4.0 Local Environmental Factors

This section describes key environmental factors within the context of the local area. This section addresses topographical features, geology and soils, climate, surface and groundwater, riparian zones and wildlife corridors.

4.1 Topographical Features

The low lying areas of Townsville are predominantly floodplains naturally formed via erosion of nearby mountain ranges. Waterway deposition of sediment over many millennia has created a lowland coastal floodplain that is generally north-west to south-east oriented. In the south where the ranges extend the farthest from the coast, the floodplain extends inland by approximately 30km. By comparison the northern portion of the floodplain is narrow and elongated (approximately 5km wide) due to the close proximity of the ranges to the sea. The largest urban area of the Townsville Local Government Area (LGA) is built within the floodplains of the Ross and Bohle Rivers (Hopley, 1970; Trezise *et al*, 1990; Townsville City Council, 2010) (see Figure 1 above).

The dominant mountain ranges that back the floodplains are the Paluma Range, Pinnacles Range and Hervey Range. The Pinnacles and Hervey Ranges are approximately 30km from and are generally aligned with the orientation of the coastline. These ranges are approximately 730m at their highest respective points. The Paluma Ranges are more north-south oriented, and decrease in height from north to south (approximately 1000m at the highest point within the Townsville LGA). Other elevated points of note that are not included within these aforementioned ranges include Castle Hill, Mount Louisa, Mount Stuart Range, Mount Elliott, Cape Cleveland, Muntalunga Range, The Sister Mountains and Many Peaks Range (Cape Pallarenda) (Maunsell McIntyre, 2001; Trezise *et al*, 1990).

The Coral Sea bounds the Townsville LGA, of which the two main local embayment's are Cleveland Bay (between Cape Cleveland and Cape Pallarenda) and Halifax Bay (from Cape Pallarenda northwards). Several off-shore islands are found within the respective Halifax and Cleveland Bays. The nearest is Magnetic Island which at its closest point to the mainland is approximately 4km north-east of Cape Pallarenda. Magnetic Island is located within the Great Barrier Reef World Heritage Area and Great Barrier Reef Marine Park. The inshore boundary of the Marine Park around Magnetic Island extends from Kissing Point to the Black River, inclusive of the Bohle River on the mainland coast.

The topography of the proposed alignment is gently undulating ranging from below 10m AHD to 20m AHD. The proposed alignment includes waterways associated with Saunders Creek and Stoney Creek (inclusive of their tributaries), and tributaries of the Bohle River which flow into the Great Barrier Reef Marine Park. The Great Barrier Reef World Heritage Area is 6 km downstream from the project area. All waterways crossed by the proposed road alignment feed eventually into the Bohle River which drains into the Reef, through the state declared Bohle Fish Habitat.

4.2 Geology and Soils

The dominant mountain ranges were formed via sedimentary and volcanic processes that began between 460 and 600 million years ago. Intrusion of granite into the sedimentary and volcanic rocks then occurred followed by an erosive period approximately 100 to 55 million years ago. This erosive period removed much of the softer rock exposing components of the harder rocks beneath (mostly granite but some rhyolite and andesite). From 65 million years ago the modern Coral Sea Basin began its formation off the north-eastern coast via the diverging and subduction of the earth's crust. Ten million years later the spreading of the crust within the Coral Sea Basin effectively ceased. From this point in time westward erosion of the coastal area exposed harder rock creating mountainous landforms (e.g. Fredericks Peak on the Pinnacles Range) and created an escarpment (e.g. Hervey Range). Sediment from this erosion moving to the east began to infill the 'new' coastal area and the continental shelf. Sea level fluctuations over the last two million years meant the coastline was inundated and exposed to weathering until approximately 6,000 years ago when the sea level reached its present height (approximately). The coastline 6,000 years ago was slightly westwards from its present position. Offshore sediment build-up and Castle Hill and Many Peaks Range acting to capture the littoral movement of sediment have assisted in creating the modern-day coastline (Trezise *et al*, 1990).

The sediment laid down from the processes mentioned above grades from coarse mostly gravel deposits on the lower extent of the mountains and hills to silt, sand, clay and gravel at the coastline. Waterways carried sediment towards the coastline depositing it as the energy of the water diminished. Trezise *et al* (1990) and Hopley (1970)

conclude that there are a number of older now abandoned waterway channels that have over time been infilled with more recent sediments. Modern waterway channels have cut into older sediments thereby depositing newer alluvium within the channel.

The soils of the Townsville coastal lowland are strongly influenced by the erosion of the retreating escarpment and from the fluctuating sea level. Chenier ridges are found to the south of the lowland, north of the Ross River are a complex integration of mostly alluvial and colluvium fans, of beach ridges and clay deposits (Hopley, 1970).

The dominant soil type in Townsville is solodic (a heavy clay with high levels of sodium), usually found within duplex soils where the B horizon contains the solodic material. The A horizon is predominantly a thin sandy or silty loam layer. Solodic soils can form an impenetrable layer with the duplex soil when wet, preventing the percolation of water further down into the soil. Where the gradient of land is low this can cause ponding of stormwater. When exposed to the elements the solodic soils are highly dispersive. This is an issue in Townsville where the climate includes heavy downpours during the summer months (see section 4.3) that can easily wash away a thin unprotected A horizon exposing the highly erodible B horizon. Plumes of sediment are often seen off the north Queensland coastline during the wet season due largely to the climatic factors and the soil types of the area, section 4.4 provides further discussion on this topic.

Gilgai-forming clay soils that create shallow depressions and rises through the wet and drying processes of the soil are occasionally present. The soils may expand when wet and crack when dry. Other soils types include those formed on the newer alluvial deposits (i.e. respective red and yellow earths and red podosolics) (Hopley 1970; Lokkers, 2000, C&R Consulting, 2007).

Hopley (1970) found that cementation had occurred in soils on the coastal lowland, particularly those associated with waterways and on the coastline. The exception was the gravels located on the lower extent or at the base of the highlands. Cementation occurs when there is fluctuation in the water table and the cementing material (silica, iron or calcium carbonate) accumulates in the soil. This process usually occurs within 300mm to 600mm of the ground surface and can cause water retention at a subsurface level. The retention of water at a subsurface level provides vegetation with a water source in times when surface water is usually not available, discussion of this topic is furthered in the sections below.

TRR4 will be located primarily on Quaternary age unlithified deposits of clay, silt, sand and gravel, with floodplain alluvium on higher terraces. In the north towards Deeragun, geological mapping shows a north-west to south-east trending exposure of the Permian age Julago Volcanics Formation comprising rhyolitic to andesitic lava, tuff, volcanic breccia interspersed with sedimentary deposits such as sandstone, siltstone, shale and coal seams. The flanks of the Julago Volcanics are covered by talus (scree) deposits comprising boulders and cobbles with interstitial sand and clay (AECOM, June 2012).

The proposed alignment is situated over a coastal plain with duplex soils around Mt Bohle and the Bohle River, and alluvial deposits along the length of Saunders Creek and Stoney Creek (Lokkers, 2000; Hopley, 1970). These soils are typical of those found on Townsville coastal plains, and as a rule are particularly susceptible to sheet and gully erosion and dispersion. Both gully and sheet erosion are observed over the alignment.

There is a low probability of occurrence of acid sulfate soils in the study area, except in the stream beds (Mueller, P., *pers*. *com*.). Good quality agricultural land (GQAL) is mapped in the Townsville City Council *City Plan 2005* as occurring around Saunders Creek, but GQAL is not recorded in the City of Thuringowa Planning Scheme (2003) over the same area. The *Rural Resources Study* (Buckley Vann Town Planning, 2011) undertaken on behalf of Townsville City Council notes that the land within the Bohle Plains is suitable for grazing purposes but is limited for agricultural purposes due to lack of water and good quality land.

4.3 Climate

The climate of the majority of the Townsville LGA is described as dry tropical. The geographical position of Townsville and the mountain ranges to the south and south-west of the coastal plain effectively create a rain shadow for the coastal floodplains for most of the year. The exception is in the northernmost area of the LGA where the Paluma Ranges are less than 10km from the coast and as they are more north-south aligned they better capture the prevailing south easterly trade winds. The rainfall here is more frequent and higher than the remainder of the LGA, hence the inclusion of the Paluma area in the wet tropics classification.

There are two distinct weather patterns in Townsville and while it is much dryer than other parts of the tropics in Australia due to its geographical location, it still experiences distinct wet and dry seasons. During spring the monsoon trough begins to descend over the northern part of Australia bringing increasing temperatures, rain and

humidity. Summer means increasing storm activity and subsequent rainfall. This period includes the 'wet season' which usually lasts from late December through to early April. The retreat of the monsoon trough back to the north of Australia, generally during April, brings temperate conditions with much lower rainfall and humidity (i.e. the dry season).

The rainfall typically associated with the monsoon trough is heavy but spasmodic, Bureau of Meteorology (BoM) notes that monsoons bring 'bursts' of rain. The wet season provides Townsville with approximately 80% of its annual rainfall in one quarter of the year (using mean annual rainfall figures).

Townsville experiences on average an annual rainfall of 1143mm (over an average 91 rain days). However, the amount of rain that falls each year is extremely variable, an example provided on the BoM public website notes that in 2000 there was 2400mm of rain (wettest on record) and the following year was the second driest with 467mm of rainfall recorded (BoM, no date).

4.4 Surface and Groundwater

The Townsville Water Quality Improvement Plan (WQIP) (Gunn *et al*, 2010) breaks the Townsville LGA into two catchments (exception is in the south of the LGA where several catchments flow towards the Burdekin and are included in this WQIP). The southern catchment is known as the Ross River Basin, its namesake being its major waterway the Ross River, and the northern is called the Black River Basin also named for its main river system (Black River). The main catchments are broken down into 10 sub-basins as shown in Table 1. TRR4 falls within the Ross River Basin and the Bohle River sub-basin.

Table 1 Sub-Basins of the Black Ross WQIP Area

No.	Sub-basin	Main waterways/catchments	Area (Ha)
1.	Crystal Creek	Crystal Creek, Lorna Creek, Ollera Creek, Scrubby Creek, Hencamp Creek	23,969
2.	Rollingstone Creek	Rollingstone Creek, Surveyors Creek, Saltwater Creek, Leichhardt Creek	22,003
3.	Bluewater Creek	Bluewater Creek, Sleeperlog Creek, Althaus/Deep Creek, Healy Creek	29,037
4.	Black River	Black River, Alice River, Alick Creek, Log Creek, Scrubby Creek, Canal Creek	30,377
5.	Bohle River	Bohle River, Saunders Creek, Stony Creek, Louisa Creek, Town Common	32,229
6.	Lower Ross River	Ross River, Ross Creek, Pallarenda, Mundy Creek, Esplanade	13,475
7.	Upper Ross River	Ross River, Six Mile Creek, Sachs Creek, Antill Plains Creek, Toonpan Lagoon, Mt Stuart	75,460
8.	Stuart Creek	Stuart Creek, Sandfly Creek	10,371
9.	Alligator Creek	Alligator Creek, Crocodile Creek, Cocoa Creek, Cape Cleveland	26,489
10.	Magnetic Island	Gustav Creek, Petersen Creek, Gorge Creek, Endeavour Creek, Retreat Creek, Butler Creek	4,990

Source: Gunn et al, 2010.

The head waters of the waterways of the Townsville LGA are in the highlands where the 1st and 2nd order waterways have a relatively short but steep descent, converging to form 3rd and 4th order waterways on the coastal lowland (C&R Consulting, 2007). Surveys of several waterways in the Black Basin note the minimal gradient along the length of the systems on the lowland (AECOM, April 2010).

The nature of the climate in Townsville means that the majority of the waterways are ephemeral, where flows are short in duration and usually confined to the wet season. These types of waterways usually do not have or contain minimal riparian vegetation. However, while surface flows may not be visible there are riverine systems on the coastal lowlands that may sustain subsurface water throughout the year. This is due to the geology and soil types of the highlands and coastal floodplains allowing water to seep and be held within shallow aquifers. Other waterways on the floodplain may have been modified for development or for flood-proofing purposes resulting in retention or maintenance of surface or subsurface water year round. A consistent supply of water allows the establishment of a well-developed riparian zone (C&R Consulting, 2007, Townsville SOE, 2003).

Water Quality

Prior to amalgamation in 2008, the former Townsville and Thuringowa City Councils commenced a program in partnership with the Queensland State Government agency the then Department of Environment and Resource Management (now the respective Departments of Environment and Heritage Protection, and Natural Resources and Mines). The program Creek to Coral (C2C) aims (in part) "…*To maintain healthy waterways and wetlands (i.e. from Creek to Coral) within the Townsville Coastal Dry Tropics catchments, through improvements in water quality and ecosystem health…*" The C2C program, among other things, interprets the human-based impacts on water quality at a catchment-wide down to local waterway level, provides goals to be achieved (water quality objectives) and provides mechanisms to reduce pollutants mobilised in runoff impacting on water quality. The ultimate aim is to protect the Great Barrier Reef via improvement of water quality from the Black River and Ross River Basins. Within Queensland, Townsville has the greatest urban population outside of South East Queensland. Townsville is predicted to increase in population from 191,119 persons in 2011 to 295,578 persons in 2031 (Office of Economic and Statistical Research, 2012).

The research undertaken to produce the 2010 Townsville WQIP (Gunn *et al*) sought to provide a baseline of water quality for the basins ultimately to identify environmental values and form water quality objectives for the local area. The Black River Basin is considered the lesser impacted of the two catchments, the overall health of this system is considered to be slightly impacted while the majority of the Ross River Basin, including the Bohle River sub-basin, is heavily impacted. This is an expected outcome given the majority of the urban area and coastal lowland is located within the Ross River Basin. The predominant land use for the Black River Basin (~1,060km^2) is noted as grazing with small areas of horticultural uses and approximately 28% of land is protected by legislation for conservation/ecological purposes. While the Ross River Basin (~1,700km^2) also has a predominant land use of grazing, the area taken up by the practice is of a higher percentage than the Black's. This coupled with the urbanised area means that approximately 72% of the basin has been cleared. Approximately 18% of the land in the Ross River Basin is held in protected estate by the Commonwealth and State Governments (Connell Wagner, 2008).

The WQIP states that water quality objectives need to recognise the tropical climate experienced in Townsville and particularly the variable rainfall intensity in any given year. The largely seasonal rainfall means that the majority of waterways in Townsville are ephemeral therefore the levels of pollutants vary considerably depending on land use, stream flow and the amount of rainfall in any given event (Gunn *et al*, 2010).

TRR4 alignment is contained within the Bohle River Sub-basin which forms part of the greater Ross Basin system. The Bohle River Sub-basin waterways typically drain from their headwaters in the south/south-west towards the coastline in the north/north-east. The waterways within the TRR4 consist of Saunders Creek and Stoney Creek, plus their tributaries, and tributaries of the Bohle River. The direction of flow of these waterways is generally consistent with that of the waterways within the sub-basin, tending from the south-west to the north-east towards their respective confluence points at the Bohle River.

All the waterways within the TRR4 alignment are noted in the WQIP as being entirely lowland freshwater systems, and are situated on a relatively flat coastal plain. Stoney Creek is noted as being highly incised in the middle (in the vicinity of TRR4) and upper reaches, contained within a localised flat, narrow catchment with vegetation present that is associated with creek lines/river systems and associated riparian vegetation on alluvial plains. Saunders Creek also has a relatively flat and narrow local catchment with vegetation present that is associated with creek lines/river systems and associated riparian vegetation on alluvial plains. Both Saunders and Stoney Creeks have largely undeveloped local catchments south of the Bruce Highway. The topography and climate of

the coastal plain over which TRR4 is situated means that many of the waterways are ephemeral with flows visible for a short time after rain has fallen. Many of the tributaries of Saunders and Stoney Creeks and the tributaries of the Bohle River may not have defined bed and banks and may only serve as drainage features (AECOM, 2010; C & R Consulting, 2007; Gunn and Manning, 2010).

As noted in section 4.2 above the soils within the alignment are known for being dispersive and highly erodible. The Townsville geology, topography and climate together with the soil types combine to have a natural impact on water quality through sediment loading. This is exacerbated by land uses that, for example, clear vegetation, expose bare ground, provide large areas of hardstand surfaces, and redirect stormwater flows. Water quality is also impacted by the introduction of other types of pollutants (besides sediment and nutrients e.g. nitrogen and phosphorus) from land use activities within the catchment. The main land uses (as of 2010) within the Bohle River Catchment consist of agricultural uses (mainly grazing) (almost 60%), residential (approximately 15%) and nature conservation (approximately 10%). In the Black Ross Basins, activities associated with developing urban areas are the highest contributor to sediment loading in waterways while the greatest contributor of other pollutants comes from agricultural use and developing areas. Removal of vegetation, especially in riparian margins, can assist in an increase of sedimentation and mobilisation of nutrients into waterways as vegetation acts as a stabiliser of soil, can slow down water flows and can trap pollutants and nutrients (Gunn and Manning, 2010).

The existing land uses within the proposed TRR4 alignment consist of predominantly agricultural (approximately two-thirds of the alignment) within the remainder being within an urban environment adjacent to residential land uses. The vegetation within the TRR4, especially within the riparian margins, is generally in good health where the land is utilised for grazing but is in a poorer state within the urban area (AECOM, July 2012).

4.5 Riparian Zones and Wildlife Corridors

Townsville's riparian zones[1] are especially important for faunal movement and/or refuges given the climate, geology, soils and land use activities. For this reason Chenoweth (2011) notes that there are a number of state and locally significant wildlife habitat corridors mapped along waterways in the LGA. The previously mentioned natural effects have resulted in growth conditions for vegetation that generally consists of open woodlands with minimal understorey on the coastal lowlands (Plate 1 and Plate 2). Vegetation thickens and diversifies around riparian areas where there is surface and/or subsurface water present (Plate 3). The almost year round supply of water to riparian zones provides greater floral diversity and ecosystem health (C&R Consulting, 2007). The riparian zone is vitally important in the provision of habitat for native fish species. The health of the vegetation within the riparian zone directly affects the diversity of aquatic species and size of populations within this environment. Food, breeding and nursery resources are available to many species within this zone. Riparian vegetation is important also for provision of nutrients, shading, erosion and sediment control, stabilising beds and banks of waterways, and protection from predators (Pusey *et al*, 2003). Fauna assemblages, as previously mentioned, are at their most diverse within these zones.

Land use activities have impacted on open lowlands through vegetation clearing, modification of stormwater flows and other anthropocentric practices (introduction of non-endemic vegetation, application of chemicals, etc.) for urban development, hobby farming and agriculture. With the exception of the riparian areas of the highly urbanised areas (e.g. Ross Creek in Townsville City) the riparian margins of the LGA are generally intact. The planning schemes that are in effect for the Townsville LGA both recognise the importance of riparian zones as wildlife and environmental corridors and seek to protect them through development controls (Chenoweth, 2011; City of Thuringowa, 2003; Townsville City Council, 2005). A map of wildlife corridors is included in Figure 3 with the formal protected area estate in Townsville. Wildlife corridors allow movement between habitat areas (e.g. inland wetlands) and are particularly evident in the northern area of the Townsville LGA to link the highlands with the lowlands and coastal area.

Riparian habitat along the proposed alignment, in particular Saunders Creek and Stoney Creek, comprises potential protected species habitat. Riparian habitat also provides a refuge for many species during the dry season as well as acting as dispersal corridors (Woinarski *et al*., 2000). Riparian habitat is mapped as an area of high biodiversity under the regional ecosystem mapping. Protected species that could possibly occur in riparian

[1] *The riparian zone includes the immediate vicinity of the stream, which consists of the bed, banks and adjacent land…The width of the riparian zone can vary greatly depending on the type of river or stream and the catchment* (Water and Rivers Commission, 2000).

habitat within the proposed alignment include the grey goshawk *Accipiter novaehollandiae,* Rainbow bee-eater *(Merops ornatus)* and rufous owl *Ninox rufa*.

The *City of Thuringowa Planning Scheme*, Map 5.2; Natural Areas represents Saunders Creek and Stoney Creek as 'Environmental Corridors'. .

Saunders Creek and Stoney Creek have semi-permanent sources of water present while the tributaries of the Bohle River appear to be largely ephemeral.

Saunders Creek and Stoney Creek connect with the Bohle River which in turn flows out into Halifax Bay, part of the Great Barrier Reef World Heritage Area and Great Barrier Reef Marine Park, and into the declared Bohle Fish Habitat Area.

Fish

Protecting fish passage and fisheries habitats is paramount in ensuring the sustainability of fish and other aquatic species. Fish species can move between freshwater and marine habitats and between waterways and flood ponding areas in the wet season in different stages on their life cycle. It is important to maintain these regimes for ecological sustainability reasons. Barriers to fish movement can be physical (e.g. a culvert), chemical (e.g. suspended material), hydraulic (e.g. high velocity flow) or biological (e.g. low dissolved oxygen) (AECOM, October 2012; Department of Primary Industries, no date).

The majority of the species found in the lower reaches of the watercourses on the coastal lowlands are freshwater species however they can migrate into the upstream reaches (e.g. empire gudgeon). Several species require passage or move between fresh and salt water (e.g. barramundi and mangrove jack). A list of fish species, including pests, that may be present on the Bohle River catchment are contained in Table 2 below (Allen *et al*, 2002; Department of Agriculture, Fisheries and Forestry, *pers. comm.* 2012).

Correspondence with the Department of Agriculture, Fisheries and Forestry (email exchange with Alana O'Brien on 11 July 2012) notes that the fish species provided within Table 3 may be present in the watercourses associated with TRR4. The majority of the species are freshwater species that will be found in the lower reaches of the watercourses, however they can migrate into the upstream reaches (e.g. empire gudgeon) and a few require passage or move between fresh and salt water (e.g. barramundi and mangrove jack) (Allen *et al*, 2002).

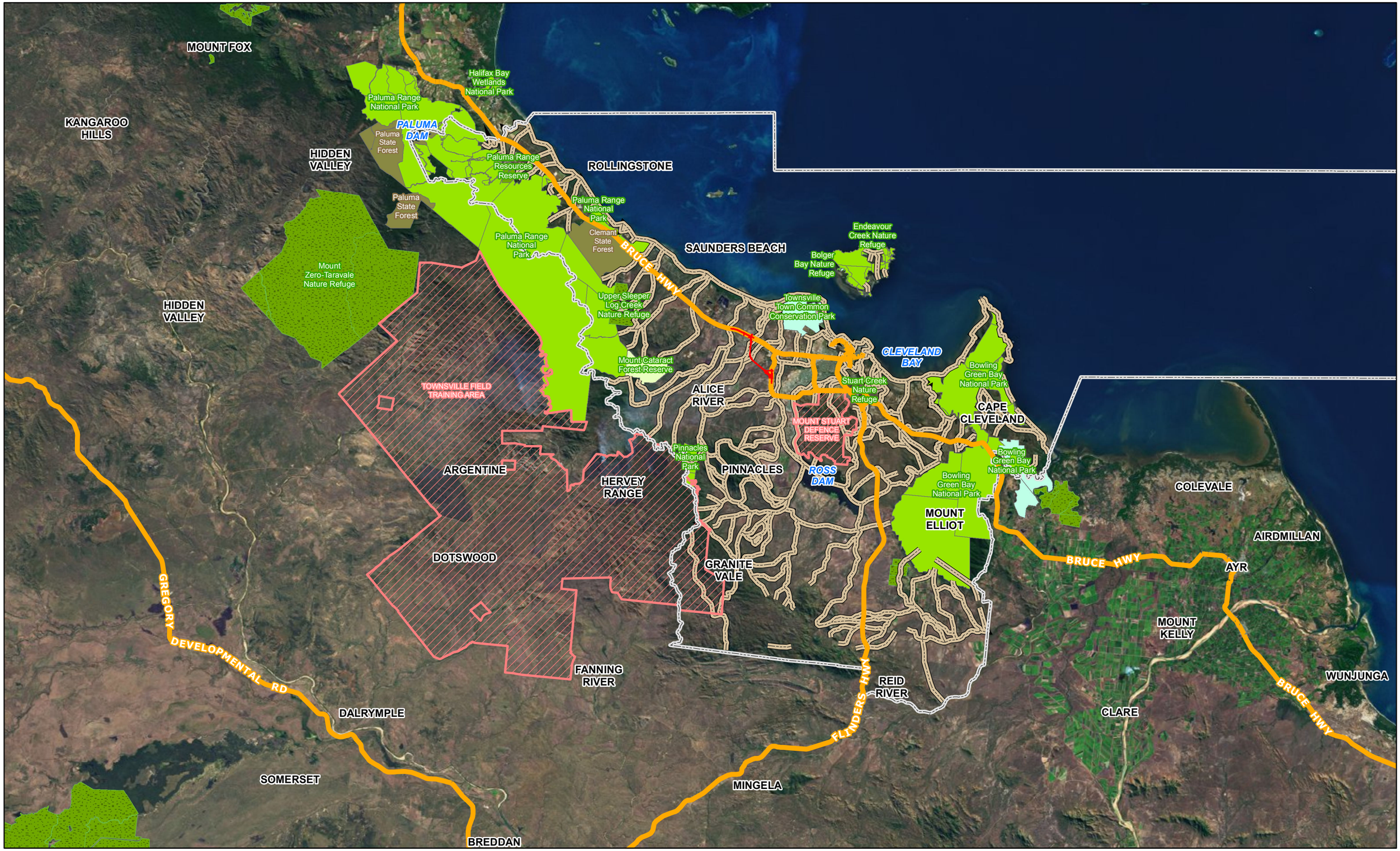
Table 2 Fish Species that may be present within the Bohle River Catchment

Species name	Common name
Ambassidae spp.	Glass perchlet
Ambassis agassizi	Agassiz's glass perchlet
Amniataba percoides	Banded grunter
Anguilla reinhardti	Long-finned eel
Arrhamphus sclerolepis	Snub nosed garfish
Craterocephalus stercusmuscarum	Fly-specked hardyhead
Gambusia holbrooki	Gambusia*
Gerres filamentosus	Spotted silver-belly
Giurus margaritacea	Snakehead gudgeon
Glossamia aprion	Mouth almighty
Hypseleotris compressa	Empire gudgeon
Hypselerotris klunzingeri	Western carp gudgeon
Hypseleotris spp.	Midgley's carp gudgeon
Kuhlia rupestris	Jungle perch
Lates calcarifer	Barramundi
Leiopotherapon unicolour	Spangled perch

Species name	Common name
Lutjanus argentimaculatus	Mangrove jack
Megalops cyprinoides	Tarpon / oxeye herring
Melanotaenia splendida splendida	Australian rainbowfish
Mogurnda adspersa	Purple spotted gudgeon
Nematalosea erebi	Bony bream
Neosilurus ater	Black catfish
Neosilurus hyrtlii	Hyrtl's tandan
Ophisternon bngalanse	Swamp eel#
Oreochromis spp.	Tilapia*
Poecilia reticulate	Guppy*
Pseudomugil signifier	Pacific blue eye#
Strongylura krefftii	Freshwater long tom
Toxotes chatareus	Seven spot archer fish#

Potential habitat exists, however these species may not be present in the upper reaches of the watercourses.

* Pest fish (i.e. introduced species). Source: DAFF, July 2012



PROJECT ID 60264706
LAST MODIFIED CFS 17-Apr-2013
FILE NAME 60264706G_ENV_58v2

AECOM

N

Scale: 1:550,000
(when printed at A3)

0 2.5 5 10 Kilometers

Legend

- Highways
- TRR4 Project
- Wildlife Corridors
- Prohibited Areas
- Nature Refuges
- Conservation Park
- Forest Reserve
- National Park
- Resources Reserve
- State Forest
- Townsville Local Government Area

TOWNSVILLE RING ROAD SECTION 4

Townsville Green Space and Wildlife Corridors

Figure 3

Plate 1 **Broad-leaved paperbark *Melaleuca viridiflora* woodland on the Bohle Plains, Townsville (within the proposed TRR4 alignment)**

Plate 2 **Narrow-leaved ironbark *Eucalyptus crebra* woodland on the Bohle Plains, Townsville (within the proposed TRR4 alignment)**

Plate 3 **Riparian habitat on the Bohle Plains, Townsville (within the proposed TRR4 alignment)**

4.6 Native Vegetation

The project area lies within the Townsville Coastal Plains Province of the Brigalow Belt Bioregion (Sattler & Williams, 1999). Most of the proposed TRR4 alignment is covered in native vegetation on alluvial plains comprised of paperbark woodlands, fringing riverine wetlands and eucalypt woodlands. The proposed TRR4 alignment crosses watercourses that are mapped as high ecosystem diversity and provide significant wildlife habitat corridors. In addition, an area adjacent to Stoney Creek is listed as high value regrowth in the RE mapping. High value regrowth watercourses are mapped within the proposed alignment of TRR4 with the riparian vegetation along the watercourses is largely intact but containing some weed species (these are discussed in section 6.2.5.3).

Table 3 identifies the Regional Ecosystems (REs) within the footprint.

Table 3 **Regional Ecosystems in and Adjacent to the TRR4 Footprint**

RE Description	VMA Status	EPBC Biodiversity Status
11.3.12 *Melaleuca viridiflora* with occasional *M. argentea* +/- *M. dealbata* woodland to open-woodland. Occasional midstratum of *Grevillea pteridifolia* and *Acacia leptocarpa*. Ground layer of perennial grasses such as *Themeda triandra, Elionurus citreus, Ectrosia leporina, Eriachne rara, Eremochloa bimaculata, Thaumastochloa pubescens, Eragrostis brownii* and *Ischaemum australe*. Occurs on older alluvial plains on strongly duplex clay soils with restricted drainage. Fire Management: season: Mid-dry season. Intensity: Low to moderate.	Least concern	No concern at present
11.3.25b Riverine wetland or fringing riverine wetland*. Melaleuca leucadendra and/or M. fluviatilis, Nauclea orientalis open forest.* A range of other canopy or sub canopy tree species also occur including *Pandanus tectorius, Livistona* spp., *Eucalyptus tereticornis, Corymbia tessellaris, Millettia pinnata, Casuarina*	Least concern	Of concern

RE Description	VMA Status	EPBC Biodiversity Status
cunninghamiana, Livistona decora, Lophostemon suaveolens or L. grandiflorus, rainforest species and, along drainage lines, *Eucalyptus camaldulensis or E. tereticornis.* A ground layer of tall grasses such as *Chionachne cyathopoda, Mnesithea rottboellioides or Heteropogon triticeus* may be present. Often occurs on coarse sand spits and levees within larger river channels. Fire management: Season: Primarily early dry season. Intensity: Low.		
11.3.30 *Eucalyptus crebra* or *E. paedoglauca* and *Corymbia dallachiana* woodland. Forms an open-woodland to open forest in places. Has a grassy ground layer of *Heteropogon contortus, Bothriochloa bladhii, Themeda triandra, Sehima nervosum, Enneapogon* spp., with forbs such as *Indigofera* spp., *Glycine tabacina, Galactia tenuiflora* and *Tephrosia juncea* common. Occurs on older floodplain complexes on Cainozoic alluvial plains. Fire management: Season: Early dry season when there is good soil moisture, with some later fires in the early storm season or after good spring rains. Intensity: Primarily low to moderate, with occasional high intensity fires.	Least concern	No concern at present
11.3.35 *Eucalyptus platyphylla, Corymbia clarksoniana woodland.* This association usually occurs as woodland of *Eucalyptus platyphylla* and *Corymbia clarksoniana* with *Corymbia tessellaris* occurring in some areas. A low tree layer of species such as *Planchonia careya, Pandanus spiralis, Melaleuca viridiflora* or *M. nervosa* and *Petalostigma pubescens* is often present. The ground layer is usually grassy with common species including *Themeda triandra, Heteropogon contortus, Mnesithea rottboellioides* and *Bothriochloa decipiens,* together with herbs or forbs such as *Glycine tabacina, Galactia tenuiflora or Sida hackettiana.* Occurs on Cainozoic alluvial plains. Older floodplain complexes, major stream levees and lighter deltaic deposits. Fire management: Season: Early dry season when there is good soil moisture, with some later fires in the early storm season or after good spring rains. Intensity: Primarily low to moderate, with occasional high intensity fires.	Least concern	No concern at present

Seasonally flooded *Melaleuca viridflora* woodland, consistent with RE 11.3.12, covers a large portion of the area. Where this habitat was dominant the epiphytic black orchid *Cymbidium canaliculatum* was widespread. This RE was found to commonly have canopy species such as *E. crebra, C. dallachiana* and *E. platyphylla*.

Grassy woodland with *C. crebra* (often in conjunction with *C. dallachiana*) or *E. platyphylla* canopy and *Melaleuca viridiflora* midstorey, representing RE 11.3.30 and 11.3.35, were both recorded vegetation communities within the footprint. RE 11.3.30 and 11.3.35 are distributed in adjoining areas to the alignment and were sometimes not clearly defined. Common midstorey species recorded in open woodland in both RE's was *Grevillea striata*, *Petalostigma pubescens*, *Planchonia careya* and multiple *Acacia spp*. (including *A. bidwillii* and *A. simsii*). Common grasses recorded included *Heteropogon contortus* and *Themeda triandra*.

Riparian habitat, closely aligned with RE 11.3.25b, within the proposed alignment consisted primarily of canopy species including *Corymbia clarksonia*, *Corymbia tessellaris*, *Melaleuca leucadendra* and sub canopy species including *Acacia* spp., *Pandanus cookii*, *Leucaena leucocephala**, and *Ziziphus mauritiana**. Groundcover species often included *Mnesithea rottboellioides* and *Megathyrus maximus**.

One species of protected flora was identified in the alignment being the bog figwort *Rhamphicarpa australiensis* (Near Threatened, NC Act). Bog figwort is a small annual herb up to 30 cm tall with an egg shaped capsule with a distinct conical beak (Calvert *et al*., 2005). Plants turn black and die back during the dry season and are hard to survey during the dry season since some plant characteristics are absent.

The bog figwort occurs in a range of open Eucalypt and Melaleuca woodlands, usually in moist poorly drained areas, often growing in association with other small ephemeral wetland species (Calvert *et al.,* 2005). It has been found to be commonly associated with *Melaleuca viridiflora* and an understorey dominated by numerous sedges and grasses.

5.0 Summary of Field Effort to Address MNES

The following field assessments have been undertaken in relation to MNES since the lodgement of the referral in September 2012:

- A five day (three person) dry season field survey for Black-throated Finch between 10-14 December 2012 within Lot 1 SP232873, with field tasks including water source watching, targeted searches and habitat assessment.
- A five day (two person) wet season field survey using the same methodology as above for Black-throated Finch between 8-12 April 2013 in the above lot. Note in both of these surveys, observations of location and activity of Squatter Pigeon was also obtained.
- Eight nights of passive acoustic monitoring using Song Meter 2 (SM2 BAT+) in sites not previously monitored from 17-20 December, followed by a further deployment of four nights at one site using an Anabat from 23-26 December (due to failure of one of the aforementioned SM2 BAT+) within the proposed road alignment, and with a baseline monitoring site to the south of the alignment in the above lot.
- Burrow scope investigations of tree hollows with a 90^0 nest box camera for 15 hours (two people).

Table 4 below presents the full suite of field assessment inclusive of the above field work that has been carried out for the TRR4 project which is now available to determine the impact of the project on Black-throated Finch (BTF), Squatter Pigeon, Bare-rumped Sheathtail Bat, and matters of state significance. Section 6.0 draws on these studies to respond to the DoE information request.

Table 4 Field Effort to Understand Biodiversity Value and Likely Impact of TRR4

Nature of Field Survey	Field Survey Period	Effort	Reference
Threatened flora and fauna survey	14-25 May 2012	Two person, five day, with flora and fauna assessments (transects) every 500 m along the concept alignment, diurnal surveys for birds, direct searches for mammals, reptiles and amphibians, searches for signs of fauna (tracks, scats, shed skins, diggings, etc.), spotlighting for nocturnal fauna in the broader area, and three nights of passive acoustic monitoring (SM2 BAT+) off the alignment with associated Spectrum analysis.	AECOM, September 2012. TRR4 Flora and Fauna Survey.
Targeted field survey for BTF	5-8 June 2012 (early dry season) (with earlier reconnaissance survey on 28 May 2012)	Two person, four day over pre-determined transects searching for BTF and nests and recording information on vegetation communities encountered.	NRA (July 2012). Townsville Ring Road Section 4 Project Black-throated Finch (*Poephila cincta cincta*) Assessment June 2012.

Nature of Field Survey	Field Survey Period	Effort	Reference
Targeted field survey for BTF	10 -14 December 2012 (dry season)	Three person, five day with field tasks including water source watching, targeted searches and habitat assessment of TRR4 road reserve and Lot 1 SP232873.	NRA (June 2013). Townsville Ring Road Section 4 Project. Black-throated Finch Supplementary Assessment December 2012 and April 2013.
Targeted field survey for BTF	8-12 April 2013 (wet season)	Two person, five day with field tasks including water source watching, targeted searches and habitat assessment of TRR4 road reserve and Lot 1 SP232873	NRA (June 2013). Townsville Ring Road Section 4 Project. Black-throated Finch Supplementary Assessment December 2012 and April 2013.
Roost Tree Survey for Bare-rumped Sheathtail Bat	14-15 & 20-21 August 2012	Two person, four (10 hour) day assessment of number and type of potential roost sites within the two lane road alignment. Daytime roost searches (36 hours)	AECOM (September 2012). Townsville Ring Road 4 Threatened Bat Roost Tree Survey.
Acoustic monitoring	10-14 September 2012	16 detector nights using SM2 BAT+ and associated Spectrum analysis on the proposed TRR4 two lane road alignment (note as a result of failure of one Song Meter 2, only 12 detector nights achieved	RPS (November 2012). Townsville Ring Road, Stage 4. Assessment of Occurrence Threatened Bat Species.
Acoustic monitoring Burrow scope investigation Vegetation transects and Lidar analysis	17 – 20 & 23 -26 December 2012	Eight nights of passive acoustic monitoring (using SM2 BAT+ and Anabat) and burrow scope investigations of tree hollows with a 90^0 nest box camera for 15 hours (two people) on alignment. LiDAR analysis of vegetation communities based on transects data and subsequent analysis and prediction of hollows in Lot 1 SP232873.	RPS (April 2013). Townsville Ring Road, Stage 4. Assessment of Bare-rumped Sheathtail Bat.
Survey for and habitat characterisation for the Northern Spadefoot Toad	21 & 23 March 2013	4 person hours investigating suitable locations for nocturnal surveys; and total of 2 person hours dusk-nocturnal survey (listening for calls; searching for and investigating any eye-shine) on TRR4 alignment. GIS analysis	AECOM (June 2013) Northern Spadefoot Toad (*Notadan melanoscaphus*) Supplementary Information.

Nature of Field Survey	Field Survey Period	Effort	Reference
		of key habitat features to predict potential habitat on the alignment and in adjacent woodlands.	
Reconnaissance survey for the proposed Dalrymple Interchange	21 August 2013	Two person, one (8 hour) day, undertaking three habitat assessments, two tree hollow quadrats along the alignment.	AECOM (September, 2013)
Reconnaissance survey for the proposed Kalynda Parade Extension	2 October 2013	One person, four hour reconnaissance survey.	AECOM (November) 2013

All original survey reports finalised since the referral was lodged are located in the appendices to this assessment (Appendices B, C & D).

6.0 Response to the Information Request

The section addresses each of DoE's information requirements specifically as well as providing a response to the impacts on MNES as an integrated statement in Section 6.2. This section builds on the matters addressed in the original referral which is available on the DoE website at http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=referral_detail&proposal_id=6562.

6.1 Matters of National Environmental Significance

6.1.1 Likely Presence of Matters of National Environmental Significance

> Provide detailed information on the likely presence, distribution, ecology and habitat of listed threatened species, communities or other matters of National Environmental Significance (MNES) likely to and/or potentially occurring at the project site and adjacent areas. Information should be obtained from previous records, fauna databases, scientific literature and other reports.

Response:

As noted in the submitted referral, the MNES listed below are in, near or have the potential to occur in or near the project site.

- Listed threatened species:
  - *Geophaps scripta scripta* (Squatter Pigeon (southern subspecies));
  - *Rostratula australis (*Australian Painted Snipe);
  - *Poephila cincta cincta* (Black-throated Finch);
  - *Rhinolophus philippinensis* (Greater Large-eared Horseshoe Bat);
  - *Hipposideros semoni* (Semon's Leaf-nosed Bat);
  - *Saccolaimus saccolaimus* (Bare-rumped Sheathtail Bat);
- Listed migratory species (identified in Table 4);
- Great Barrier Reef World Heritage Area (National Heritage values have been considered the same as the World Heritage values
- Great Barrier Reef Marine Park.

The Great Barrier Reef World Heritage Area is 6 km downstream from the project area. All waterways crossed by the proposed road alignment feed eventually into the Bohle River which drains into the Reef. It is not expected that there will be significant impacts on the Great Barrier Reef World Heritage Area. Sediment control measures will be in place for the construction period, including sediment detention ponds at strategic locations. All efforts to minimise riparian vegetation clearance on waterways crossed by the alignment will be made. Since the referral was lodged in September 2012, some protected matters have been added to the database. Table 5 outlines the updated search findings on protected matters since the referral was lodged and provides a cross tabulation to the various project documents that have assessed the potential impact on these MNES. The table also provides commentary on whether new matters are likely to be found in the project site or nearby. Detailed discussion on the species confirmed for the TRR4 and adjacent area occurs in the following sections.

Table 5 Updated Protected Matters Search Threatened and Migratory Species (post referral lodgement) 2013

Species	Current EPBC Status	Likelihood of Occurrence	Comment
Birds			
Botaurus poiciloptilus Australasian Bittern	Endangered	Unlikely	Addressed in the Referral – Table 3
Erythrotriorchis radiatus Red Goshawk	Vulnerable	Unlikely	Addressed in the Referral – Table 3
Geophaps scripta scripta Squatter Pigeon (southern)	Vulnerable	Confirmed	Addressed in Section 6.1.2 below
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern)	Endangered	Highly unlikely	Addressed in the Referral – Table 3
Rostratula australis Australian Painted Snipe	Vulnerable	Possible, seasonal visitor	Addressed in Section 6.1.3 below
Mammals			
Dasyurus hallucatus Northern Quoll	Endangered	Unlikely	Addressed in the Referral – Table 3
Hipposideros semoni Semon's Leaf-nosed Bat, Greater Wart-nosed Horseshoe-bat	Endangered	Possible	Addressed in Section 6.1.5 below
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala	Vulnerable	Highly unlikely	Addressed in the Referral – Table 3
Pteropus conspicillatus Spectacled Flying-fox	Vulnerable	Unlikely	Have not been detected during past TRR4 surveys. This species is associated primarily with rainforest and sometimes with mangroves. Suitable habitat absent.
Rhinolophus philippinensis (large form) Greater Large-eared Horseshoe Bat	Endangered	Possible	Addressed in the Referral – Table 3
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheathtail Bat	Critically Endangered	Confirmed	Addressed in Section 6.1.8 below

Species	Current EPBC Status	Likelihood of Occurrence	Comment
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo	Vulnerable	Highly unlikely	Addressed in the Referral – Table 3
Plants			
Streblus pendulinus Siah's Backbone, Sia's Backbone, Isaac Wood	Endangered	Unlikely	Addressed in the Referral – Table 3
Reptiles			
Denisonia maculata Ornamental Snake	Vulnerable	Unlikely	Addressed in the Referral – Table 3
Egernia rugosa Yakka Skink	Vulnerable	Unlikely	Addressed in the Referral – Table 3
Migratory Birds			
Apus pacificus Fork-tailed Swift	Marine migratory	Possible	May use the area temporarily, since suitable habitat is present. Mostly occur over inland plains but sometimes above foothills or in coastal areas, often over cliffs and beaches and also over islands and sometimes well out to sea. Swifts can occur over settled areas, including towns, urban areas and cities. Preference is for dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh, at treeless grassland and sandplains covered with spinifex, open farmland, and inland and coastal sand-dunes.
Ardea alba Great or White Egret	Marine migratory	Possible	Addressed in the Referral Section 3.1 (e)
Ardea ibis Cattle Egret	Marine migratory	Possible	Possible wet season habitat use. Uses predominately shallow, open and fresh wetlands including meadows and swamps with low emergent vegetation and abundant aquatic flora. They have sometimes been observed in swamps with tall emergent vegetation.
Migratory Reptiles			
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile	Marine migratory	Unlikely	Addressed in the Referral Table 4

Species	Current EPBC Status	Likelihood of Occurrence	Comment
Migratory Terrestrial Species			
Haliaeetus leucogaster White-belled Sea Eagle	Migratory terrestrial	Possible	The White-bellied Sea-Eagle is found in coastal habitats and has a widespread distribution.
Hirundapus caudacutus White-throated Needletail	Migratory terrestrial	Possible	This species might aerially use the project area and has been recorded roosting in trees in forests and woodlands, both among dense foliage in the canopy or in hollows.
Hirundo rustica Barn Swallow	Migratory terrestrial	Unlikely	The Barn Swallow is recorded in open country in coastal lowlands, often near water, towns and cities.
Merops ornatus Rainbow Bee-eater	Migratory terrestrial	Confirmed	Addressed in the Referral Section 3.1 (e)
Monarcha melanopsis Black-faced Monarch	Migratory terrestrial	Possible	The Black-faced Monarch is found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating
Monarcha trivirgatus Spectacled Monarch	Migratory terrestrial	Possible	The Spectacled Monarch prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves
Myiagra cyanoleuca Satin Flycatcher	Migratory terrestrial	Possible	Satin Flycatchers mainly inhabit eucalypt forests, often near wetlands or watercourses
Rhipidura rufifrons Rufous Fantail	Migratory terrestrial	Possible	Wet sclerophyll forests, often in gullies dominated by eucalypts. Occasionally occur in secondary regrowth, following logging or disturbance in forests or rainforests.
Migratory Wetland Species			
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Migratory Wetland	Possible	This species might use the site temporarily in the wet season. Permanent and ephemeral wetlands.
Rostratula benghalensis (sensu lato) Painted Snipe	Migratory Wetland Vulnerable	Possible	This species might use the site temporarily in the wet season. Inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans.
Anseranas semipalmata	Migratory Wetland	Possible	This species might use the site temporarily in the wet season.

Species	Current EPBC Status	Likelihood of Occurrence	Comment
Magpie Goose			Magpie Goose is seen in floodplains and wet grasslands. Some individuals, mostly younger birds, may be seen at quite long distances inland.
Pandion haliaetus Osprey	Marine Species	Possible	Occurs in a variety of freshwater, brackish and marine environments. The most important habitat requirement is the presence of ample supplies of medium-sized fish obtainable near the surface of clear unpolluted water. Several birds sometimes congregate at good feeding sites. Like the White bellied Sea eagle, Ospreys might use the area temporarily.

For the species that may possibly occur on or adjacent to TRR4 (as indicated by Table 5) likely impacts are considered to be minor given that:

a) these species have not been observed during the extensive field surveys that have now been undertaken, and many of them would be temporal visitors to the area. It is possible that some of these species could be more frequent visitors in El Nino years when there is more ephemeral wetland habitat evident. However the TRR4 alignment is on the highest ground in the Bohle Plains and would not reduce the level of ephemeral wetland cover.

b) management and mitigation measures directed at reducing the confirmed EPBC threatened species on site will also reduce impacts on migratory and other threatened species that may use the area seasonally.

6.1.2 Squatter Pigeon (southern subspecies) *Geophaps scripta scripta*

The Squatter Pigeon (southern subspecies) *Geophaps scripta scripta* (Vulnerable, EPBC Act and NC Act) was found in two separate areas in the state land south of the TRR4 road reserve during a field survey in May 2012, within 800 m south west of the proposed alignment. On both occasions the species was recorded in vicinity of an access track (AECOM, September 2012). During the Black-throated Finch (BTF) surveys (see section 4.3 of Appendix B) on the 10th to 14th December 2012 and the 8th to 12th April 2013, Squatter Pigeon have been sighted in 21 locations adjacent to the TRR4 road reserve (NRA, 2013). In total, 23 Squatter Pigeon sightings have been recorded for the study area around TRR4. Figure 4 shows the distribution of these sightings in relation to the proposed road alignment.

Behaviourally, the Squatter Pigeon is a shy and secretive species often first detected by call but may be difficult to flush from cover (Higgins *et al.* 2001). The recommended survey methods for Squatter Pigeon under "*Survey Guidelines for Threatened Birds*" include area searches or transects surveys in suitable habitat and flushing surveys also likely to be useful in areas less than 50 ha (DEWHA, 2010). The following survey effort has been suggested by DEWHA (2010):

- Area searches/transect surveys of 15 hours for 3 days, or
- Flushing surveys of 10 hours for 3 days.

Survey effort to understand the distribution of Squatter Pigeon in the project area and surrounds has considered these factors, and is documented in Table 6.

The distribution of the Squatter Pigeon (southern) extends from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coastline between Proserpine and Port Curtis (near Gladstone), and south to scattered sites throughout south-eastern Queensland.

Breeding occurs, from spring to summer although birds are said to be capable of breeding throughout most of the year, producing two broods of young per year (North, 1913-14). The nest is a depression scraped into the ground and sparsely lined with grass, and is placed beneath a tussock of grass. The female usually lays two creamy-white eggs that are incubated for a period of about 17 days. The chicks remain in the nest for approximately 2-3 weeks. The Squatter Pigeon feeds on the seeds of grasses, legumes and other herbs and forbs, and sometimes eats fallen seeds from acacias. It also feeds on insects and ticks. Birds also commonly forage in and around stockyards where they pick ticks from and inspect the droppings of livestock, drink from troughs, and rest in the shade of posts and railings (Porter 2006, pers. comm.).

Habitat ranges from freshwater swamp to dry heath vegetation, typically with dense vegetation up to 1 m high (Littley & Cutten, 1994). The species also occurs mainly in grassy woodlands and open forests that are dominated by eucalypts (Frith, 1982; Leach, 1988). Squatter Pigeon has been recorded in sown grasslands with scattered remnant trees (Leach 1988), disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements, in scrub and acacia growth, and remains common in heavily-grazed country north of the Tropic of Capricorn. The species is commonly observed in habitats that are located close to bodies of water (SEWPaC, 2013). The Squatter Pigeon has been observed foraging along roads and railway lines (Longmore, 1976; Lord, 1956) and around settlements with domestic fowl (Lord, 1956) and is commonly found in the grassy understorey of eucalypt woodlands, usually with ready access to water. Sandy areas dissected by gravel ridges are preferred and burnt areas are frequented (Frith, 1982).

The combined threats of habitat clearance, habitat degradation and predation are thought to have caused the decline in Squatter Pigeon populations that occurred during the late 19th and early 20th centuries (North, 1913-14). Furthermore, the Squatter Pigeon may potentially be threatened by the establishment of buffel grass pasture, and its associated management practices (such as blade-ploughing), in central Queensland. It has been suggested that drought and bushfires may exacerbate the impacts of other threatening processes and, consequently, contribute to or accelerate some population declines (North, 1913-14). Declines in Squatter Pigeon (southern) numbers in central Queensland have followed a severe drought in 1901-02 (Barnard & Barnard, 1925).

No recovery, conservation or threat abatement plans are available for this subspecies. However, the conservation and long-term survival of the Squatter Pigeon depends on the maintenance and restoration of the subspecies' habitats, and the alleviation of mortality caused by predators, particularly cats and foxes. The following actions have been recommended (SEWPaC, 2013):

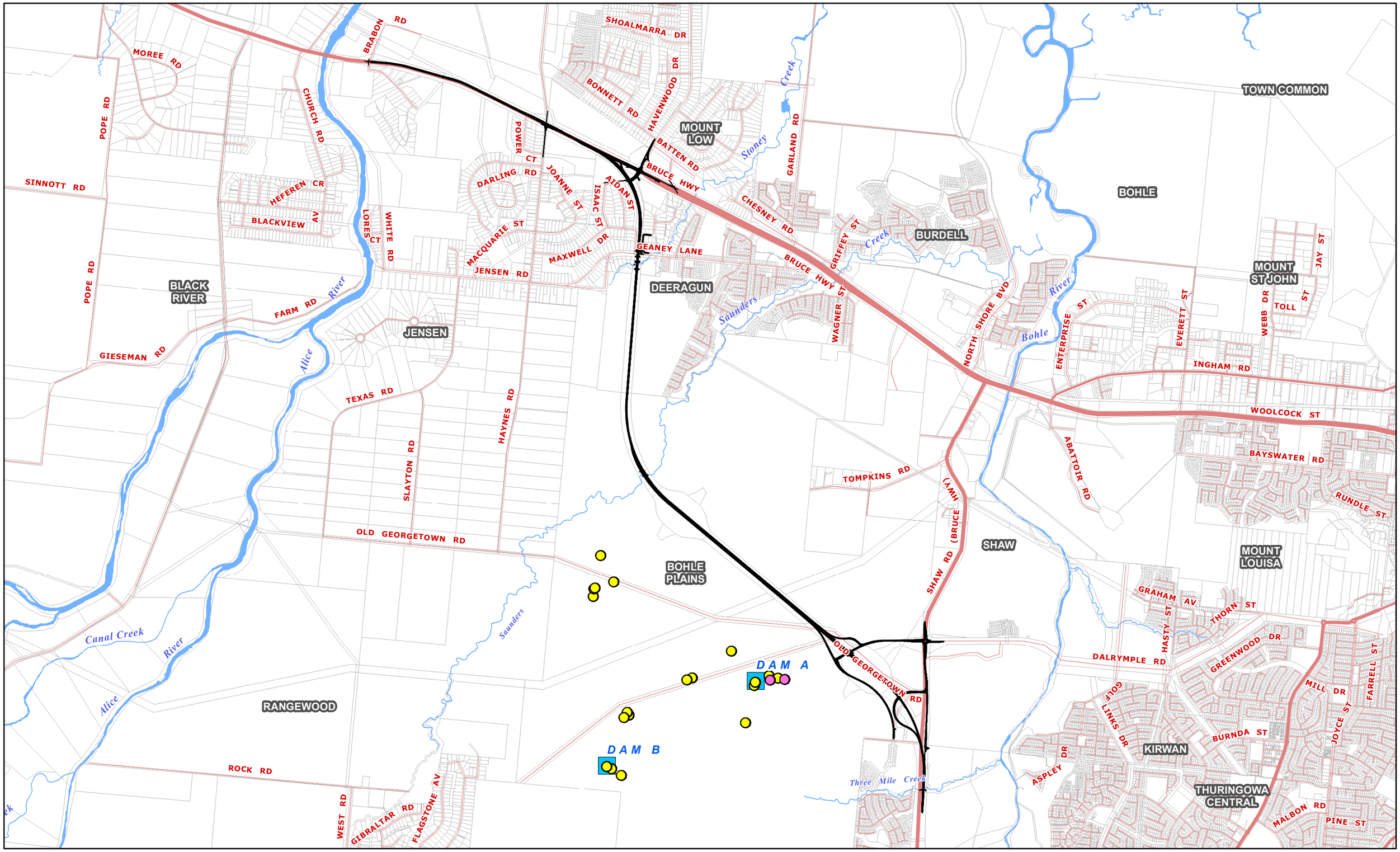
- Determine the population size and distribution of the Squatter Pigeon in southern Queensland and New South Wales and assess the pigeon's conservation status and requirements (Garnett & Crowley, 2000).
- Undertake studies in northern or central Queensland to determine the relationship between pigeon abundance, tree density and stocking rates (Garnett & Crowley, 2000).
- Establish sites for population monitoring. If possible, these sites should be established with the co-operation of local land-owners and/or conservation organizations (Garnett & Crowley, 2000).
- Develop a public education program and community-based tree planting scheme to revegetate favoured habitat types (Garnett & Crowley, 2000).
- Establish control measures for predators (especially cats and foxes) at important sites (EPA, 2006).
- Establish conservation measures to protect grassy woodlands and forests (EPA, 2006).

As indicated in Figure 4 Squatter Pigeon distribution as found from the various surveys for the TRR4 project, is south of the proposed road alignment, with the closest sighting location some 800m to the south west. This species has been found either singly or in small groups (2-4 individuals) at the cattle stockyards, along access tracks, near Saunders Creek and most commonly in the woodland areas around the two farm dams sited 1 km and 3 km south west of the proposed road. Table 6 below lists the locations Squatter Pigeon has been seen over the last year and provides an indication of the likely population numbers observed.

Table 6 NRA data on Squatter Pigeon during May & December 2012 and April 2013 Surveys

Map Id	Latitude	Longitude	Date	Time	Comments
1	-19.2828	146.6615	6/06/2012	9:02 am	1 x Squatter Pigeon drinking from roadside pool
2	-19.3025	146.6612	10/12/2012	9:58 am	3 x Squatter Pigeon
3	-19.3032	146.6623	10/12/2012	13:42 pm	1 x Squatter Pigeon at stock dam
4	-19.2937	146.6770	10/12/2012	18:31 pm	1 x Squatter Pigeon
5	-19.2927	146.6787	10/12/2012	19:03 pm	4 x Squatter Pigeon
6	-19.2929	146.6797	10/12/2012	19:21 pm	3 x Squatter Pigeon
7	-19.3022	146.6606	11/12/2012	8:15 am	3 x Squatter Pigeon
8	-19.2843	146.6592	11/12/2012	16:08 pm	1 x Squatter Pigeon
9	-19.3022	146.6606	11/12/2012	17:45 pm	1 x Squatter Pigeon
10	-19.28	146.6600	11/12/2012	18:10 pm	1 x Squatter Pigeon; near stockyards
11	-19.2934	146.6772	12/12/2012	6:00 am	1 x Squatter Pigeon
12	-19.2968	146.6631	12/12/2012	13:38 pm	3 x Squatter Pigeon; foraging
13	-19.2934	146.6772	13/12/2012	7:15 am	2 x Squatter Pigeon
14	-19.2965	146.6629	13/12/2012	17:00 pm	2 x Squatter Pigeon
15	-19.2901	146.6745	13/12/2012	7:02 am	3 x Squatter Pigeon
16	-19.2971	146.6626	13/12/2012	12:10 pm	1 x Squatter Pigeon
17	-19.2835	146.6592	8/04/2013	9:09 am	1 x Squatter Pigeon
18	-19.2929	146.6701	8/04/2013	11:12 am	2 x Squatter Pigeon
19	-19.2977	146.6761	9/04/2013	12:07 pm	2 x Squatter Pigeon feeding on track
20	-19.2931	146.6696	10/04/2013	1:10 pm	1 x Squatter Pigeon
21	-19.2834	146.6594	11/04/2013	12:23 pm	1 x Squatter Pigeon

Potential impacts to Squatter Pigeon are addressed in detail in Section 6.2.4.



PROJECT ID 60264706
LAST MODIFIED CFS 25-Nov-2013
FILE NAME 60264706_ENV_57v3

AECOM

Cadastre, Study Area, Water body provided by Townsville City Council 2011.
Squatter Pigeon - AECOM 2012 and NRA 2013
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Watercourse - © 2010 PSMA Australia Pty Ltd

N

Scale: 1:40,000
(when printed at A3)

0 500 1,000 2,000 Metres

Legend

- Squatter Pigeon AECOM Survey
- Squatter Pigeon NRA Survey
- Dam Locations
- Highways
- Main Roads
- Local Roads
- TRR4 Project
- Property Boundary

TOWNSVILLE RING ROAD SECTION 4

Sightings of Squatter Pigeon in Relation to TRR4 Proposed Road Alignment

Figure 4

6.1.3 Australian Painted Snipe (*Rostratula australis*)

While seasonally inundated areas occur in the TRR4 road reserve which could be utilised by Australian Painted Snipe on an intermittent basis, no permanent wetlands are found within the proposed road alignment. This species was not found during the May 2012 field survey, and has not been observed in subsequent surveys in the TRR4 environs (NRA, 2013). Whilst considered marginal, habitat for the species may be present in the adjacent state land south of the alignment where a farm dam provides a permanent water source and contains rushes (AECOM, September 2012). This dam is about 1 km to the south west of the road reserve and will not be impacted by the road construction works.

Widespread throughout Australia, but more commonly anticipated from eastern states, Australian Painted Snipe's preferred habitat is the margins and shallows of well vegetated, permanent or ephemeral wetlands. Australian Painted Snipe are known to seasonally migrate throughout Australia showing a seasonal preference for Central Queensland areas through autumn and winter. Preference is often cited for low dense cover such as lignum and tea tree, though the species is also cited as occurring in inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and irrigation systems. The loss and alteration of wetland habitat is probably its biggest threat, introduction of exotic grasses for pasture clearing of vegetation and pugging at wetlands edges is also cited as an issue. Predation by cats and foxes, and trampling of nests by cattle could potentially occur due to the nesting of the species on the ground (AECOM, September 2012; AECOM, May 2013; Geering *et al*, 2008).

The Australian Painted Snipe is one of several bird species that appear to respond to climatic signals for breeding. The onset of the wet season may trigger the bird to breed in northern Australia, however it has been observed to breed year round in Australia when conditions are suitable. Females can be polyandrous, mating with more than one male and building more than one nest, although the nests are usually built close together. The nests are typically found on small islands in freshwater wetlands within a slight hollow lined with leaves and stems of vegetation (generally grasses). However nests have also been recorded on mats of thick weed within wetlands, within available marine and freshwater vegetation, and in or near swamps. Females usually lay between two to six eggs in a clutch, and may have up to four clutches annually. The male takes over once the eggs are laid, incubating the eggs for 15-21 days and then caring for the young. The chicks have the ability to leave the nest fairly soon after hatching and can be independent from the parent after several days (SEWPaC, 2012; Geering *et al*, 2008).

The diet of this bird consists of "…*vegetation, seeds, insects, worms and molluscs, crustaceans and other invertebrates*" (SEWPaC, 2012). Foraging can occur on/within mud flats, shallow water, marshy vegetation and sometimes in grasslands and recently ploughed fields. Foraging usually occurs from dusk through to dawn with the middle of the day spent hiding in thick vegetative cover (SEWPaC, 2012; Curtis et al, 2012; Geering *et al*, 2008).

SEWPaC's Species Profile and Threats Database (2012) notes the population of the Australian Painted Snipe is unknown, but estimates it to be between a few hundred and 5,000 individuals. Geering *et al* (2008) provides respective estimated flyaway and Australian populations of 1,500. The Bird Australia's Threatened Bird Network May 2012 (biannual) newsletter dedicated to the Australian Painted Snipe states that the two wet seasons over 2009 to 2011 have been supportive of the birds breeding and the recent reporting has been the best since 2005. The 2008/2009 wet season count recorded 11 individuals, whereas the extensive flooding in the 2009/2010 and 2010/2011 wet seasons saw approximately 400 individuals counted across all states except Tasmania. The Bird Australia newsletter and other reports (e.g. Geering *et al*, 2008; SEWPaC, May 2013; etc.) note that the nomadic nature of the species makes the ability to gain definite counts of the population difficult. Queensland Museum records do not have any records for Townsville and no recent records in Queensland, with the last from the 1980s presumably because records are not being provided to the museum.

No threat abatement or recovery plans exist at a Commonwealth Government level for this species however there are recovery outline and conservation advice documents available via the SEWPaC website (2012). SEWPaC notes that the work undertaken by Bird Australia's Threatened Bird Network (biannual counts, database development and habitat assessment) is a supported recovery action. Other recovery actions recommended are:

- Protect and manage habitat at principal breeding and wintering sites and, as a precautionary measure, identify and protect any additional habitat used by the Australian Painted Snipe in the last 10 years.
- Develop guidelines, in consultation with landholders, for the management of suitable wetlands.
- Initiate control programs for feral animals, and erect fencing to prevent grazing and trampling of wetlands by cattle, at suitable wetlands.

- Rehabilitate selected wetlands that were formerly used for breeding.
- Undertake further research to determine movements and improve knowledge of habitat preferences.
- Monitor the population at the landscape scale using, to begin with, the Atlas of Australian Birds, and determine the breeding range.
- If deemed necessary, from the results of population monitoring, develop techniques to maintain a population in captivity.
- Encourage participation of community groups and other relevant bodies in the recovery effort (SEWPaC 2012).

Australian Painted Snipe occurs erratically in Townsville. Formal records, where individuals have been known to exist, are listed in Table 7 below and the locations indicate that where the species has been seen before they have been generally found near permanent water bodies.

Table 7 Australian Painted Snipe Records in Townsville

Date	Location	Source
April 2013	Woodstock (-19.54296 146.83570)	Atlas of Living Australia
April 2013	Woodstock As above	Atlas of Living Australia
2009	Stock dam near Cluden	NRA 2011
1992	Blakeys Crossing (-19.21 146.75)	Atlas of Living Australia
1977	Town Common (west of airport) (-19.25 146.78)	Atlas of Living Australia
1969	South of Cape Cleveland (-19.41, 147.08)	Atlas of Living Australia
1954	Town Common (west of airport)	Atlas of Living Australia
1938	Hyde Park (19.28 146.78)	Atlas of Living Australia

This species is considered highly unlikely to be impacted by the TRR4 Project.

6.1.4 Greater Large-eared Horseshoe Bat (*Rhinolophus philippinensis*)

Further investigation as noted in Section 6.1.8.1 has indicated that this bat is not present within or adjacent to the TRR4 corridor.

6.1.5 Semon's Leaf-nosed Bat (*Hipposideros semoni*)

Further investigation as noted in Section 6.1.8.1 has indicated that this bat is not present within or adjacent to the TRR4 corridor.

6.1.6 Williams' Tylophora (*Tylophora williamsii*)

This species is no longer listed under the EPBC Act, nor the NC Act.

6.1.7 Black-throated Finch (*Poephila cincta cincta*)

Conduct targeted field surveys of the subject site and surrounding areas to determine the presence, numbers and location of the Black-throated Finch (Southern).

Response:

The surveys undertaken to understand the presence, numbers, distribution and habitat condition of the BTF to date are summarised below. The majority of the information is taken from the report submitted by NRA following their survey efforts in December 2012 and April 2013 (NRA, 2013).

6.1.7.1 Investigations

A flora and fauna survey was undertaken to determine the actual or potential presence of threatened flora and fauna species as listed under the NCA and the EPBC Act within and adjacent (i.e. on Lot 1 SP232873) to the alignment of the proposed TRR4. The May 2012 survey was undertaken over a period of five days during the dry season (14th to 25th of May 2012) (AECOM, September 2012).

Targeted BTF surveys were then undertaken during the:

- Dry season (winter) over four days from 5th to 8th June 2012;
- Dry season (summer) over five days from 10th to 14th December 2012; and
- Wet season (autumn) over five days from 8th to 12th April 2013.

All survey periods were considered to appropriately represent dry and wet season conditions (as identified) for the targeted species considering the specific weather conditions at that time.

A two day targeted BTF survey was carried out on 20th and 21st October 2011 for a project unrelated to TRR4 but on land immediately adjacent to the proposed road alignment also provided late dry season (October 2011, i.e. spring). This two day field survey included the observation of two water sources (a stock dam and a trough) and a habitat assessment respectively targeting BTF. No BTF were observed, however the habitat assessment noted that the vegetation present provided foraging and nesting opportunities for the species.

NRA Environmental Consultants (NRA) were engaged to undertake field studies and reporting regarding BTF in June 2012. NRA also undertook December 2012 and April 2013 surveys in order to fulfil the Commonwealth Government's request for further information on BTF. NRA hold extensive BTF related records and have been a major provider of BTF sighting reports to the Queensland BTF Recovery Team (NRA, 2013).

6.1.7.2 Survey Methodology

The June 2012 NRA study involved a desktop assessment and reconnaissance survey, which then informed the targeted survey. The desktop survey reviewed the:

- Proposed route of TRR4;
- Soils mapping;
- Regional Ecosystem (EHP mapping);
- Aerial photography;
- NRA BTF habitat mapping; and
- NRA BTF sightings database.

The desktop review and reconnaissance survey provided information for development of a site specific survey framework. The survey methodology included a two person team traversing pre-determined transects to record sightings, nests and basic vegetation types. BTF sighted during the survey were followed (wherever possible) to record information on their behaviour and activity.

The December 2012 and April 2013 surveys both revisited the documentation (including updated information) that was reviewed in the June 2012 desktop assessment (NRA, 2013 is found in Appendix B). Additionally, information collected from previous TRR4 related studies was utilised to inform the development of subsequent respective survey methodologies and reporting.

The December 2012 and April 2013 surveys both involved:

- Water source watching;
- Targeted searches; and
- Habitat assessment.

Five stock dams were identified for timed observation that were within proximity to the TRR4 alignment and, as determined by habitat modelling could provide habitat for BTF. The level of survey effort given to each of the dams (Dams 1 to 5) was decided by proximity to TRR4, within consideration also given to the availability of previous information and likelihood of BTF occurrence at the respective sties. Three field staff were involved with the dry season survey and detailed information on survey effort is provided in Appendix B Section 3). Water troughs were recorded at two locations that, while unlikely to supply a reliable water source to BTF, could possibly provide water if suitable access was available to the birds (i.e. a perch). The troughs are steep sided and may fluctuate in water supply due to livestock management.

Targeted searches were made around the stock dams and along the TRR4 alignment where based on the previous 2012 surveys BTF was likely to occur. BTF sighted during the survey were followed (wherever possible) to record information on their behaviour and activity. Nests found were also recorded.

NRA (2013) noted that the habitat assessments were made "… similar to the quaternary level assessments as described by Neldner *et a*l. 2012…" although modified to meet the data collection requirements specific to the assessment of BTF. Recording of vegetation assemblages where BTF were observed and where there were marked changes in vegetation types or condition was undertaken as part of the habitat assessment.

The wet season survey in April 2013 involved a five day survey by two field staff. In this survey, greater survey effort targeted the areas where the BTF had previously been observed in the dry season survey and the southern extent of the TRR4 alignment where assessments to date had noted that this area was more likely to be impacted by the project. The survey involved both targeted searches and habitat assessment (NRA, 2013).

6.1.7.3 Surveys Results

The weather for December 2012 was typical of this time of year in Townsville. Daytime temperatures were between 31.7°C and 32.8°C and night-time between 21.8°C and 24.2°C. Minimal rainfall (i.e. 10mm) was recorded in the three months prior to this survey therefore water was restricted to the stock dams and water troughs. BTF would be expected to be concentrated around the water sources where vegetation and access to the water was suitable. The BTF were located in two general areas approximately 1.5km apart, being Dam 1 and Dam 3.

The wet season survey (April 2013) was a drier than normal season however water was present in the ephemeral streams and wetlands in the adjacent state land (Lot 1 SP232873). The temperatures were between 23.1°C and 30.0°C during the day. An observation made by the team during the survey was the difficulty in detecting BTF at times due to light rain and breezes (the noise from wind and rain may have masked or discouraged calls). April falls within the late wet season, at this time BTF are "…preparing to breed or are caring for eggs, nestlings or attendant young…" (NRA, 2013). BTF's remain within close proximity to their nests during this period. The Commonwealth Government's Species Profile and Threats database (2012) notes that BTF may range between 280m from nests near semi-permanent water sources to 400m from permanent water sources. By contrast the birds may range up to 3km during non-breeding periods (SEWPaC, 2009).

No extreme weather or other noteworthy event e.g. cyclone, flood, fire etc., occurred in the survey area in the months prior to the December 2012 or April 2013 surveys.

A summary of the December 2012 results are available in Table 8 below. Dam 1 was a centre for a population of approximately 20 mainly adult birds. At various times during the observation periods, birds made up of mostly adult pairs regularly came to drink at this dam. Groups of 4 to 7 BTF were also frequently noted, the maximum group size counted was 15 BTF within a mixed-species flock (with Double-bar Finches). Nests thought to or known to belong to BTF were encountered approximately 300m to 430m north-west of Dam 1. Due to the number of BTF observed there would be more nests than those seen, however these were not found by the survey team.

Approximately 470m north-east of Dam 3, a separate group of 20 BTF were observed foraging but there was only one instance where birds were seen drinking from Dam 3 (a group of seven). Nests were also discovered near the group of foraging birds. This suggests that this population of BTF have found an alternative source of water to Dam 3 and it is supposed that it is one of the water troughs. The nearest water trough (north of Dam 3) was observed to have a perch available (a stick placed in the trough) which would allow the birds access. Due to the number of BTF observed there would be more nests than those seen by the survey team.

A nest that was noted in the May 2012 survey approximately 180m from the TRR4 alignment was revisited in the December 2012 survey (west of TRR4). While the nest was in good condition, no BTF were observed in the vicinity of this nest (this was the same result as the June 2012 survey).

As expected the April 2013 (wet season) survey observed BTF over a wider range than that in the dry season. The birds were seen in pairs or small groups, with juveniles often seen in the company of the adult BTF. Table 9 provides a summary of sightings of BTF in the wet season. For continuity the sightings broadly relate to Dam 1 and Dam 3 (NRA, 2013).

Approximately 700m north-east of Dam 1 'Location A' two adult BTF with two juveniles were seen approximately 230m from TRR4. Nests were found in close proximity to the location of the sightings. The nearby ephemeral second order waterway contained long pools of water which suggests that this family group's wet season activities centre around this waterway and not Dam 1. Records from recent studies show that this is the closest to the alignment that the birds and nests have been observed.

'Location B' was the most active of all locations with a broad relationship to Dam 1, this location included the dam proper and the area within 300m. An adult pair and/or small groups of adults with and without juveniles were observed maintaining a near constant presence in this location. Nests found north and north-west of Dam 1 were likely to be a smaller number than those expected given the population of BTF at the dam.

'Location C' refers to the area between 300m and 500m of Dam 1 where three separate sightings of BTF occurred. Two individuals (adults) were seen to the west of the dam and a family of two adults and three juveniles was observed to the south. The source of water for these birds is unknown, and could be either Dam 1 or gilgai. Given the presence of a family group and the distance to the dam, the gilgai are the more likely source.

'Location D' is approximately 800m to 1km south of Dam 1 and 1.2km north-east of Dam 3. Two birds, that may have been the same individual, were sighted and it is unknown which dry season population they belong to given their location. The source of water for these birds is also unknown but as above is thought to be from with Dam 1 or gilgai.

'Location E' centres on Dam 3 and is inclusive of the area 200m outwards. One adult pair, four BTFs (unknown if juveniles were present) and two nests (both within 100m west of the dam) were sighted. Activity in the wet season was much lower than the dry season at this dam.

'Location F' relates to the brief sighting of four BTF (unknown if juveniles were present) on an access track approximately 1.1km to 1.3km north of Dam 3. The BTF were not seen again and no nests were found during a search. Water was present in deep wheel ruts on the track and in gilgai.

'Location G' is located 1.9km north of Dam 3 and about 1.6km from a permanent stock dam on a neighbouring property (to Lot 1 SP232873). The two adult BTF were observed in this location were near a small ephemeral wetland about four meters in diameter, and it is possible that in the dry season these birds contracted to the neighbouring land's dam rather than Dam 3.

The May 2012 sighted nest (located west of TRR4) was revisited in this wet season survey and noted as being in good condition. It is therefore likely that this nest had recently been used by either BTF or Double-bar Finches sometime earlier in the 2013 wet season.

Figures 5 and 6 below illustrate the extent of BTF breeding and dry season habitat as modelled by NRA for this project.

Table 8 Dry Season Black-throated Finch Survey (December 2012) Summary of Sightings Only

Stock Dam No.	Adult Birds Observed (approximately)	No. of Juvenile Birds	Nests Nearby	Distance to TRR4 (approximate)
1	Pairs and groups (commonly 4 -7 birds, maximum 15 birds) *Population estimated to consist of 20 birds*	None recorded	Within 300m – 400m (others likely to be present besides those recorded)	1km south-west
2	None recorded	None recorded	None recorded	1.3km south

Stock Dam No.	Adult Birds Observed (approximately)	No. of Juvenile Birds	Nests Nearby	Distance to TRR4 (approximate)
3	Group of 20 (foraging north-east of the dam) Drinking observed once		4 near the 20 foraging birds (others likely to be present besides those recorded)	2.5km south-west
4	None recorded	None recorded	None recorded	3.3km south-west
5	None recorded	None recorded	None recorded	1km north-east

Table 9 Wet Season Black-throated Finch Survey (April 2013) Summary of Sightings Only

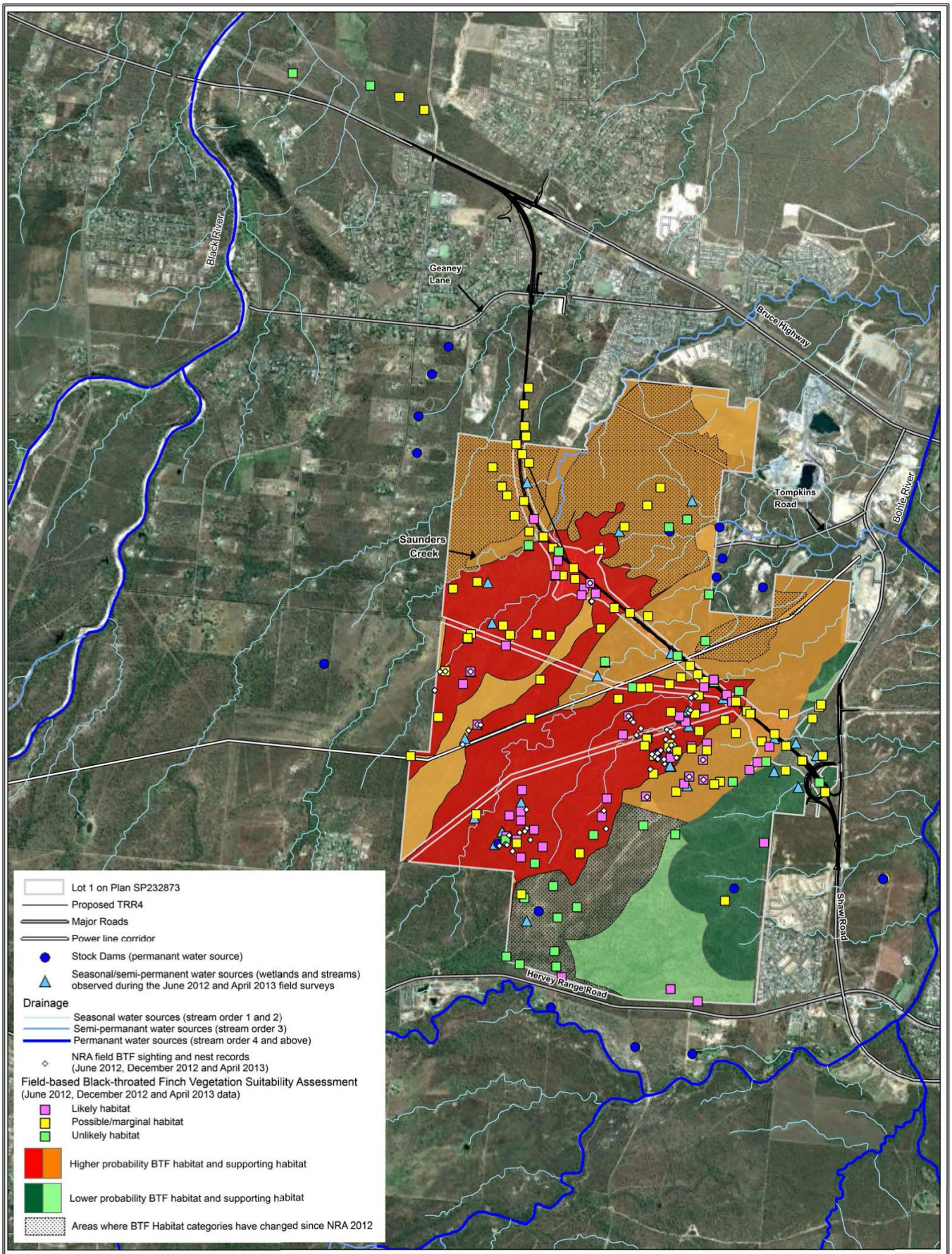
Stock Dam No.	Location in proximity to Stock Dam	Adult Birds Observed (approximately)	No. of Juvenile Birds	Nests Nearby	Distance to TRR4 (approximately)
1	A: ~700m north	2	2	In the vicinity of the sighting	230m
	B: 300m	Adult pairs and adults with juveniles in groups frequently seen within this location. Largest group = 13 BTF		North and north-west of the dam	700m to 1.1km
	C: 300m to 500m	4	3	None recorded	700m to 1.5km
	D: 800m to 1km[2]	2 (may have been the same individual)	0	None recorded	2km
3	E: 200m	6 (adult pair and group of 4 (unknown if adult or juvenile))		2 recorded within 100m (both west of Dam 3)	2.7km
	F: 1.1km to 1.3km north	4 (unknown if adult or juvenile)		None sighted	2.1km
	G: 1.9km north	2	None recorded	None recorded	1.6km

6.1.7.4 Discussion

The two respective populations of 20 BTF centred on Dams 1 and 3 on Lot 1 SP232873 are considered a medium sized population for Townsville. The populations on Lot 1 SP232873 are becoming increasingly isolated due to the land management practices and development pressures in the surrounding areas. Weeds are considered a major issue and in particular rat's tail grass (*Sporobolus* sp.) and chinee apple (*Ziziphus mauritiana*) need to be managed to prevent degradation of BTF habitat. On Lot 1 SP232873, and within close proximity of TRR4, the BTF breeding habitats and dry season habitats are considered important. Particularly the areas around the permanent water sources as these are a limiting factor in the presence of the BTF.

Impacts from TRR4 on the BTF are discussed in detail in Section 6.2.2.

[2] Also ~1.2km north-east of Dam 3.



NRA Environmental Approval & Compliance Solutions
www.natres.com.au

PROJECT: Townsville Ring Road Section 4 Project Black-throated Finch Supplementary Assessment
TITLE: Potential distribution of BTF habitat during the breeding season

JOB NO: 248068
DATE: June 2013

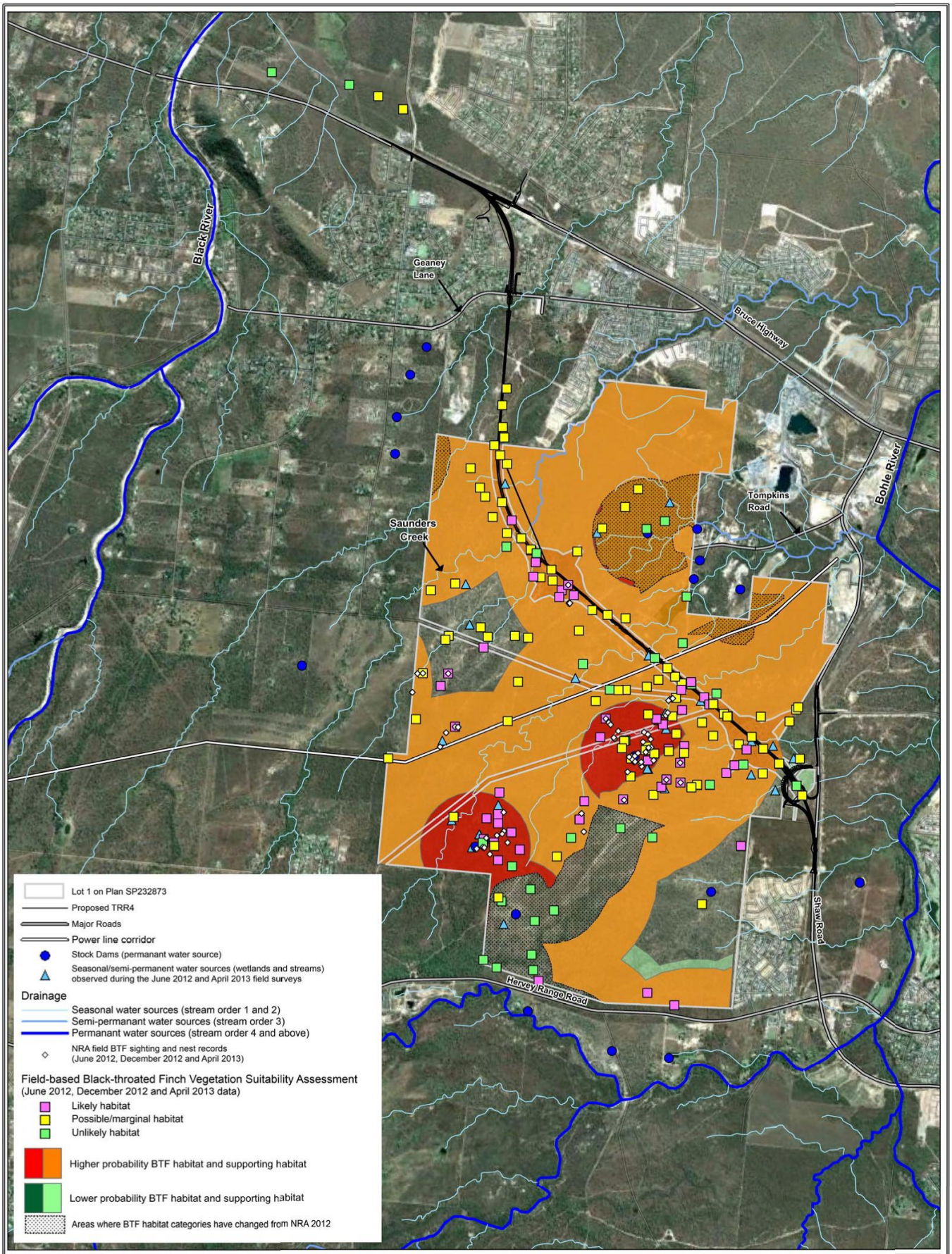
N

SOURCE:
© State of Queensland (Department of Natural Resources and Mines) 2010.
© State of Queensland (Department of Environment and Resource Management) 2010
© State of Queensland (Department of Natural Resources and Water) 2009
Google Earth
File Path: Y:\MAPINFO\248068\248068_potential_btf_breeding_130607.wor

0 1 2
Kilometres

Figure 5

Recommended print size: A3



NRA Environmental Approval & Compliance Solutions
www.natres.com.au

PROJECT: Townsville Ring Road Section 4 Project Black-throated Finch Supplementary Assessment
TITLE: Potential distribution of BTF habitat during the dry season

JOB NO: 248068
DATE: June 2013

N

SOURCE:
© State of Queensland (Department of Natural Resources and Mines) 2013.
© State of Queensland (Department of Environment and Resource Management) 2010
© State of Queensland (Department of Natural Resources and Water) 2009
Google Earth

0 1 2
Kilometres

Figure 6

Recommended print size: A3

6.1.8 Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus*)

Conduct further surveys to quantify the impact of the proposed action on the Bare-rumped Sheathtail Bat. It is suggested that targeted tree roost surveys and observations be carried out on trees that are likely to provide roosting habitat for the species.

Response:

The surveys undertaken to understand the presence and possible locations of the Bare-rumped Sheathtail bat to date are summarised below:

A Song Meter 2 (SM2 BAT+) recorder placed at Dam A (south of the alignment) for three nights in May 2012. Echolocation results indicated that *S. saccolaimus* was very likely present.

A tree roost survey was undertaken in a 40 metre search radius (representing the two lane alignment) along the length of the TRR4 alignment over four days in August 2012. No echolocation recorders were used as the overnight temperatures were too low. As part of this survey, day time roost searches were undertaken over 4 (nine hour) days (36 hours) (AECOM, September 2012a). As reported in the referral documentation likely roost trees were identified, although no bats were observed. Mapping of potential roost trees is presented in Figure 7.

Four SM2 BAT+ recorders were placed in the study area for four nights to provide 16 detector nights (three sites on the alignment and one at Dam A as a baseline) in September 2012. One recorder failed (with Site 4 having no data recorded) and only 12 detector nights were achieved (RPS, 2012). Echolocation results indicated that the presence of *S. saccolaimus* was highly probable and spectrum analysis from this survey was provided to SEWPaC the week after the EPBC referral information for TRR4 had been lodged. The final 2012 survey report became available after the Commonwealth Government decision on TRR4 as a controlled action decision and is discussed below (found in Appendix C).

Two SM2 BAT+ recorders were placed along the alignment in December 2012 in sites not previously monitored to achieve an additional 8 nights passive acoustic monitoring (at Sites 4 and 8). One of the SM2 BAT+ recorders failed and was replaced with an Anabat recorder for a further four survey nights (Site 8) to achieve a total of 8 survey nights (RPS, 2013). Results are discussed below.

Burrow scope investigations of tree hollows with a 90^{o} nest box inspection camera system undertaken by two people for 3 hours a day for five days along the alignment (15 hours). Results are discussed below.

Site inspection, LiDAR data analysis and aerial photograph interpretation to determine the extent of suitable habitat and presence of *S. saccolaimus* in the adjacent habitat. These results are also discussed below.

Data from the Song Meters were downloaded and sent to a bat echolocation specialist for analysis as WAC files (Balance! Environmental). Sequence files were filtered and identified in comparison with a reference call database, with a range of multivariate statistical analysis to compare call parameters with similar species. Table 10 below identifies each site location by coordinate and site description with mapping of the full set of passive acoustic monitoring locations presented in Figure 8. Table 11 summarises the survey effort within the alignment and in the adjacent habitat.