinity (ppt) – the salt concentration of water, measured directly as dissolved salts
- Temperature (°C) – a measure of the degree of hotness or coldness of water. It is a form of pollution and can impact on riverine biota and associated biological and chemical processes
- pH – a measure of acidity or alkalinity of water. Most freshwater and estuarine biota have a range of tolerances between 6.5 and 8
- Dissolved oxygen (% saturation and mg/L) – a measure of the amount of oxygen dissolved in water. Dissolved oxygen is vital for many forms of riverine and estuarine biota including native fish and is also vital for the functioning of healthy aquatic ecosystems.

Waterway classification and aquatic habitat assessments

The distribution and types of aquatic habitat across the project boundary was described and mapped covering all wetland habitats, creeks and rivers, including their immediate riparian habitats, and swamps and marshes. At a minimum, each waterway crossing was assessed and classified in accordance to standard NSW Fisheries guidelines *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003) to determine waterways classification as per Table 2-20.

Sites with likely or known threatened species habitat were classified as Class 1 (as identified by NSW DPI or during targeted surveys). Due to the habitat preferences of the Oxleyan Pygmy Perch, ephemeral, unnamed and often undefined watercourses, which were near to Oxleyan Pygmy Perch Habitat were classified conservatively as Class 2 recognising the potential of these watercourses for Oxleyan Pygmy Perch dispersal, rather than the Class 3 or Class 4 classification these sites would normally receive in accordance with these guidelines.

The design principles established for this project specify that under the preferred crossing structures for identified Class 1 waterways are bridges. These would preferably be single-span with the pylons/piers located outside the main channel.

Table 2-20: Fish habitat classification criteria for watercourses and recommended crossings types

| Classification | Characteristics of waterway type |
|---------------------------------|---|
| Class 1- Major fish habitat | Major permanently or intermittently flowing waterway (eg river or major creek), habitat of a threatened fish species |
| Class 2 - Moderate fish habitat | Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks and with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area. |
| Class 3- Minimal fish habitat | Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats. |
| Class 4 – Unlikely fish habitat | Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free standing water or pools after rain event (eg dry gullies or shallow floodplain depression with no permanent wetland aquatic flora). |

(Source: Fairfull & Witheridge, 2003)

At most sites, a general habitat assessment was conducted using either a modified AUSRIVAS habitat assessment proforma or using the Riparian, Channel and Environmental (RCE) inventory, both of which consider factors such as stream width, depth, flow rate, riparian vegetation, aquatic macrophytes and visual assessments of water quality (refer to Table 2-18). The purpose of the habitat assessments was to provide information on habitat condition which was used as an indicator of species presence where threatened fish were found to be absent. The identification of threatened species habitat was not influenced by the different habitat assessment techniques used.

2.5. Important wetlands

A desktop review of relevant policy, planning and legislative frameworks, reports and GIS information was undertaken to identify Ramsar, SEPP14 and Nationally Important Wetlands in the project boundary. The Department of Sustainability, Environment, Water, Populations and Communities provides a listing of Wetlands of International Importance under the Ramsar Convention (known as 'Ramsar wetlands'). This information was sourced via the Australian Wetlands Database.

SEPP14 Wetlands refer to coastal wetlands of State significance under the *State Environmental Planning Policy No. 14 – Coastal Wetlands*. GIS information was used to locate SEPP14 wetlands in the project boundary and study area. Nationally important wetlands in New South Wales were identified through review of '*A Directory of Important Wetlands in Australia*' (Environment Australia 2001) and GIS information.

Previous studies and reports were also reviewed as part of the desktop approach to assessing wetlands. These were:

- Working papers for the previous project developments
- Environment Australia (2001). *A Directory of Important Wetlands in Australia*, Third Edition. Environment Australia, Canberra
- Estuary management plan for the Corindi River and Clarence River
- Umwelt (2003) *Estuary Management Plan: Clarence Estuary*. Report No. 1485/R04/V3 prepared for Clarence River County Council.

2.6. Subject species assessment

State and nationally listed species identified from the preferred route field surveys and background data search were assessed to identify their likelihood of occurrence in relation to habitats along the project boundary. This assessment was based on the known habitat requirements for each species and compared with the habitats and their condition identified across the project boundary. In determining the likelihood of occurrence of a threatened species, the following information was consulted:

- OEH Threatened Species Profile Database - a component of the Biobanking assessment methodology credit calculator tool
- Atlas of NSW Wildlife (OEH) for a 20 kilometre buffer search area along the length of the project boundary to identify previous records of threatened flora and fauna
- Surveys undertaken along the project boundary to identify the types and conditions of the flora and fauna habitats present and the species assemblage
- OEH state-listed threatened species profiles (<http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>)
- DSEWPaC Commonwealth listed Species Profile and Threats Database (SPRAT) (EPBC Act) (<http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>).

The likelihood of a species occurring was classified according to the criteria in Table 2-21.

Table 2-21: Likelihood of species occurrence criteria

| Likelihood of occurrence | Criteria |
|--------------------------|--|
| Unlikely | <ul style="list-style-type: none"> Species highly restricted to certain geographical areas not within the study area. Specific habitat requirements were not present in the study area. |
| Low | <ul style="list-style-type: none"> Species not recorded during field surveys and fit one or more of the following criteria: <ul style="list-style-type: none"> Have not been recorded previously in the study area/surrounds and for which the study area would be beyond the current distribution range. Use specific habitats or resources not present in the study area. A non-cryptic perennial flora species that was specifically targeted by surveys and not recorded. |
| Medium | <ul style="list-style-type: none"> Species not recorded during ecological surveys undertaken 2006 to 2012 that fit one or more of the following criteria: <ul style="list-style-type: none"> Have infrequently been recorded previously in the study area/surrounds. Use specific habitats or resources present in the study area but in a poor or modified condition. Unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration. Cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded. |
| High | <ul style="list-style-type: none"> Species recorded during ecological surveys undertaken 2006 to 2012 or species not recorded that fit one or more of the following criteria: <ul style="list-style-type: none"> Have frequently been recorded previously in the study area/surrounds. Use habitat types or resources that were present in the study area that are abundance and/or in good condition within the study area. Known or likely to maintain resident populations surrounding the study area. Known or likely to visit the site during regular seasonal movements or migration. |

2.7. Significance assessments

Significance assessments were conducted for species, populations and communities that have been positively identified or that have a moderate or high potential to occur in the study area.

For threatened biodiversity listed under the *Threatened Species Conservation Act 1995*, the assessment considered the heads of consideration for Threatened species assessment as suggested in the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The guidelines present methods to consider the impacts on biodiversity of projects assessed under Part 3A as updated by Part 5.1 of the *Environmental Planning and Assessment Act 1979*, including presenting heads of consideration for determining the significance of impacts.

For threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* significance assessment have been completed in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, Water, Heritage and the Arts 2009).

Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats.

In assessing the significance of the impacts, consideration has been given to the distribution of threatened species and the areas of potential habitat. For example some species, populations or communities are restricted to discrete project sections such as *Angophora robur*, Lowland Rainforest or Emus. Conversely some species are widespread and occur across all project sections, eg microchiropteran bats which use a range of habitats and are dependent on specific microhabitat features which are widespread and not restricted to localised areas.

Where there is reasonable doubt regarding the likely impacts, or where detailed information is not available, a significant impact has been assumed as a precautionary approach.

In the case of a threatened plant species, where multiple populations occur in the study area, each population was assessed separately. In this instance a local population was identified as those individuals occurring as a cluster of individuals and that could reasonably be expected to be cross-pollinating within the population and were assessed on a section by section basis.

2.8. Taxonomy and nomenclature

Names of plants used in the assessment are taken from Harden (1992, 1993, 2000, and 2002) with reference to PlantNet (Royal Botanic Gardens and Domain Trust 2012) or recent taxonomic changes. Common and scientific names are used for plant species in the first instance followed by common names. Scientific and common names (where available) are provided in plant lists in Appendix G. Names of vertebrate fauna follow the Census of Australian Vertebrates (CAVS) database maintained by the Department of Sustainability, Environment, Water, Populations and Communities (2012). Common names are frequently used in the report for fauna. Scientific names are included in species lists found in Appendix H and Appendix I.