

APPENDIX B ECOLOGICAL ASSESSMENT



Ecological Assessment Manton Dam Return to Service POWER and WATER CORPORATION



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Appendix B	Easement land unit assesment sites
Appendix C	WTP land unit assesment sites
Appendix D	Weed record locations
Appendix E	Threatened species likelihood of occurrence analysis

ABBREVIATIONS AND GLOSSARY

easement	Water pipeline easement between the Manton Dam Wall and Water Treatment Plant
EcOz	EcOz Environmental Consultants
NT EPA	Northern Territory Environmental Protection Authority
NAFI	North Australia and Rangelands Fire Information
NT Flora and Fauna	Northern Territory Government Flora and Fauna Division
project area	Water Treatment Plant and pipeline easement combined
PWC	Power and Water Corporation
RTS	Return to Service
SOCS	Sites of Conservation Significance
WTP	Water Treatment Plant

1 INTRODUCTION

Power and Water Corporation (PWC) is proposing to recommission Manton Dam as a freshwater supply for Darwin to meet growing water needs. In order to return Manton Dam to service, a new water pipeline and water treatment plant needs to be built. These new developments comprise the 'project area' assessed in this report and form part of the broader Manton Dam Return to Service (RTS) project.

The Manton Dam RTS project requires approval by the NT Environmental Protection Authority (NT EPA). To inform and support the approval application, EcOz Environmental Consultants (EcOz) was engaged by PWC to investigate the ecological values of the project area. Some of the project area had been the subject of previous biodiversity studies commissioned by PWC. An environmental gap analysis undertaken by EcOz in 2022 found these prior studies to be out of date, and identified a need for fresh ecological assessment of the project area.

To address these ecological knowledge gaps, this report presents the methods and results of surveys for:

- Land unit verification and habitat mapping of the project area
- Sensitive and significant vegetation within or near the project area
- Threatened species identified as occurring (or likely to occur) within the project area.

This report does not assess whether the development will have a significant impact on any threatened species.

1.1 Proposed development

The water reservoir footprint will not be altered as part of returning Manton Dam to service. Instead, this report focuses only on the two new developments footprints – the water pipeline easement and the water treatment plant (WTP). The location of these is depicted in Figure 1-1

1.1.1 Easement

A new 600 mm watermain pipeline will extend between Manton Dam and the proposed new WTP in Noonamah. Commencing at the Manton Dam pump station, the pipeline will run east to the Stuart Highway – a distance of roughly 500 m. It will then pass under the Stuart Highway and run north along an easement east of the Stuart Highway for approximately 21 km. Here the pipeline will again pass under the Stuart Highway – near the southern end of Strauss WWII Airstrip, Noonamah – and enter the WTP. The majority of the pipeline will be buried underground and run along an existing easement. However, some new easement land will be required close to the WTP. Any electricity supply that is needed will be within this easement. The easement passes close to numerous rural properties and intersects both Freehold Land and Vacant Crown Land.

1.1.2 Water treatment plant

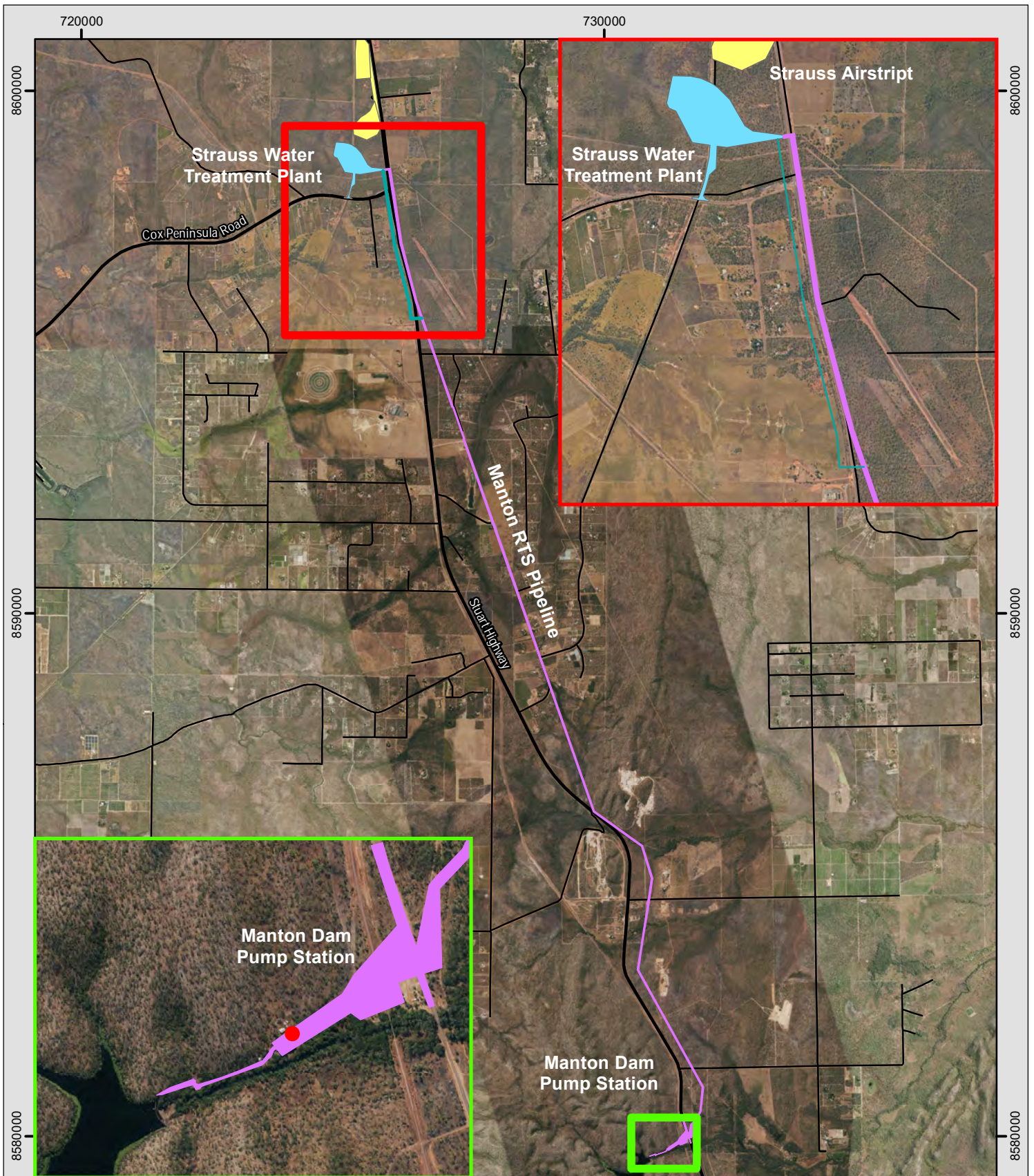
Located at the south end of Strauss WWII Airstrip, Noonamah, the WTP will be constructed in the southern portion of an existing 'Utilities' zoned future development site on Vacant Crown Land Lot 418 and 2929 Hundred of Strangways; as well as Private Freehold Land Lot 4131 Hundred of Strangways. An access road will be constructed to the WTP from Cox Peninsula Road. The access road corridor ranges from 30 m to 150 m wide within Vacant Crown Land Lots 2929 and 2930, Hundred of Strangways. The site has a utilities corridor running north-south through the centre (Vacant Crown Land Lots 2929 and 2930 Hundred of Strangways) that contains current infrastructure.







1.2 Previous research


Dating back to 2009, four ecological studies have been undertaken for the Manton Dam RTS project (AECOM 2009, Jacobs Group's 2017, EcOz 2021 & EcOz 2022). The most recent of these, an environmental gap

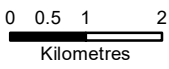
analysis undertaken by EcOz (2022), concluded that a new ecological assessment needed to be undertaken for the project area. The reasoning for this included:

- The extended time since the original two surveys.
- The northernmost 3.8 km of the easement had been realigned from the western side of the Stuart Highway to the eastern side – Figure 1-1.
- The western half of the WTP had not been assessed.
- Changes to some threatened species status and knowledge of distribution, necessitating a revision of the threatened species likelihood of occurrence in the project area (EcOz 2021). Consequently, additional threatened species needed to be considered in the project area.
- The need to determine if sandsheet heath is present in the west of the WTP.




-  Principal road
-  Minor road
-  Previous easement alignment
-  Strauss airstrip
-  Strauss Water Treatment Plant
-  Manton Dam RTS Pipeline Easement





Kilometres



MAP INFORMATION
 Scale: 1:100,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 14/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 1-1. Map of Manton Dam RTS project area

2 GENERAL ECOLOGICAL ASSESSMENT

In 2022, EcOz undertook a general ecological assessment across the project area to assess the land units and habitat in the project area. This allowed for identification of significant vegetation types and of habitats suitable to support threatened species. The findings guided subsequent targeted surveys of threatened species. Weed occurrences across the project area were also documented.

The general ecological assessment was carried out in two parts over six days. The main part was from 19 to 23 March 2022. Of this, the first two days were spent surveying the WTP, and the remaining three days were spent surveying the easement. For the easement, a 25 m buffer was applied to the pipeline track, and the area contained within this was assessed – this equates to a 50 m wide strip of land. The survey was undertaken on foot except for ~5 km of the easement – from Coulton Park Farm South to Coulton Road, Acacia Hills – which had to be done on quad bike due to access restrictions. A 400 m section of the easement adjacent to Affleck Road, Acacia Hills, could not be traversed. That section of easement bisects private freehold land and passes extremely close to residential homes.

The second part of the general ecological assessment was conducted on 17 November 2022 to assess new areas incorporated into the project area due to boundary changes. The WTP and south section of the easement between the Manton Dam Wall and Stuart Highway were further assessed on this visit.

The WTP is located on a gentle westerly slope supporting woodland. In the west is a floodplain that drains north into the Elizabeth River then Darwin Harbour. The easement transects gently undulating plains with sections of woodland and floodplain. Minor non-perennial streams are crossed that variously drain west towards Darwin Harbour and east towards Adelaide River. Nearer the southern end of the easement the ground becomes more undulating and rockier. Immediately to the south of the project area is Manton River which flows into Adelaide River.

The Manton Dam RTS project is surrounded by various land uses associated with Darwin's rural area and the surrounding region. These include a protected area (Manton Dam Recreational Reserve), rural residential properties, various forms of agriculture, quarries and sites of historic significance.

2.1 Land units and habitat mapping

A land unit is a reasonably homogenous area of land surface that is distinct from surrounding terrain with consistent landform, soil and vegetation properties (Jessop & King 1997). Each land unit has a characteristic pattern on aerial imagery. The small scale of land units is useful for identifying habitat features that may support threatened species and sensitive vegetation types.

For the Manton Dam RTS project, NT Government land unit mapping at 1:25,000 resolution (DEPWS 2010) depicted 18 land units occurring across the project area (Appendix A). These land units were verified on the ground through vegetation site assessments, photo points and general observation. All mapped land units were visited. Vegetation site assessments were standardised to level five in the National Vegetation Information System, and in line with the *NT guidelines and field methodology for vegetation survey and mapping* (Brocklehurst et al. 2007). Within each stratum (upper, mid and ground), the three dominant species were recorded and general structure was noted. The results are detailed in Appendix B and Appendix C, including site reference images.

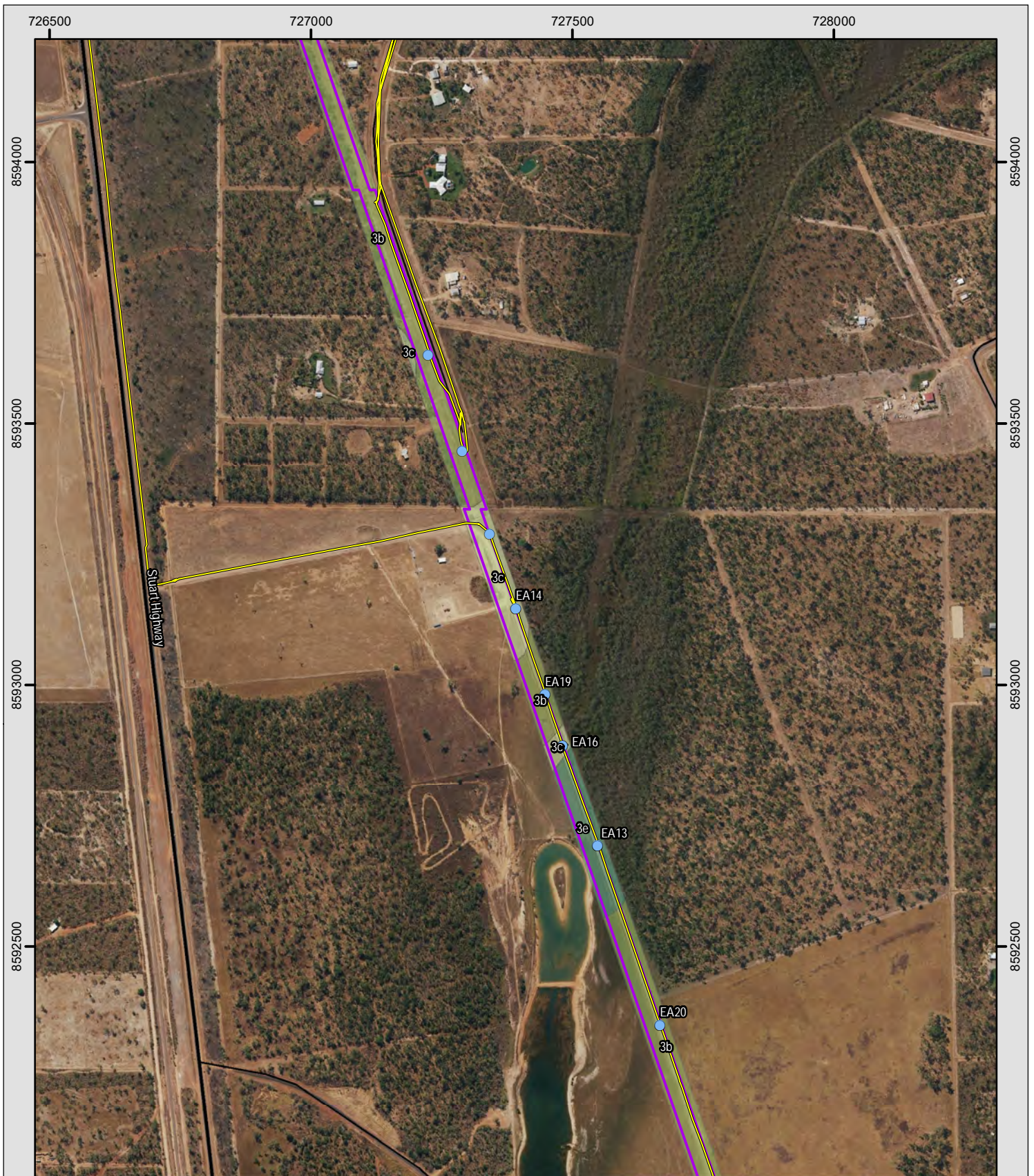
2.1.1 Easement

Seventeen of the 18 NT Government land units mapped within the project area occur along the easement (only land unit 6b is unique to the WTP). All land units along the easement were assessed and found to be accurate, with minor variations as is normally expected. The long, thin dimensions of the easement are impractical to provide mapping of the full length in this report, and so to avoid production of a large number of

maps, Figure 2-1 is presented as an example section of land units along the easement east of the Stuart Highway. This is representative of the assessment area boundary relative to the project area boundary and survey effort – i.e. tracks and waypoints collected in the field – along the easement east of the Stuart Highway. Additionally, the mix of surrounding land uses observed in this map are representative of surrounding land uses along the easement. Figure 2-2 presents land units for the easement between the Manton Dam Wall and Stuart Highway.

The natural environment along the entire easement has been heavily modified (Figure 2-3). Throughout the majority of the easement east of the Stuart Highway, there is a cleared corridor with dirt vehicle track to support current infrastructure located in the easement – an aboveground pipeline and overhead powerlines. This cleared corridor is generally devoid of trees – with temporary regrowth occurring in some areas – and has high infestation by weed species – see Section 2.3. Bordering this cleared corridor is a mix of cleared land for agriculture, infrastructure and private residential blocks, as well as sections of remnant vegetation (Figure 2-1). There is an extensive (~7.5 ha) man-made ponded waterbody adjacent to the easement at Coulton Park Farm, Acacia Hills.

The section of easement west of the Stuart Highway near Manton Dam Wall is heavily disturbed with the current Adelaide-Darwin railway line crossing the site and much of the remainder currently being used as the Manton Dam Wall Picnic Area – including bitumen roads, mowed lawns and historical infrastructure / information (Figure 2-4). Some remnant vegetation is present adjacent to Manton River, including riparian vegetation discussed in Section 2.2.1. There is heavy weed infestation spreading from an unmaintained patch of land adjacent to the railway line.



- Survey Effort
- Survey Effort
- Manton Dam
- RTS Pipeline Easement

Land Units

- 3b
- 3c
- 3e
- Principal road
- Minor road



0 75 150 300
Metres



MAP INFORMATION
 Scale: 1:10,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 2-1. Map of an example section of the easement east of the Stuart Highway depicting land units, survey area survey effort and surrounding land uses



- Survey Effort
- Survey Effort
- Principal road
- Manton Dam RTS Pipeline Easement
- Riparian Vegetation

Land Units

- 1c
- 2b2
- 7a



0 37.5 75 150
Metres



MAP INFORMATION
 Scale: 1:5,500 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 2-2. Map of easement between the Manton Dam Wall and Stuart Highway depicting land units, survey effort, surrounding land uses and riparian vegetation



Figure 2-3. Images of the easement condition east of the Stuart Highway



Figure 2-4. Images of the easement condition between the Manton Dam Wall and Stuart Highway

2.1.2 Water treatment plant

Three NT Government land units are mapped within the WTP – 3a, 3c and 6b. Onground verification found these units to represent the general patterns of landform, soil and vegetation across the WTP; however, boundary lines were found to be inaccurate. Additionally, the broad woodland classification of 3c was further subdivided into two different woodland types – woodland to the west (Figure 2-5) and open woodland to the east (Figure 2-6). Land unit 3a comprised woodland with redder soil, less gravel and more diverse shrub layer (Figure 2-7). Land unit 6b comprised a drainage line (Figure 2-8). A corridor running north-south through the centre of the WTP was allocated as disturbed land because it has already been significantly modified to support surrounding infrastructure – including an underground pipeline, above ground powerlines and underground cables (Figure 2-9). These land unit boundaries are indicated in Figure 2-10 and a summary of these land units is provided in Table 2-1. Appendix C presents vegetation site and photo-point data for the WTP.

Much of the WTP is remnant native vegetation. Large hollow-bearing trees were found across the site (discussed in 2.2.2), as were large logs lying on the ground. There was an abundance of mid-storey native fruit trees; particularly Kakadu Plum (*Terminalia ferdinandiana*), Pandanus (*Pandanus spiralis*) and Cocky Apple (*Planchonia careya*).

Much of the site burned in 2022, thinning the understory layer (Figure 2-11). North Australia and Rangelands Fire Information (NAFI) indicates the WTP experiences frequent fires; with the area being burnt approximately once every two years for the last decade (NAFI 2022). This is supported by the observed widespread regrowth of Annual Spear Grass (*Sorghum* sp.) with the onset of wet season rains.

Historic human disturbance was found throughout the remnant native vegetation (Figure 2-12). This included earth mounds, 44-gallon drum structures and cement slabs likely from WWII activities associated with Strauss WWII Airstrip to the north. The old railway line passes through the WTP parallel to the disturbed land before veering off to the north-east. Smashed Overland Telegraph Line insulators, a two-wheel dirt track and a car body/rubbish dump site were found in the east of the site.

No sandsheet heath community was found within the WTP (discussed in Section 2.2).

Few weeds were observed across the WTP. Those found were predominantly located along the north-south disturbed corridor (discussed in Section 2.3).



Figure 2-5. Image representational of land unit 3c – woodland in the WTP (VS03)



Figure 2-6. Image representational of land unit 3c – open woodland in the WTP (VS04)



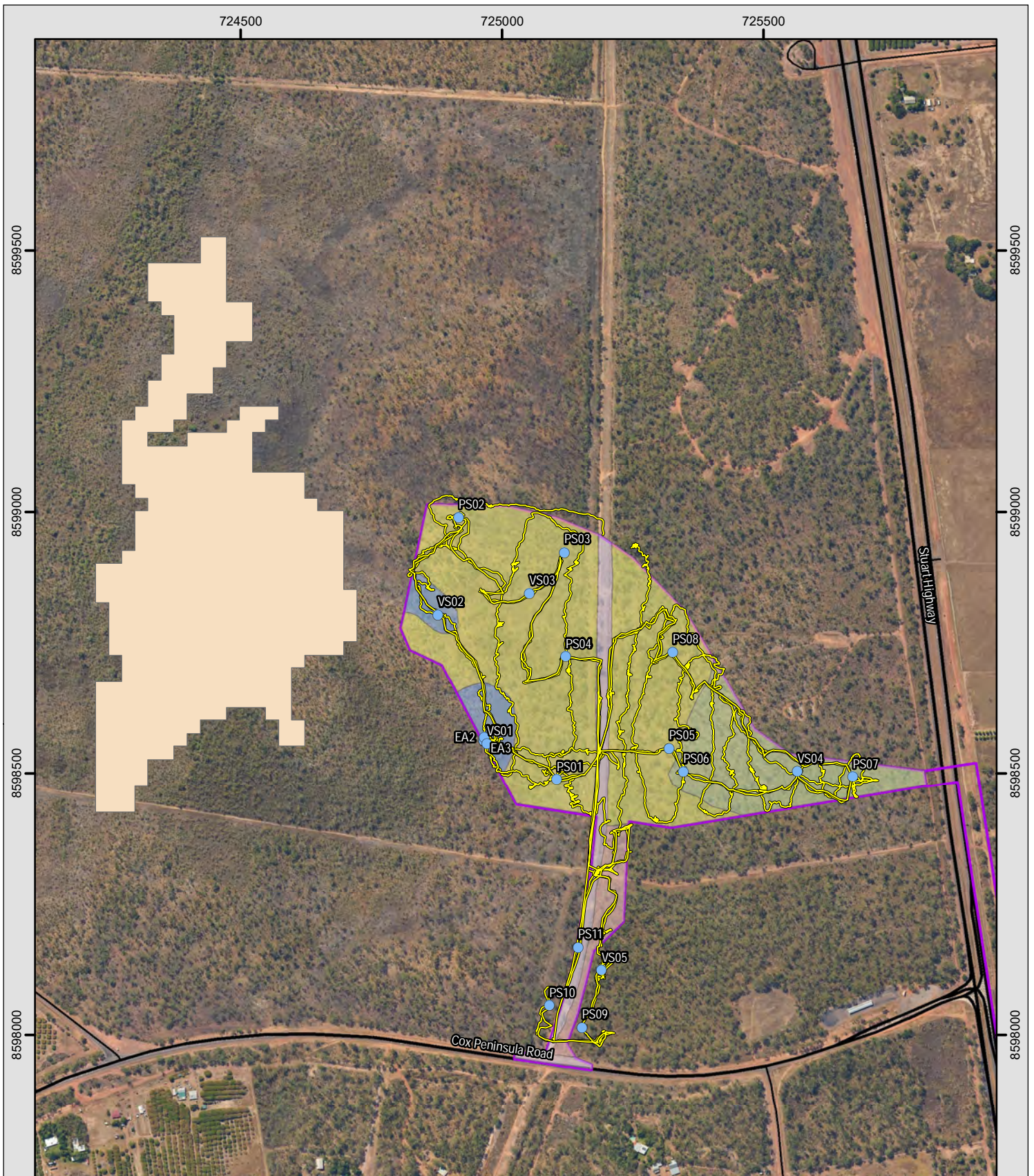
Figure 2-7. Image representational of land unit 3a in the WTP (VS05)



Figure 2-8. Image representational of land unit 6b drainage county in the WTP (VS01)



Figure 2-9. Image representational of the disturbed land running north-south through the centre of the WTP (PS11)



- Survey effort
 - Survey effort
 - Principal road
 - Minor road
 - Project area
 - High likelihood sandsheet heath
- | Land Units | |
|-----------------------------------------------------------------------------------------------------------------------------|------------------|
| | 3a |
| | 3c-open woodland |
| | 3c-woodland |
| | 6b |
| | Disturbed |



0 75 150 300
Metres



MAP INFORMATION
 Scale: 1:10,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 2-10. Map of adjusted land units for the WTP with survey sites indicated and position of sandsheet heath vegetation to the west

Table 2-1. Summary of land units across the WTP

Land unit	Landform	Soil	Vegetation
3a	Gentle sloping plain <1 % west-south-west aspect	Red-brown clay loam sand with sparse gravel	<i>Eucalyptus Erythrophleum</i> (Ironwood) woodland over a diverse sparse shrubland and open grassland
3c – woodland	Side slope 1-3 % west-south-west aspect	Brown-grey sandy clay loam with surface gravel	<i>Eucalyptus</i> woodland over sparse shrubland and open grassland
3c – open woodland	Side slope <2 % west aspect	Grey-brown sandy clay loam with surface gravel	<i>Eucalyptus</i> open woodland over sparse shrubland and open grassland
6b	Gentle slope <2 % west-north-west aspect	Grey-brown sandy clay loam with surface gravel, some debil debils	Drainage - <i>Melaleuca</i> and <i>Corymbia</i> open woodland over open shrubland and sparse grassland
Disturbed	Flattened ground with long parallel raised mounds	Varied – including road fill brough from other locations	Regularly slashed of vegetation with some peripheral shrubs remaining



Figure 2-11. Images showing loss of understory vegetation during fires at the WTP in 2022



Figure 2-12. Images of disturbance across the WTP

2.2 Significant vegetation

In the NT, significant vegetation types are listed under the *Land Clearing Guidelines* (DEPWS 2021a) due to their vulnerability to impacts by adjacent land uses, limited distribution and/or inherently high biodiversity values. They are rainforest, monsoon vine forest, vine thicket, closed forest, riparian vegetation, mangroves, sandsheet heath and vegetation containing large trees with hollows suitable for fauna. Under the *Land Clearing Guidelines*, buffers should be implemented around sensitive or significant vegetation to retain and protect these vegetation communities.

Based on desktop and field analysis, the following significant vegetation types occur within the project area:

- Riparian vegetation
- Vegetation containing large trees with hollows suitable for fauna.

NT Government spatial modelling (DEPWS 2014) indicates there is a high likelihood of sandsheet heath vegetation community occurring approximately 85 m west of the WTP boundary (Figure 2-10). This has been validated through one NT Government vegetation survey site that confirmed the presence of sandsheet heath species (DEPWS 2009). The western portion of the WTP was therefore assessed for this vegetation community – no sandsheet heath was found in the project area. This western portion of the WTP was found to be drainage country inundated from naturally-occurring wet season floodwater (see land unit 6b on Figure 2-10).

2.2.1 Riparian vegetation

Riparian vegetation is a distinct forest community occurring on the banks of rivers or streams that directly influences the adjacent water body' (DENR 2018b). When in good condition, riparian vegetation is considered a sensitive vegetation type as it supports a unique selection of habitat features that are relied upon by a range of flora and fauna species. Riparian vegetation provides refuge habitat and habitat corridors; improves water quality by filtering terrestrial run-off; stabilises banks and reduces erosion; and supports terrestrial and aquatic habitats by maintaining natural light, temperature and oxygen levels within waterways (DENR 2018b).

The south end of the easement – between Manton Dam Wall and the Stuart Highway – runs adjacent to Manton River which hosts riparian vegetation along its banks. The proposed project area encompasses a small area (~ 0.4 ha) of this riparian vegetation. Data were collected for a vegetation site and photo site within the riparian vegetation (see Appendix B for data). Example site photographs are presented in Figure 2-13. The location of riparian vegetation within the project area is mapped in Figure 2-2. The project area changed since these data were collected, thus PS12 is now outside the project area. However, this site is similar to the riparian vegetation observed to the north-east of this location (on the east side of the railway line).

The western patch of riparian vegetation was well established, with a full canopy, thick leaf litter, very loamy soil, and flying-foxes roosting in the vicinity of the site. The site had African Mahogany trees established in the upper strata and Gamba Grass starting to invade the ground strata.

The eastern patch of riparian vegetation was more disturbed, occurring as well-established regrowth vegetation along the railway corridor. African Mahogany and Gamba Grass were also invading this area.

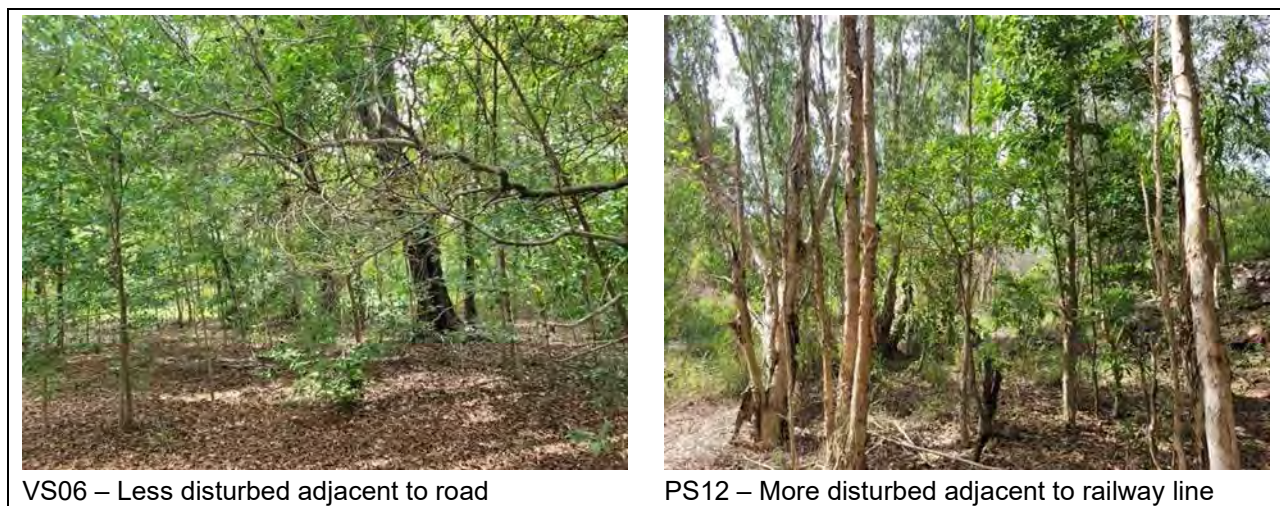
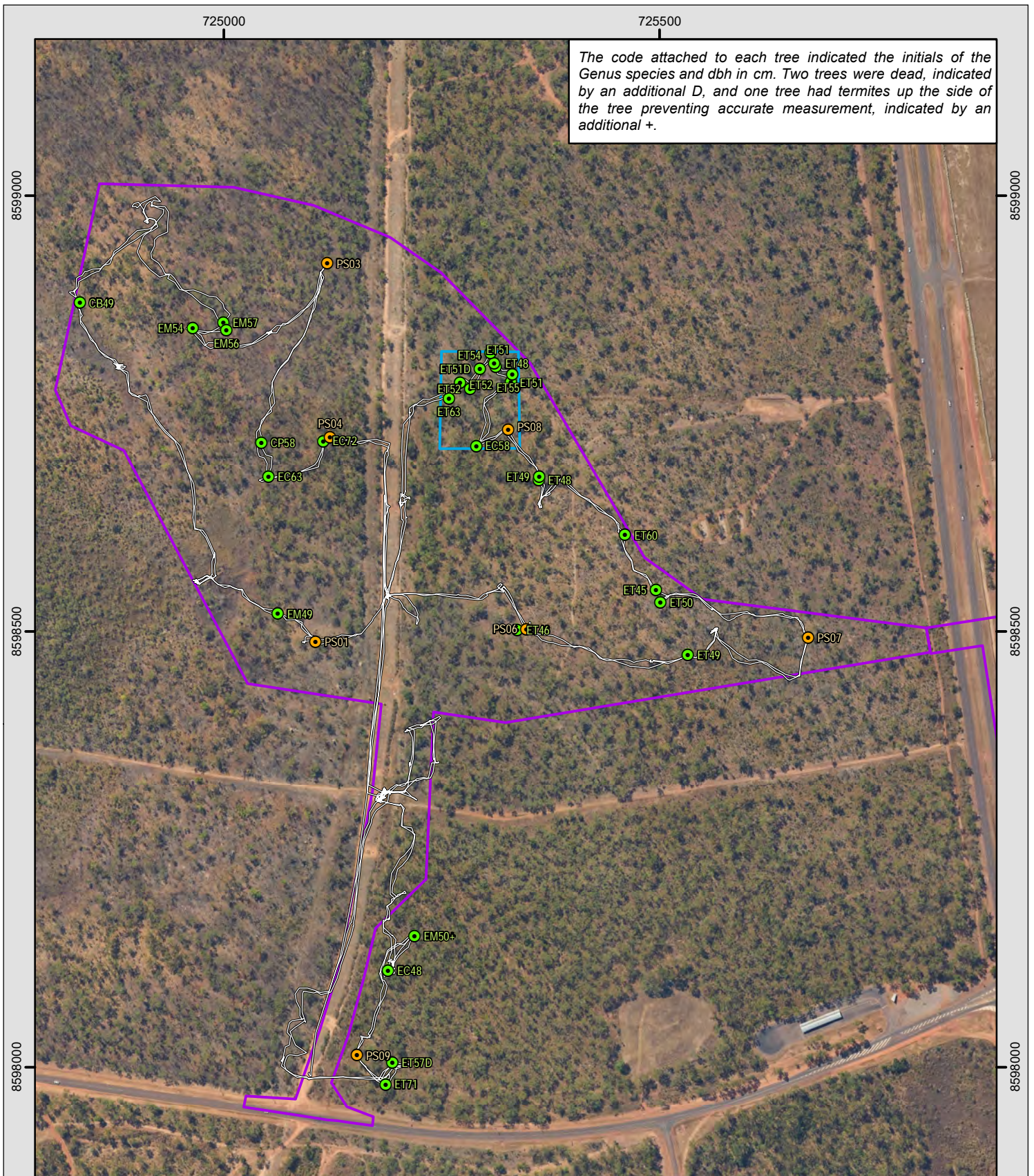


Figure 2-13. Images of riparian vegetation in the easement

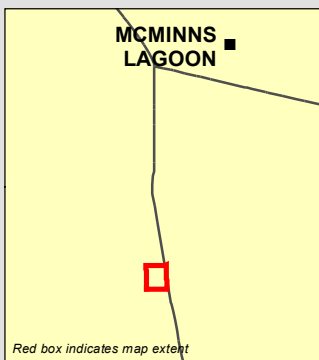
2.2.2 Large trees with hollows

Tree hollows provide valuable habitat for fauna (DENR 2018a). In the NT, *Eucalyptus miniata* and *Eucalyptus tetradonta* forest with either five or more stems growing greater than 50 cm in diameter at breast height (dbh) per hectare, and/or 30 or more stems greater than 40 cm dbh per ha with hollows suitable for fauna are considered to be of high value for biodiversity (DEPWS 2021a). When encountering large trees of different species NT Flora and Fauna are available to advise on the size-density significance and hollow bearing value. Large trees with hollows suitable for fauna are considered high value under the *Land Clearing Guidelines* requiring a 250 m buffer from the edge of the large trees. However, when habitat connectivity can be maintained and risk to habitat is low a smaller buffer may be applied (DEPWS 2021a).

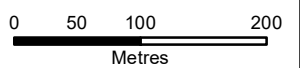
Large trees were documented at seven assessment sites (for site photos see PS01, PS03, PS04, PS06, PS07, PS08 & PS09 in Appendix C) and incidentally along the path travelled in the WTP (see Figure 2-14 for map of survey site locations and path travelled). Assessment sites were used to prompt lookout for large trees and were spread across the WTP to provide coverage of the whole area. Documentation included recording the species, location and dbh of large trees and photographing some of these trees (see example trees in Figure 2-15). Species of large trees encountered were *Eucalyptus miniata*, *Eucalyptus tetradonta*, *Erythrophleum chlorostachys*, *Corymbia bleeseri* and *Corymbia porrecta*. Most of these trees occurred as a scattering of one to three individuals. However, one region in the north-east of the WTP reached the *Land Clearing Guidelines* of high value due to presence of more than five trees with stems greater than 50 cm dbh per hectare (see distribution map in Figure 2-14).



The code attached to each tree indicated the initials of the Genus species and dbh in cm. Two trees were dead, indicated by an additional D, and one tree had termites up the side of the tree preventing accurate measurement, indicated by an additional +.



- Photo points
- Large trees
- Survey effort
- Example 1 ha
- Project area



MAP INFORMATION
 Scale: 1:6,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 14/02/2023
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DATA SOURCE
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 Project data: EZ21257
 Imagery: NTLIS

Figure 2-14. Map of large trees with hollows suitable for fauna across the WTP



Corymbia porrecta 58 cm dbh



Erythrophleum chlorostachys 63 cm dbh



Eucalyptus tetradonta 60 cm dbh



Eucalyptus miniata 54 cm dbh

Figure 2-15. Images of large trees with hollows suitable for fauna at the WTP

2.3 Weeds

Weed species were recorded following Northern Territory Government Weed Management Branch guidelines (DLRM 2015). Details recorded were weed species, location, patch diameter size (20, 50 or 100 m) and density category as presented below:

- 1 = Absent, no weeds of this species in this area.
- 2 = < 1%, Very few, not many weeds eg: single plant, perhaps with seedlings.
- 3 = 1 -10%, More than one or two isolated plants but not a lot eg: a few small plants.
- 4 = 11-50%, A lot, up to half the area covered eg: a tree, dense patches of weeds.
- 5 = > 50%, Dominant cover is weed, more than half covered eg: thickets, monocultures.

Weeds were recorded incidentally during the general ecological assessment. Codes used in this report represent the species common name and patch diameter followed by '-' density category (e.g. GG100-4 represents a Gamba Grass patch 100m in diameter and 11-50% density).

2.3.1 Easement

Weed species observed in the easement were:

- African Mahogany (*Khaya senegalensis*)
- Annual Mission Grass (*Cenchrus pedicellatus*)
- Calopo (*Calopogonium mucunoides*)
- Flannel Weed (*Sida cordifolia*)
- Gamba Grass (*Andropogon gayanus*)
- Hyptis (*Mesosphaerum suaveolens*)
- Neem (*Azadirachta indica*)
- Sida (*Sida acuta*)
- Snake Weed (*Stachytarpheta* spp.)
- Wild Passionfruit (*Passiflora foetida*).

Along the easement section east of the Stuart Highway, Gamba Grass was the most common weed, followed by Hyptis, Annual Mission Grass and Calopo. In the easement west of the Stuart Highway near the Manton Dam Wall, Gamba Grass and African Mahogany were most prevalent. See Figure 2-16 for example photographs of weed infestations along the easement. Weed locations are mapped in Figure 2-17, with GPS locations provided in Appendix D.



Gamba Grass (GG100-4) - easement east of the Stuart Highway



Hyptis (Hypt100-4) - easement east of the Stuart Highway



Calopo (C20-2) - easement east of the Stuart Highway



Annual Mission Grass (AMG100-4) and Hyptis (Hypt100-4) - easement east of the Stuart Highway

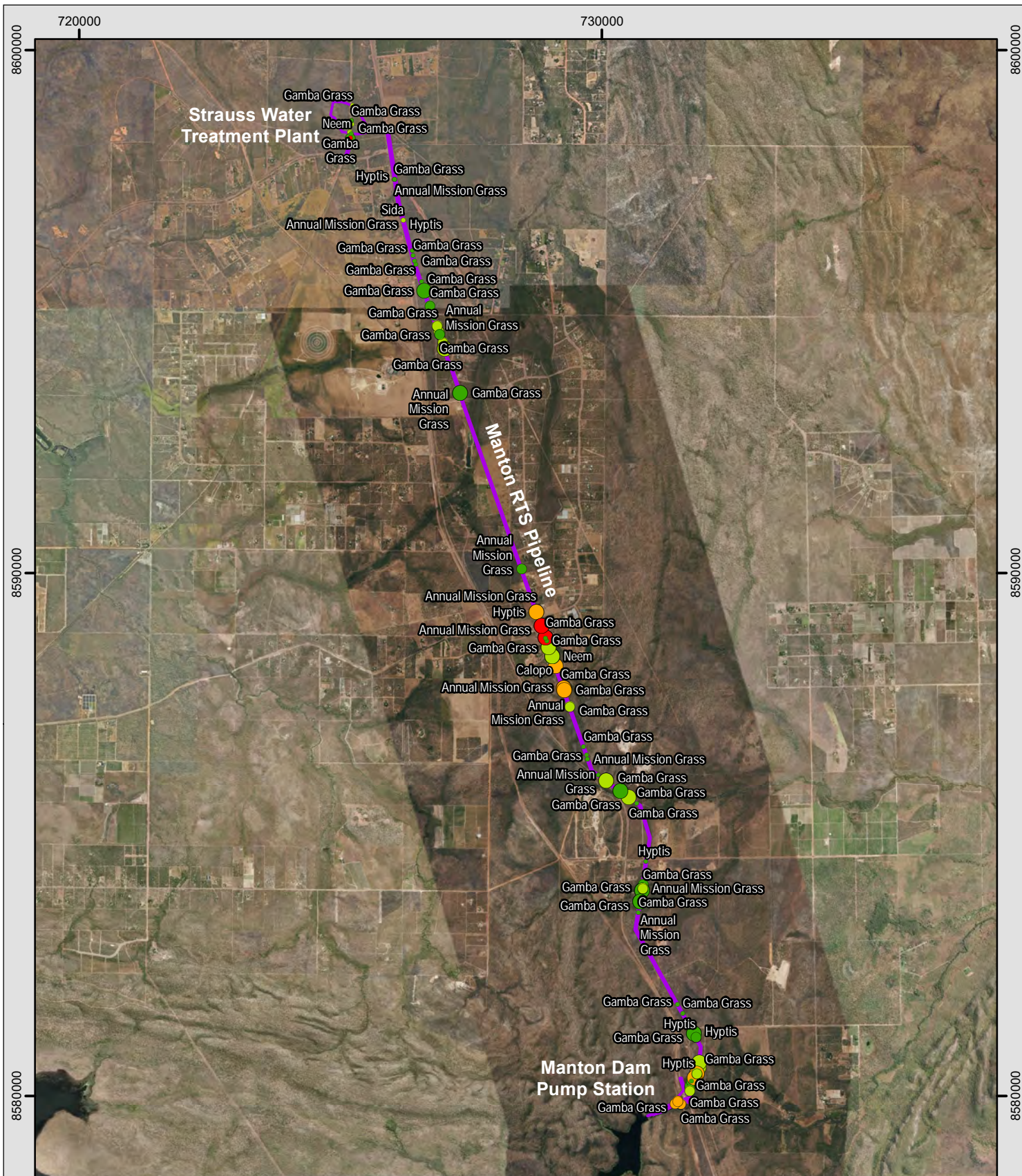


African Mahogany (AM50-4) and Gamba Grass (GG50-4) - easement west of the Stuart Highway



Gamba Grass (GG50-4) - easement west of the Stuart Highway

Figure 2-16. Photographs of weed infestations along the easement



Patch density

- < 1%
- 1 - 10%
- 11 - 50%
- > 50%

Project area

Size of point on map indicates patch



0 0.5 1 2
Kilometres



MAP INFORMATION
 Scale: 1:100,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZZ1257
 Imagery: NTLIS

Figure 2-17. Map of incidental weed records in the easement

2.3.2 Water treatment plant

Weed species observed in the WTP were:

- Gamba Grass (*Andropogon gayanus*)
- Hymenachne (*Hymenachne* sp.)
- Hyptis (*Mesosphaerum suaveolens*)
- Neem (*Azadirachta indica*)
- Stylo (*Stylosanthes* sp.)

Gamba Grass and Hymenachne were the most common weeds and tended to dominate the sites they occurred at. Most weeds in the WTP were observed along the north-south disturbed corridor. See Figure 2-18 for example photographs of weed infestations in the WTP. Weed locations are mapped in Figure 2-19, with GPS locations provided in Appendix D.

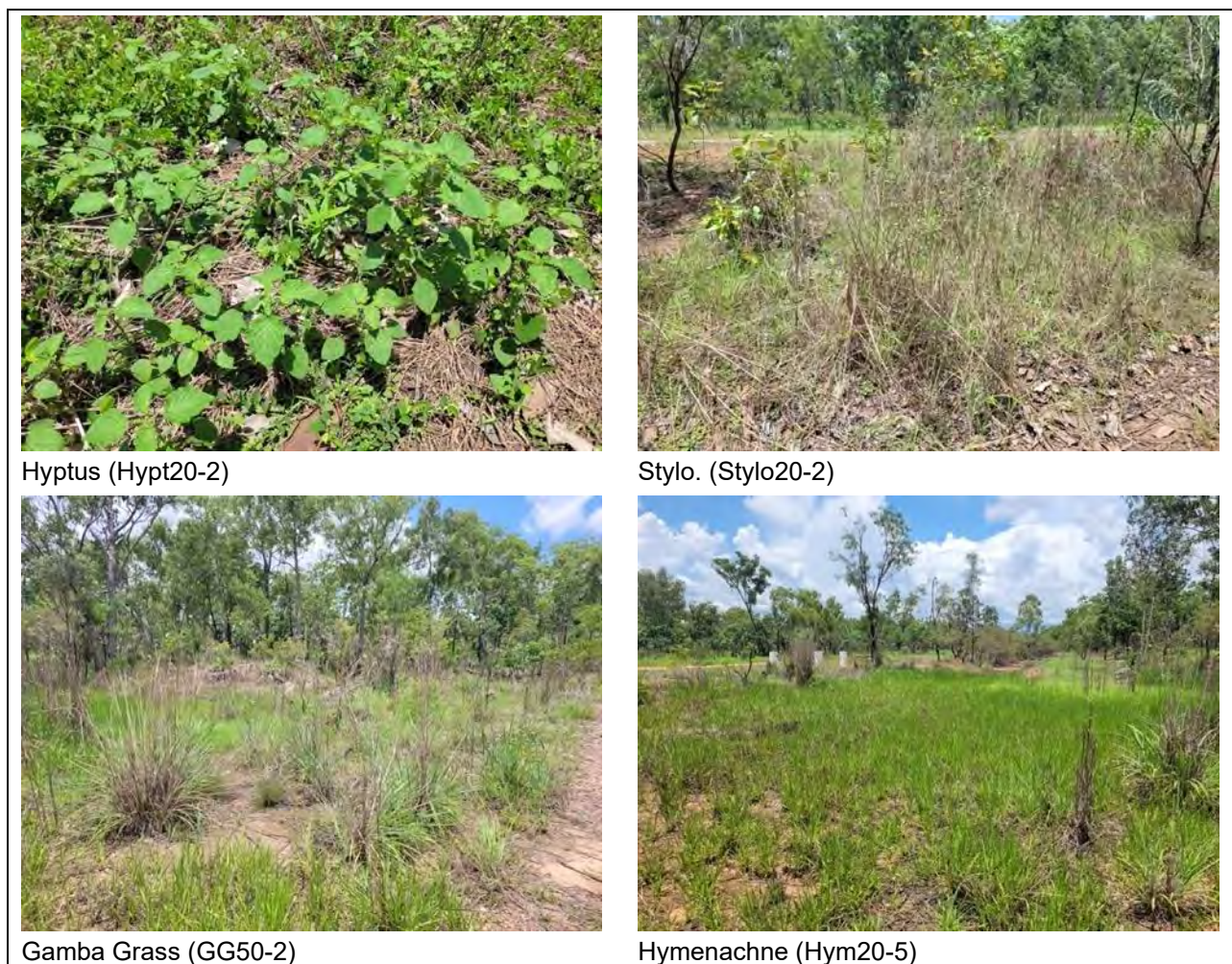
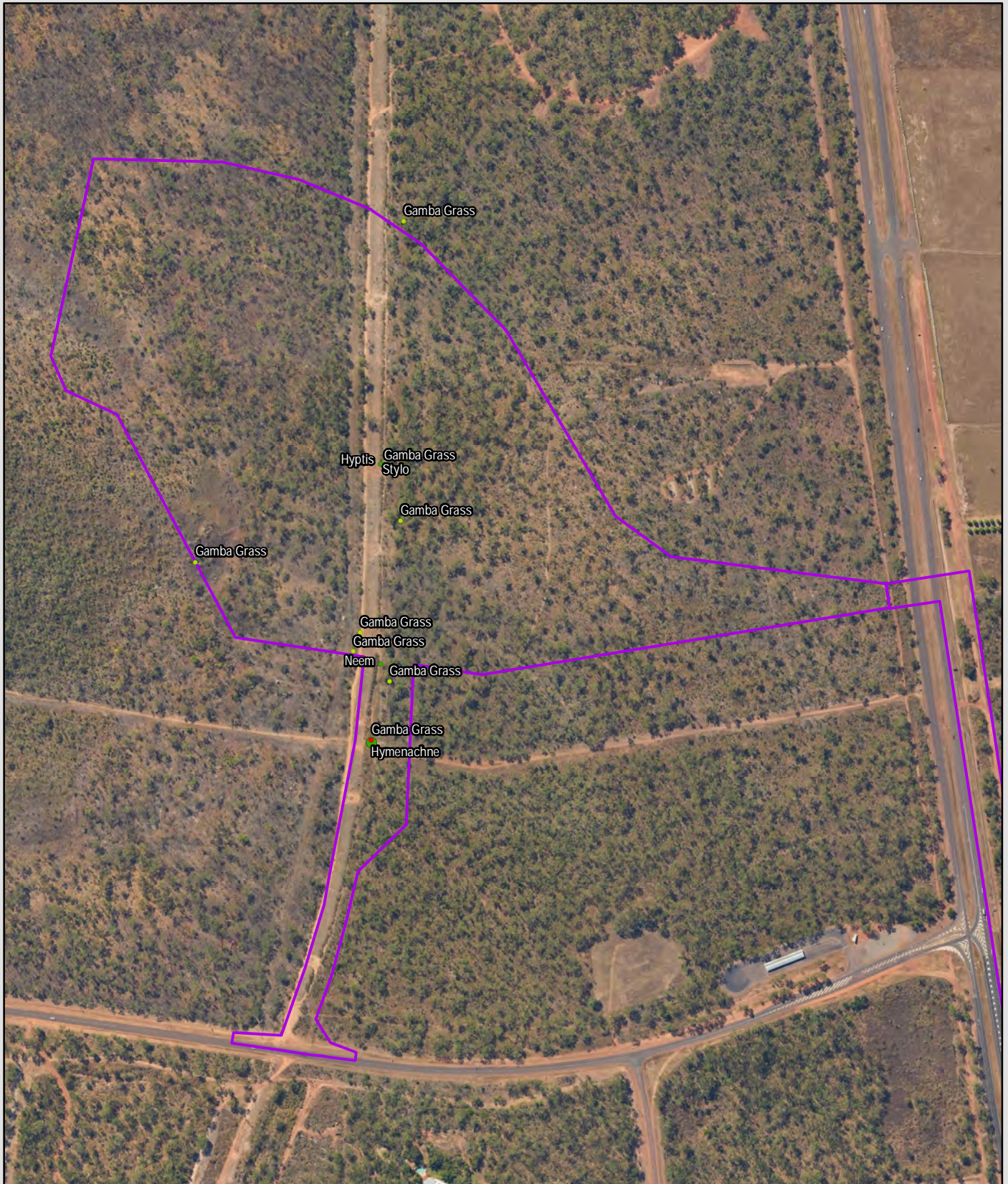


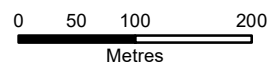
Figure 2-18. Photographs of weed infestations in the WTP disturbed corridor



Patch density

- < 1%
 - 1 - 10%
 - 11 - 50%
 - > 50%
- Project area

Size of point on map indicates patch



MAP INFORMATION
 Scale: 1:6,500 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 2-19. Map of incidental weed records in the WTP

3 THREATENED SPECIES

The International Union for the Conservation of Nature nominates a set of criteria used to identify species at risk of extinction. These criteria are used to define categories of risk which are used by the NT Government to determine which threatened species are listed under the *Territory Parks and Wildlife Conservation Act (TPWC Act)*, and by the Commonwealth Government to determine which threatened species are listed under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. This report focusses on species that are listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) under either Act, collectively termed threatened species.

This section presents the results of targeted surveys for threatened species, and uses that information to complete a likelihood of occurrence assessment. This process is not a risk assessment as it does not take into account project activities and their potential impacts.

A preliminary assessment of the threatened species with a medium or high likelihood (defined in Appendix E) of being presented within the project area – based on proximate records and habitats present – was undertaken by EcOz ecologists. This resulted in the following list of species:

Table 3-1. Preliminary assessment of threatened species with a medium or high likelihood of occurring in the project area

Likelihood	Species	Class	Habitat type	Habitat restrictions	Status	
					EPBC	TPWC
HIGH	Black-footed Tree-rat (Kimberley and mainland NT subspecies) (<i>Mesembriomys gouldii gouldii</i>)	Mammal	Top End savanna woodland and drainage areas	Habitat relatively widespread	EN	VU
	Northern Brushtail Possum (<i>Trichosurus vulpecula. Arnhemensis</i>)	Mammal	Open forest	Habitat relatively widespread	VU	-
	Mertens' Water Monitor (<i>Varanus mertensi</i>)	Reptile	Edges of watercourses, swamps and lagoons	Restricted	-	VU
	Darwin Cycad (<i>Cycas armstrongii</i>)	Plant	Top End savanna woodland	Habitat relatively widespread	-	VU
	a shrub (<i>Helicteres macrothrix</i>)	Plant	<i>E. tectifera</i> , <i>E. miniata</i> or <i>E. tetradonta</i> woodland on clayey or sandy soils. Associated with Wildman Siltstone and granitic geology.	Restricted – see model	EN	EN
	a trigger plant (<i>Stylidium ensatum</i>)	Plant	Margins of drainage depressions and poorly drained grassy flats.	Restricted – see model	EN	EN
	a herb (<i>Typhonium praetermissum</i>)	Plant	Top End savanna woodland	Habitat relatively widespread – see model	-	VU
MEDIUM	Partridge Pigeon (eastern subspecies) (<i>Geophaps smithii smithii</i>)	Bird	Open woodland	Habitat relatively widespread	VU	VU
	Bare-rumped Sheathtail Bat (<i>Saccolaimus saccolaimus nudicluniatus</i>)	Mammal	Roosts in large hollow-bearing trees. Forages	Restricted roosting habitat, but occurs widely	VU	-

Likelihood	Species	Class	Habitat type	Habitat restrictions	Status	
					EPBC	TPWC
			in broad range of habitats.	in the landscape		
	Floodplain Monitor (<i>Varanus panoptes</i>)	Reptile	Wide range of habitats	Habitat relatively widespread	-	VU
	Howard Springs Toadlet (<i>Uperoleia daviesae</i>)	Amphibian	Sandsheet heath	Restricted	-	VU
	a shrub (<i>Atalaya brevialata</i>)	Plant	Footslopes on coarse sandy soils	Restricted – see model	CR	-
	a herb (<i>Cleome insolata</i>)	Plant	Low open Grevillea/Melaleuca woodland on sandy seasonally waterlogged soils with an overlay of laterite gravel	Restricted - margins of sandsheet heath and gravelly upland drainage areas	-	VU
	a herb (<i>Typhonium taylorii</i>)	Plant	<i>Melaleuca nervosa</i> woodland on seasonally saturated sandy soils	Restricted – sandsheet heath	EN	EN
	a bladderwort (<i>Utricularia dunstaniae</i>)	Plant	Sparse grasslands/sedgeland on poorly drained white sandy flats	Restricted – sandsheet heath	-	VU
	a bladderwort (<i>Utricularia singeriana</i>)	Plant	Margins of drainage flats amongst sparse mixed grasses and sedges on sandy soils	Restricted – sandsheet heath and its margins	-	VU

Partridge Pigeon, Bare-rumped Sheath-tail Bat, Mertens' Water Monitor and Floodplain Monitor all have a moderate or high likelihood of occurring in the project area. However, these species are rarely detected during field surveys despite high survey effort. Thus, even if not detected, these species may still occur in the project area. Targeted surveys were deemed uninformative, and it is best to assume these species could occur in the project area.

3.1 Sandsheet heath species

The following threatened species are dependent on sandsheet heath:

- Howard Springs Toadlet (*Uperoleia daviesae*)
- a bladderwort (*Utricularia dunstaniae*)
- a bladderwort (*Utricularia singeriana*)
- a herb (*Cleome insolata*)
- a herb (*Typhonium taylorii*).

Field surveys verified an absence of sandsheet heath in the project area. Thus, these species have a low likelihood of occurring in the project area.

3.2 *Helicteres macrothrix*

Distribution model produced by the Northern Territory Government (Green & Cuff 2016c) indicated the presence of high-likelihood habitat for *Helicteres macrothrix* along ~5 ha of the south portion of the easement, near Lake Bennett and a short distance north of the Acacia Store. The entire easement was found to be

unsuitable habitat for this species due to the high level of modification and disturbance to the natural environment (see, e.g., Figure 3-1). Thus, further targeted surveys were not warranted.



Figure 3-1. Image of example unsuitable habitat for *Helicteres macrothrix* within a high likelihood modelled area in the easement

3.3 *Stylidium ensatum*

Distribution model produced by the Northern Territory Government (Green & Cuff 2016b) indicated the presence of high-likelihood habitat for *Stylidium ensatum* in a small area (~ 0.5 ha) of the WTP on the western boundary. However, the soil and vegetation were found to be unsuitable, with indicator plant species lacking (see, e.g., Figure 3-2). This species prefers heavier clay soils than observed at the WTP (Cowie & Westaway 2012, NTH 2013). Additionally, this species is often found association with *Melaleuca viridiflora*, *Eucalyptus alba* and *Lophostemon lactifluus*, of which only the first was found in low densities (NTH 2013). Thus, further survey work for this species was not necessary.



Figure 3-2. Images of example unsuitable habitat for *Stylidium ensatum* and *Atalaya brevialata* within modelled high likelihood and potential habitat respectively at the WTP

3.4 *Atalaya brevialata*

Distribution model produced by the Northern Territory Government (Green & Cuff 2016a) indicated potential *Atalaya brevialata* habitat is present in a small area (~ 0.5 ha) of the WTP on the western boundary. Furthermore, high-likelihood *Atalaya brevialata* habitat is modelled 680 m north of the WTP project area. However, in this modelled potential habitat within the project area, the soil was found to be unsuitable – with an absence of deep coarse sand that the species is associated with, instead with protrusions of lateritic rocks outcrops (Cowie 2014). Additionally, indicator species including *Eucalyptus tectifica*, *Corymbia foelscheana* and *Dapsilathus spathaceus* were not observed and indicator species *Melaleuca viridiflora* and *Grevillea pteridifolia* were in low abundance (Cowie 2014). Instead, upslope woodland consisted of *Eucalyptus 29iniata* and *Eucalyptus tetradonta*, while downslope drainage areas comprised *Melaleuca nervosa* and *Verticordia cunninghamii* – see Figure 3-2. Thus, further survey work for this species was not necessary.

3.5 *Cycas armstrongii*

During the general ecological survey, *Cycas armstrongii* was found to be sparsely scattered across the easement and WTP – Figure 3-3 demonstrates an example of *C. armstrongii*: density across the project area. Because no high or very high densities were observed, further targeted surveys were not required.



Figure 3-3. Image of low *Cycas armstrongii* density in the WTP

3.6 *Typhonium praetermissum*

Typhonium praetermissum is a small perennial herb that is endemic to the Darwin region. The species is listed as Vulnerable under the *TPWC Act*.

Typhonium species are seasonally dormant, existing as underground corms during dry conditions then emerging with above ground flowers and foliage after rain during the wet season. *T. praetermissum* is generally visible above ground and best surveyed between November and February (Bickerton et al. 2020 in prep), with the emergence of blue-green, slightly leathery leaves and the solitary inflorescence that may appear with or before the leaves (Holmes et al. 2005).

T. praetermissum occurs in relatively open (unshaded) woodland with characteristic red-brown clay or gravelly lateritic soils (Westaway & Cowie 2012). The distribution of this species extends from Gunn Point, south to Lake Bennett and west to the Cox Peninsula. In recent years, additional records from the Darwin region have slightly extended the species distribution and increased knowledge on their habitat requirements. The NT Government have developed a habitat model for *T. praetermissum* for the Greater Darwin region (Cuff & Green 2019). The model was utilised to indicate areas for targeted surveys in this assessment and to interpret the relationship between plants found in this assessment and other populations in the vicinity.

Threatening processes impacting this species include the loss of habitat due to clearing for residential and rural development, the spread of introduced perennial grass species such as Gamba Grass (*Andropogon gayanus*) and Mission Grass (*Cenchrus polystachios*), and digging / foraging by feral animals such as Feral Pigs (*Sus scrofa*) (Westaway & Cowie 2012).

The *T. praetermissum* distribution model indicated a high likelihood of *T. praetermissum* occurring along ~ 22.7 ha of the easement and in ~ 18.8 ha of the WTP. During the general ecological assessment, areas of modelled habitat in the easement were found to be disturbed and unsuitable for *T. praetermissum* (see, e.g., Figure 3-4). This assessment occurred during the growing season for *T. praetermissum* and no plants were observed. From these findings, further surveying was deemed not to be required.



Figure 3-4. Image of example unsuitable habitat for *Typhonium praetermissum* within a high likelihood modelled area in the easement

During the general ecological assessment, areas of modelled habitat in the WTP were found to be highly suitable for *T. praetermissum* (see, e.g., Figure 3-5) triggering a need for further targeted survey for this species.



Figure 3-5. Images of example suitable habitat for *Typhonium praetermissum* at the WTP

3.6.1 Methods

A targeted survey for *T. praetermissum* at the WTP was undertaken as soon as possible after the general ecological assessment – on 12 and 13 April 2022 – after consultation with PWC. Although this was just outside the recommended survey period for *T. praetermissum*, a reference site at Holtze was visited to ensure that plants were still visible. An additional survey for *T. praetermissum* at the WTP was undertaken on 12 Jan 2023. Prior to undertaking this survey, records of *T. praetermissum* from the 2022 survey at the WTP were visited and confirmed to be visible.

NT Government-approved surveyed methodologies were used (Bickerton et al. 2020 in prep & Cuff et al. 2020 in prep). This involves a two-step approach. The first step determines the presence or absence of *T. praetermissum* by slowly walking the target area along transects spaced at 17 m apart. If the species is observed during the presence-absence survey, a second step – a more intensive distribution and abundance survey – is then undertaken. This involves walking transects spaced 5 m apart or less, across the area(s) where plants were observed during the presence-absence survey (including a 50 m buffer around each record). The presence-absence methodology enables the survey team to relatively quickly determine whether *T. praetermissum* exists in the target area, and (if so) guides where to focus the density-abundance survey. The density-abundance survey provides a more accurate appraisal of the species' distribution and abundance across the target area.

Three EcOz ecologists undertook the presence-absence survey on 12 April 2022. The surveyors had recently finished surveying for *T. praetermissum* in the Gunn Point region, and so were well prepared for spotting this cryptic species. Transects were walked slowly in unison to ensure no transect errors were made, and that survey speed was kept consistent across all transects – helping to ensure maximum observability of *T. praetermissum* plants (see Figure 3-7 for mapped survey area). On 13 April 2022 – the day after the presence-absence survey – a thorough search was undertaken across the north-western region of the WTP – see Figure 3-7 for mapped survey area. This was undertaken as a systematic meandering approach spiralling out from the original observation site as far as highly suitable *T. praetermissum* habitat existed.¹ This survey included areas outside the WTP to obtain a broader perspective of the number of plants present and the area they encompass.

Two EcOz ecologists undertook a further presence-absence survey on 12 Jan 2023 to cover areas within the WTP in between NT Government-modelled high likelihood *T. praetermissum* habitat where the surveys from 2022 were undertaken – see Figure 3-7. Some of these additional areas were identified as potential

¹ Whilst this method differs from the guideline survey methodology, the effective coverage and follow-up survey effort in 2023 is similar enough to be confident that all plants present in the vicinity were identified.

T. praetermissum habitat during previous fieldwork. A follow-up density-abundance survey was also undertaken on 12 Jan 2023 – see Figure 3-7.

3.6.2 Results

During the presence-absence survey in 2022, two groups of *T. praetermissum* plants were identified in the WTP; a central-south group and north-west group. During the presence-absence survey in 2023, additional *T. praetermissum* plants were found in the north-west group, but no further groups were detected.

From the 2022 presence-absence survey, the central-south group comprised two plants found at one location (Table 3-2). The 2023 density-abundance survey was undertaken in a 50 m radius circle around this one location (Figure 3-7). Only two *T. praetermissum* plants were detected during this 2023 survey (Table 3-3 and Figure 3-6) and they were found in the same location as the plants from 2022. Thus, within this central-south group only two plants have been recorded.

The 2022 presence-absence survey in the WTP, and subsequent systematic meander search including land adjacent to the WTP, found a total of 13 *T. praetermissum* plants in the north-west (Table 3-2). Nine of these plants were outside the WTP boundary. This patch covered an area 250 m long north-south and 70 m wide east-west (Figure 3-7). An additional ten *T. praetermissum* plants were identified in this same north-west area during the presence-absence survey in 2023 (Table 3-3, Figure 3-6 and Figure 3-7). Half of these plants were inside, and half outside, the WTP boundary. Collectively over 2022 and 2023, 23 *T. praetermissum* plants were observed in the north-west group, with 9 plants inside the WTP and 14 plants outside the WTP. Note that some individual *T. praetermissum* plants may have been detected on both visits.

In light of the 2022 survey results, PWC indicated they will avoid the north-west corner of the WTP where the majority of *T. praetermissum* were found. Thus, density-abundance surveying of the north-west group was not carried out.

NT Atlas data indicate the nearest *T. praetermissum* record to those found in/near the project area is 4.6 km to the south-east – a record of two plants on a private property in 2020. The next nearest *T. praetermissum* records is a sub-population located in Noonamah South 4.8 km to the east. *T. praetermissum* populations are considered distinct sub-populations when separated by a minimum of 2.5 km, with refinement through consideration of habitat continuity, survey effort and barriers to pollination or dispersal between sites (Cuff & Green 2019). Given the large distance (>2.5 km) and potential barrier created by the Stuart Highway between the *T. Praetermissum* plants found in/near the project area and the nearest other *T. praetermissum* records, the plants found in/near the project area may comprise a separate sub-population.

Table 3-2. GPS location of *Typhonium praetermissum* plants found at/near the WTP in 2022

GPS data presented in GDA 2020

ID	Date	No. of Plants	Latitude	Longitude	Group
1	13/04/2022	1	-12.664502	131.070979	north-west
2	13/04/2022	1	-12.664541	131.070961	north-west
3	13/04/2022	1	-12.664828	131.071497	north-west
4	13/04/2022	1	-12.663843	131.071650	north-west
5	12/04/2022	1	-12.665282	131.070806	north-west
6	12/04/2022	1	-12.666004	131.071091	north-west
7	13/04/2022	1	-12.665286	131.070756	north-west
8	13/04/2022	2	-12.665286	131.070756	north-west
9	13/04/2022	1	-12.665286	131.070756	north-west
10	13/04/2022	1	-12.665286	131.070756	north-west
11	13/04/2022	1	-12.665438	131.070890	north-west
12	13/04/2022	1	-12.665232	131.070969	north-west
13	12/04/2022	2	-12.669219	131.074638	central-south

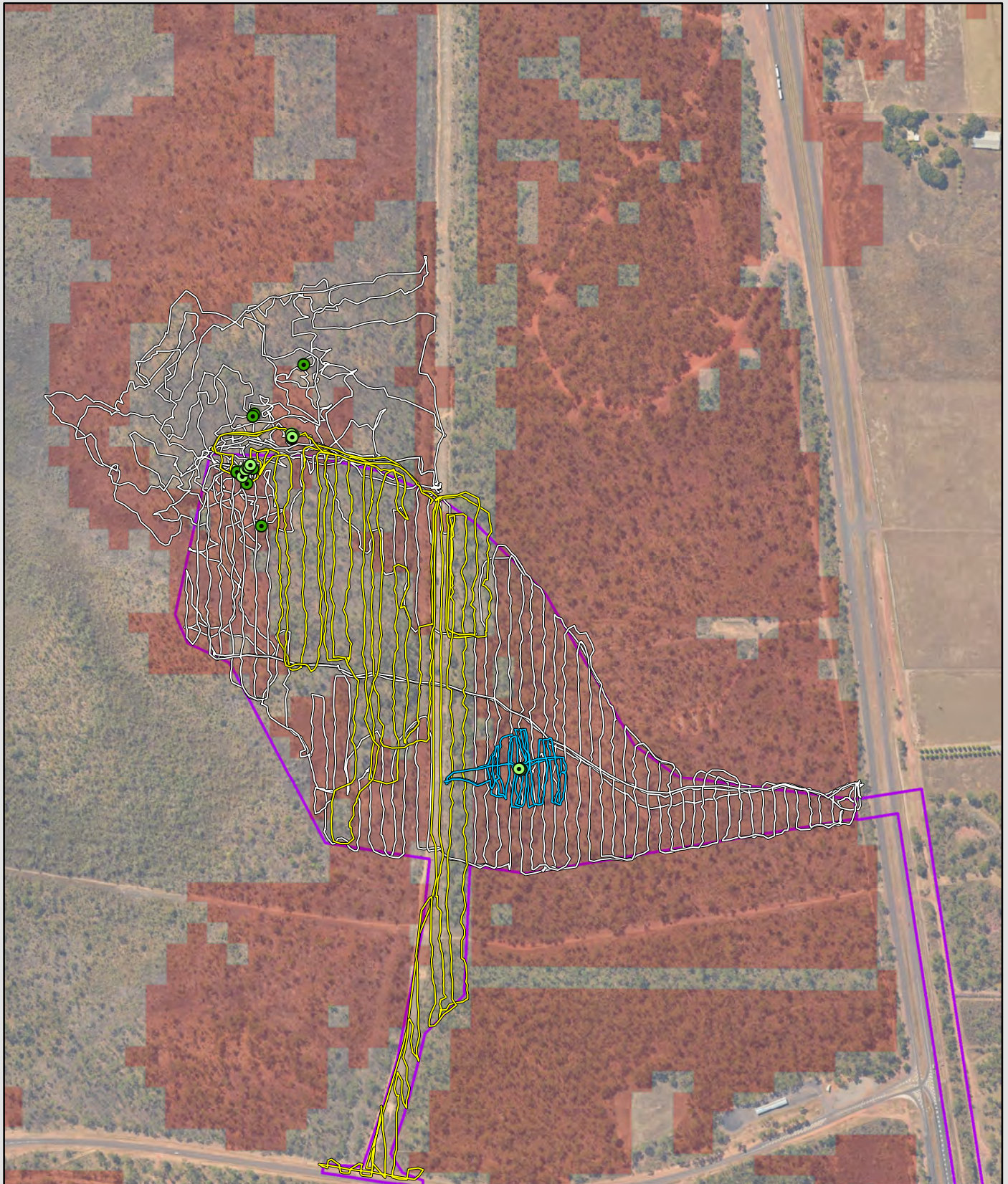
Table 3-3. GPS location of *Typhonium praetermissum* plants found at/near the WTP in 2023

GPS data presented in GDA 2020

ID	Date	No. of Plants	Latitude	Longitude	Group
1	12/01/2023	1	-12.664783	131.071514	north-west
2	12/01/2023	1	-12.664772	131.071503	north-west
3	12/01/2023	1	-12.664771	131.071500	north-west
4	12/01/2023	1	-12.664768	131.071490	north-west
5	12/01/2023	1	-12.664806	131.071498	north-west
6	12/01/2023	1	-12.665344	131.070827	north-west
7	12/01/2023	1	-12.665255	131.070871	north-west
8	12/01/2023	1	-12.665222	131.070897	north-west
9	12/01/2023	1	-12.665215	131.070920	north-west
10	12/01/2023	1	-12.665184	131.070937	north-west
11	12/01/2023	1	-12.669212	131.074619	central-south
12	12/01/2023	1	-12.669210	131.074616	central-south



Figure 3-6. Images of example *Typhonium praetermissum* plants found at/near the WTP in 2023



- Project area
- *Typhonium praetermissum* 12-13 April 2022
- *Typhonium praetermissum* 12 Jan 2023
- Presence-absence survey 12-13 April 2022
- Presence-absence survey 12 Jan 2023
- Abundance survey 12 Jan 2023
- Typhonium* high likelihood of occurrence



0 62.5 125 250
Metres



MAP INFORMATION
 Scale: 1:8,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 14/02/2023
 Client: Power and Water
 Mapper: SR

DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZZ1257
 Imagery: NTLIS

Figure 3-7. Map of *Typhonium praetermissum* survey effort and locations of plants observed at/near the WTP

3.7 Fauna camera trapping

Desktop assessment indicated suitable habitat for Northern Brushtail Possum and Black-footed Tree-rat in the project area, with records of these species within 5 km of the project area in the last five years.

The cleared corridor throughout the easement supports no suitable habitat for Northern Brushtail Possums or Black-footed Tree-rats. For much of the easement, there is a thin line of trees adjacent to the cleared strip within the project area. However, these trees alone provide minimal habitat value – see, e.g., Figure 3-8. The woodland outside the project area, which could support Northern Brushtail Possums or Black-footed Tree-rats, is not within the scope of this assessment.

During the general ecological assessment, however, suitable habitat was observed for Northern Brushtail Possum and Black-footed Tree-rat in the WTP. This included intact woodlands, large hollow-bearing trees, logs on the ground and fruiting trees. This warranted further targeted survey for these species at the WTP.



Figure 3-8. Image showing woodland trees abutting the cleared corridor through the easement

3.7.1 Methods

Australian Government survey methods for threatened mammals (DSEWPC 2011) are out-dated and do not include the Northern Brushtail Possum and Black-footed Tree-rat. Advice on surveying these species was sought from the Flora and Fauna Division of DEPWS, who recommended using camera traps at a minimum sampling density of one camera site per 20 ha of suitable habitat, with cameras deployed for four weeks. Camera trapping design and set up were guided by the following survey guidelines:

- *A guide for the use of remote cameras for wildlife survey in northern Australia* (Gillespie et al. 2015)
- *Camera trapping SOP for the Top End Long-term Monitoring Program* (Gillespie et al. 2017)
- *Optimising camera trap survey effort to reliably detect a threatened species, the black-footed tree-rat, *Mesembriomys gouldii*, in open forest and woodland of tropical savannas of the Top End, Northern Territory* (Risler 2017)

The WTP site is located on the outskirts of Darwin and adjacent to a designated tourism site – Strauss WWII Airstrip – resulting in a relatively high frequency of people utilising the area. To mitigate the chance of interference or theft of the camera traps, EcOz increased the number of cameras used and reduced the survey period. A total of 18 cameras were deployed across six sites (three cameras per site) for a period of

three weeks – from 8 June to 1 July 2022. The cameras were inspected and all images retrieved on 16 June 2022 in case of subsequent camera theft. The cameras encompassed an area of approximately 110 ha, giving one camera site per 18 ha.

The cameras were deployed in and around the WTP project area. There had been considerable dry season burning across the survey area when the cameras were deployed. Consequently, sites were selected proximate to, or within, unburnt vegetation. Site locations were guided by the presence of suitable habitat for Northern Brushtail Possums and Black-footed Tree-rats (i.e. presence of large trees, large logs on the ground, and mid-storey fruit species). At each site, cameras were spaced a minimum of 40 m apart, and sites were a minimum of 250 m apart (Figure 3-10 & Table 3-4). A habitat survey was undertaken at each site.

Camera installation involved attaching the camera to a tree at 40 cm and orientating the camera at a bait canister 1.5 m away containing rolled oats, peanut butter and honey (Figure 3-9). The field of view between camera and bait canister was cleared of any vegetation and debris that may cause the camera to ‘false trigger’. Reconyx HP digital cameras with a white flash were used. These were programmed to record from 18:00 to 07:00, on highest sensitivity, with three photographs per trigger, one second interval between photographs and no quiet period between triggers.

Table 3-4. GPS position of camera survey locations

Location name indicated site number followed by camera number, S#C#. GPS data presented in GDA 2020.

Name	Latitude	Longitude
S1C1	-12.671032	131.068243
S1C2	-12.670498	131.068968
S1C3	-12.671040	131.068973
S2C1	-12.664366	131.074424
S2C2	-12.665085	131.074374
S2C3	-12.665476	131.074110
S3C1	-12.659141	131.068044
S3C2	-12.659143	131.067477
S3C3	-12.658715	131.068329
S4C1	-12.672116	131.076053
S4C2	-12.672178	131.076579
S4C3	-12.672130	131.076942
S5C1	-12.668941	131.072087
S5C2	-12.668463	131.072071
S5C3	-12.668416	131.072553
S6C1	-12.666570	131.077079
S6C2	-12.666961	131.076710
S6C3	-12.667110	131.076220

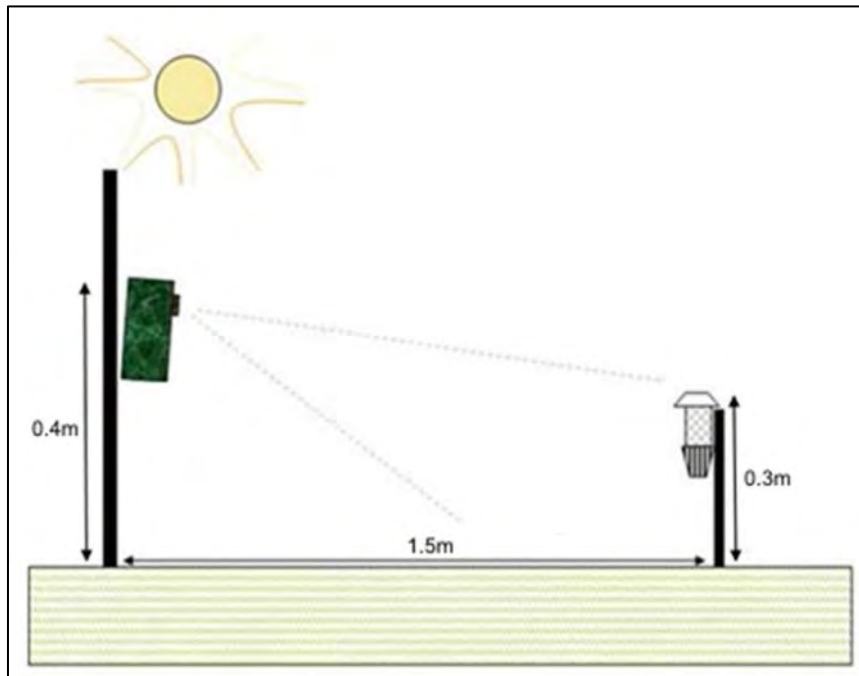


Figure 3-9. Diagram of camera set-up (Gillespie et al. 2017)

3.7.2 Results

Fauna was detected at 16 out of the 18 camera traps and at all camera sites. This comprised seven mammal species, six bird species and one introduced amphibian (summarised in Table 3-5). Two of the mammal species detected were of particular note: Northern Brushtail Possum which was one of the target species and the Pale Field-rat which is listed as Vulnerable under the *TPWC Act*. No Black-footed Tree-rats were detected.

The habitat surrounding all sites except site three consisted of open *Eucalyptus* woodland. The thickness of the mid-story shrub layer was highly dependent on fire history, with recently burnt sites having a diminished shrub layer. Site two and site five had the most diminished shrub layer. Site three consisted of an open shrubland dominated by *Melaleuca* and *Pandanus*. This site was proximate to a watercourse and sandsheet heath. Flowering or fruiting plants were documented at all sites and consisted of the following species:

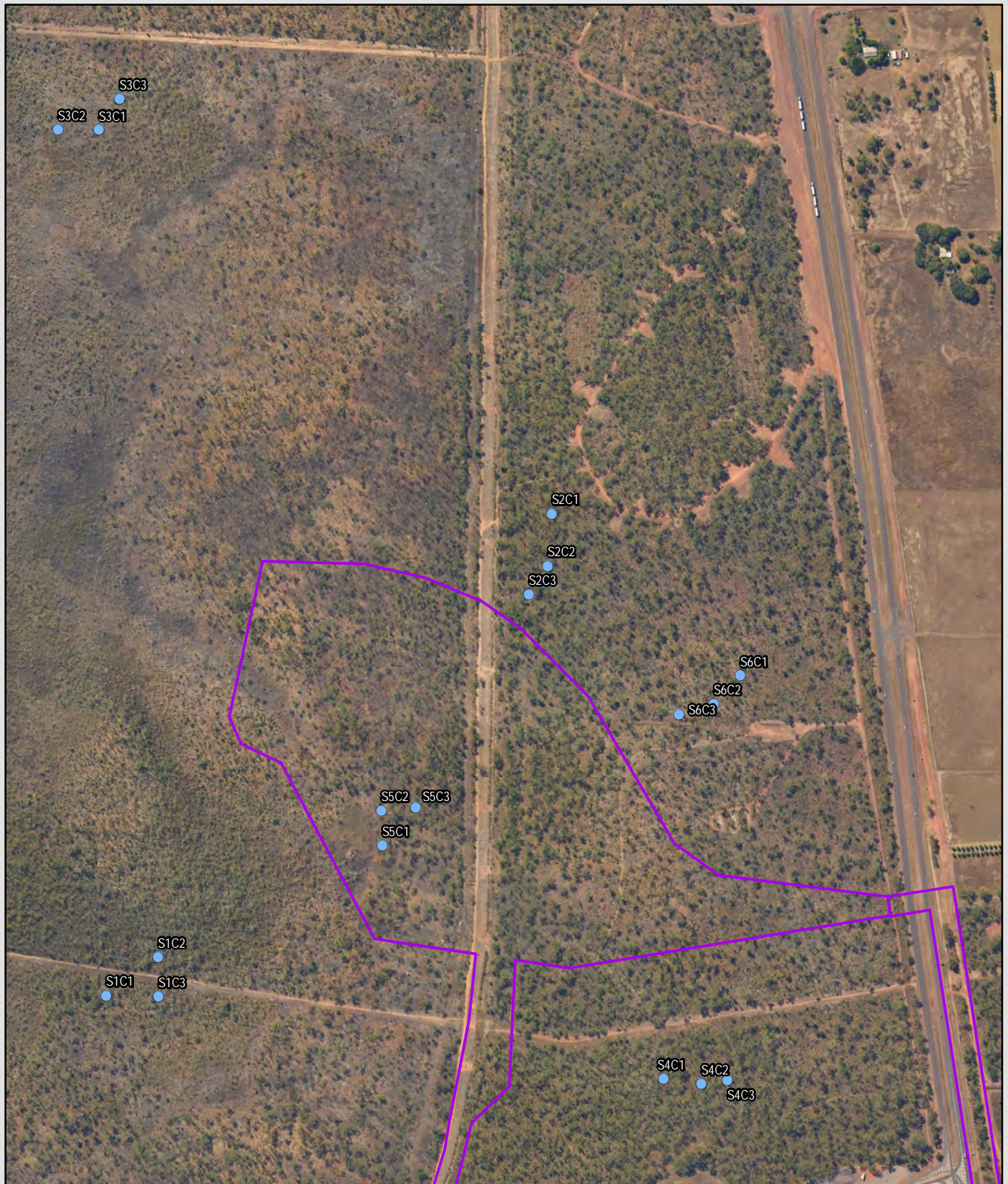
- Acacia (*Acacia* sp.)
- Banksia (*Banksia dentata*)
- Darwin Cycad (*Cycas armstrongii*)
- Darwin Woollybutt (*Eucalyptus 38iniate*)
- Pandanus (*Pandanus spiralis*)
- Rosella (*Hibiscus sabdariffa*) – introduced species
- Sand Palm (*Livistona* sp.)

Table 3-6 summarises the vegetation and Figure 3-11 provides images of the habitat at the camera trap locations. *Hibiscus sabdariffa* at site six was the only introduced species observed. Horse impacts were observed at all sites.

Table 3-5. List of species recorded on the camera traps

Scientific name	Common name	Listing		Locations recorded
		EPBC	TPWC	
Mammals				
<i>Canis familiaris</i>	Dingo	-	-	S1 (C2), S6 (C2 & 3)
<i>Isoodon macrourus</i>	Northern Brown Bandicoot	-	-	S2 (C1, 2 & 3), S4 (C1 & 2)
<i>Melomys burtoni</i>	Grassland Melomys	-	-	S4 (C3)
<i>Notomacropus agilis</i>	Agile Wallaby	-	-	S1 (C1, 2 & 3), S2 (C1), S3 (C1 & 2), S4 (C1, 2 & 3), S6 (C3)
<i>Planigale sp.</i>	Planigale	-	-	S5 (C3)
<i>Rattus tunneyi</i>	Pale Field-rat	-	Vulnerable	S1 (C2), S2 (C3), S3 (C1 & 2)
<i>Trichosurus vulpecula arnhemensis</i>	Northern Brushtail Possum	Vulnerable	-	S2 (C1, 2 & 3), S3 (C1), S4 (C1, 2 & 3), S5 (C1 & 2), S6 (C2 & 3)
Birds				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	-	-	S5 (C3), S6 (C2 & 3)
<i>Burhinus grallarius</i>	Bush Stone-curlew	-	-	S3 (C1), S5 (C3)
<i>Eurostopodus argus</i>	Spotted Nightjar	-	-	S6 (C3)
<i>Grallina cyanoleuca</i>	Magpie-lark	-	-	S5 (C3)
<i>Podargus strigoides</i>	Tawny Frogmouth	-	-	S5 (C3)
<i>Rhipidura leucophrys</i>	Willie Wagtail	-	-	S6 (C2)
Amphibians				
<i>Rhinella marina</i> *	Cane Toad	-	-	S1 (C2 & C3)

*Introduced species



- Camera site
- Project area

Location label indicated site number followed by camera number, S#C#.



0 62.5 125 250
Metres



MAP INFORMATION
 Scale: 1:8,231 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 7/02/2023
 Client: Power and Water
 Mapper: SR
DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZ21257
 Imagery: NTLIS

Figure 3-10. Map of camera trap locations across the WTP survey area

Table 3-6. Vegetation characteristics of camera survey sites

Site name	Description	Upper stratum (in order of dominance)	Mid stratum (in order of dominance)	Ground (dominant grass type)	Flowering or fruiting plants	Time since fire (years)
S1	Open woodland with dominate mid-shrub story	<i>Eucalyptus tetradonta</i> <i>Pandanus spiralis</i> <i>Banksia dentata</i>	<i>Acacia</i> sp. <i>Banksia dentata</i> <i>Grevillia pteridifolia</i> <i>Pandanus spiralis</i> <i>Livistona</i> sp.	Grass spp. Forb spp.	<i>Pandanus spiralis</i> <i>Banksia dentata</i> <i>Acacia</i> sp.	1-2
S2	Open <i>Eucalyptus</i> woodland	<i>Eucalyptus miniata</i> <i>Eucalyptus tetradonta</i> <i>Erythrophleum chlorostachys</i>	<i>Livistona</i> sp. Upper spp. saplings <i>Pandanus spiralis</i>	<i>Sorghum</i> sp.	<i>Livistona</i> sp. <i>Eucalyptus miniata</i> <i>Pandanus spiralis</i>	<1 (recent patchy cool burn)
S3	Open lowland-shrubland near watercourse & sandsheet habitat with dominate <i>Melaleuca nervosa</i> and <i>Pandanus spiralis</i>	<i>Eucalyptus miniata</i> <i>Grevillia pteridifolia</i> <i>Melaleuca nervosa</i>	<i>Pandanus spiralis</i>	Forb spp. – typical sandsheet spp.	<i>Pandanus spiralis</i>	<1 (recent scorching burn with cameras just outside burnt areas)
S4	Open <i>Eucalyptus</i> woodland with shrub mid-story	<i>Eucalyptus miniata</i> <i>Erythrophleum chlorostachys</i> <i>Eucalyptus tetradonta</i>	<i>Acacia</i> sp. Saplings <i>Livistona</i> sp. <i>Cycas armstrongii</i>	<i>Sorghum</i> sp. Grass spp.	<i>Eucalyptus miniata</i> <i>Livistona</i> sp.	1-2
S5	Very burnt open woodland with dominate <i>Eucalyptus 41iniate</i> (burnt 5 days earlier)	<i>Eucalyptus miniata</i> <i>Eucalyptus tetradonta</i> <i>Erythrophleum chlorostachys</i>	Saplings <i>Livistona</i> sp.	None – all burnt	<i>Cycas armstrongii</i>	<1 (recent scorching burn with cameras adjacent to unburnt areas)
S6	Open woodland with shrub mid-story, mosaic fire scars and surrounding historical disturbance	<i>Eucalyptus tetradonta</i> <i>Corymbia</i> sp.	<i>Livistona</i> sp. <i>Calytrix</i> sp. Saplings	<i>Sorghum</i> sp. Grass spp.	<i>Hibiscus sabdariffa</i> * <i>Livistona</i> sp.	<1 (surrounded by recent patchy burn)

*Introduced species

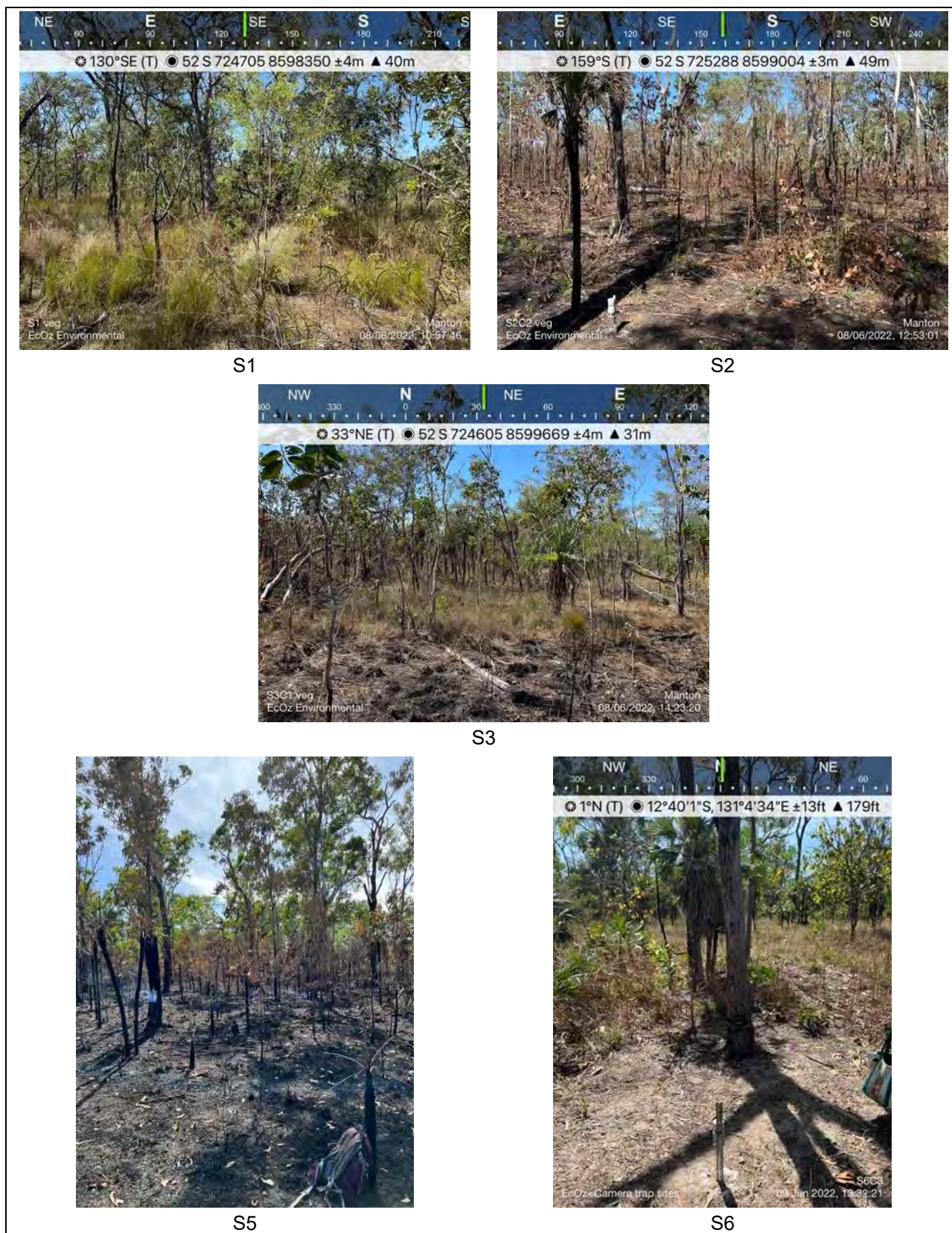


Figure 3-11. Photos (indicative) of habitat at camera survey sites

No site photo for Site 4 was recorded

Northern Brushtail Possum

The north-western sub-species of the Brushtail Possum (*Trichosurus vulpecula arnhemensis*) is listed as Vulnerable in the *EPBC Act*. A nocturnal semi-arboreal marsupial, this sub-species occurs discontinuously from the Gulf of Carpentaria hinterland near Borrooloola, in the Northern Territory, to the Kimberley, in Western Australia (Morris et al. 2016). The Northern Brushtail Possum mainly inhabits tall eucalypt open forests and woodlands with large hollow-bearing trees, particularly where the understorey contains shrubs that bear fleshy fruits, but also occurs in mangrove communities (especially where these contain hollow-bearing trees), rainforests and semi-urban areas (notably around Darwin) (TSSC 2021). Northern Brushtail Possum abundance is associated with high shrub density (Stobo-Wilson et al. 2019).

The broadscale decline of the subspecies' populations in Australia's Top End and reduction of its home range across the Northern Territory – an estimated 72 % decrease in the species' historical geographic range in north-western Australia between 1993 and 2019 – is largely attributed to frequent extensive fires, which reduces shelter sites and shrub density, thereby increasing risk of feral cat predation, as well as habitat modification from invasive grasses, namely the African Gamba grass (*Andropogon gayanus*) and Mission grass (*Cenchrus polystachios*) (Stobo-Wilson et al. 2019; TSSC 2021).

The Northern Brushtail Possum was recorded at five of the six survey sites (on 11 out of 18 cameras). Table 3-7 summarises which cameras Northern Brushtail Possums appeared on each trapping night. The site with no Northern Brushtail Possum sightings was site one, and only one camera at site three had sightings. These were to two most westerly sites; with site one located within, and site three on the edge of, drainage country as per NT Governmental land unit mapping and as verified in the western edge of the WTP during land unit mapping for this project.

The majority of nights with Northern Brushtail Possum records consisted of one visit by a single possum (21 out of 28 nights). The remaining nights with Northern Brushtail Possum records either had multiple visits by single possums or had more than one possum visit at one time. Site five camera two captured a mother possum with a juvenile on her back, and site four camera three captured a pair of possums mating. Five distinct individuals could be identified across all cameras, with the remaining individuals being a mix of males and females with no distinct markings (Figure 3-12).

Data extracted from NT Atlas indicate a number of sites with Northern Brushtail Possum records within 10 km of the WTP collected between 1995 and 2018, with the majority of these records from 2018. The nearest two records are:

- NT Flora and Fauna camera trapping 3 km to the east of the WTP in 2018. Multiple Northern Brushtail Possum sightings were recorded over a two-week period.
- EcOz camera trapping a further 1.6 km east in December 2014 and January 2015. This produced half a dozen sightings.

Habitat beyond the WTP and camera trapping locations was not assessed for suitability for Northern Brushtail Possums. Aerial imagery indicates continuity of native vegetation to the north-west of the WTP. To the east and south are main roads and private residential and industrial blocks.



Figure 3-12. Images of distinct individual Northern Brushtail Possums detected during camera trapping

Table 3-7. Summary of nights with Northern Brushtail Possum records

1 = night with a Possum sighting. Night one starts evening of 8 June and night 23 ends morning[†] July. Nights when cameras were not deployed are shown in grey.

Location	Night																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
S1C1	none																						
S1C2	none																						
S1C3	none																						
S2C1																	1						
S2C2						1							1			1							
S2C3														1					1				
S3C1												1											
S3C2	none																						
S3C3	none																						
S4C1		1															1	1				1	
S4C2						1																	
S4C3				1		1	1	1													1	1	
S5C1																			1				
S5C2								1										1	1	1			
S5C3	none																						
S6C1	none																						
S6C2					1						1	1						1					
S6C3											1												

Pale Field-rat

The Pale Field-rat (*Rattus tunneyi*) is a medium-sized rodent that was once a widespread species in the Top End (DEPWS 2021b). Historically, this species occurred in lowland *Eucalyptus* open forests and grasslands that have sandy surface soil characteristics, but the Pale Field-rat is now recorded primarily in dense vegetation along creeks (Aplin et al. 2008). An area's fire regime seems to have little effect on population numbers (Braithwaite & Griffiths 1996); instead, the level of groundwater irrigating the riparian system and, to a lesser extent, current rainfall have a much stronger influence (Braithwaite & Griffiths 1996). Due to a combination of threats, the overall population of the species is estimated to have declined by up to 30% in the past ten years (Woinarski et al 2014).

The Pale Field-rat was recorded at three of the six survey sites (on four out of 18 cameras) – Table 3-8. These were the most western and northern sites. Site one was identified as open woodland within drainage country. Site two was also identified as open woodland, but not within drainage country. Site three was identified as open shrubland on the edge of drainage country. This drainage country is portrayed in NT Government land unit mapping (DEPWS 2010) and was verified in the western edge of the WTP during land unit mapping for this project. All four nights with Pale Field-rat records consisted of one visit by a single rat (Figure 3-13).

Table 3-8. Summary of nights with Pale Field-rat records

Night one starts evening of 8 June and night 23 ends morning 1 July

Site no.	Camera no.	Night
1	2	15
2	3	16
3	1	10
3	2	5

Data extracted from NT Atlas indicate records of Pale Field-rats 6 km to the south-east in 2001, 6-7 km to the north-east in 2002 and 7 km to the north-west in 2001. The nearest and most recent record in the Darwin area is from 2014, 22 km to the north-west.



Figure 3-13. Pale Field-rat captured at site one camera two during camera trapping

4 SUMMARY

4.1 Development areas

The easement is highly disturbed with a corridor already cleared throughout much of the easement to support current infrastructure. In some areas a thin strip of vegetation remains. This includes some riparian vegetation at the south end of the easement. Many weeds were identified within the easement.

The WTP mostly consists of remnant woodland with large hollow-bearing trees, large logs on the ground and fruit-bearing trees present. The greatest disturbance to the site is a north-south corridor through the centre used for utilities. Various other disturbances are scattered throughout the WTP, with many likely to be from WWII activities associated with Strauss WWII Airstrip to the north. The site is exposed to regular fire. Few weeds were encountered, with the majority of these located in the disturbed corridor.

4.2 Values

4.2.1 Significant vegetation

Two significant vegetation types were found in the project area:

- Riparian vegetation was found in the section of the easement between the Manton Dam Wall and the Stuart Highway. This consisted of two small patches totalling ~0.4 ha. The western patch was well-established remnant vegetation and the eastern patch moderately-established regrowth vegetation.
- Large hollow-bearing trees were found scattered throughout the WTP woodlands. One patch in the north-east consisted of more than five stems greater than 50 cm dbh per hectare and thus classifies as high value old growth under the *Land Clearing Guidelines*.

Sandsheet heath was ruled out as not occurring in the project area.

4.2.2 Threatened species

The likelihood of threatened species occurring in the project area was compiled based on desktop and field assessments (procedure described in Appendix E). Appendix E provides a full list of threatened species with potential to occur in the project area and their likelihood rating. Field survey methods and results are discussed in Section 3. Table 4-1 summarises the threatened species with a medium or high likelihood of occurring in the project area.

Table 4-1. Threatened species with a moderate or high likelihood of occurring in the project area

Likelihood	Species	Status		Class	Comment on occurrence
		EPBC	TPWC		
KNOWN	Northern Brushtail Possum (<i>Trichosurus vulpecula arnhemensis</i>)	VU	-	Mammal	Detected during the camera trap survey, with multiple possums sighted across multiple cameras
	Pale Field-rat (<i>Rattus tunneyi</i>)	-	VU	Mammal	Detected during the camera trap survey, with four sightings across three cameras mainly in the vicinity of drainage country
	Darwin Cycad (<i>Cycas armstrongii</i>)	-	VU	Plant	Present in low densities across the project area
	a herb (<i>Typhonium praetermissum</i>)	-	VU	Plant	Detected in the WTP – a central-south patch of two plants and a north-west patch of ~ 9 plants (with a further ~ 14 plants outside the project area)
HIGH	Mertens' Water Monitor (<i>Varanus mertensi</i>)	-	VU	Reptile	Assumed to occur on occasion along Manton River and inundated habitat of the project area
MEDIUM	Partridge Pigeon (eastern subspecies) (<i>Geophaps smithii smithii</i>)	VU	VU	Bird	Assumed to occur on occasion within the woodland habitats of the project area
	Bare-rumped Sheathtail Bat (<i>Saccolaimus saccolaimus nudicluniatu</i> s)	VU	-	Mammal	
	Floodplain Monitor (<i>Varanus panoptes</i>)	-	VU	Reptile	

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APPENDIX A DESCRIPTION OF LAND UNITS IDENTIFIED IN THE PROJECT AREA

ID	Descriptor	Landform	Soil	Vegetation
1b	Steep ridges	<ul style="list-style-type: none"> • Steeply sloping ridge terrain on Lower Proterozoic metasediments. • Gradient commonly 10-40%, occasionally to 60%, relief between 10 and 40m. • Rock outcrop common, extensive surface stone and gravel (30-80% cover). 	Rudosol. Shallow stony lithosols. Coarse to medium textured. Very stony and gravelly. Rapidly drained.	Woodland, minor open woodland. Dominant species are generally <i>Eucalyptus miniata</i> , <i>E. tectifera</i> , <i>E. foelscheana</i> , with <i>E. dichromophloia</i> as dominant on high ridges to southwest of area, minor canopy species include <i>E. tetradonta</i> , <i>E. confertiflora</i> , <i>Xanthostemon paradoxus</i> ; open shrub understory of <i>Buchanania obovata</i> , <i>Grevillea decurrens</i> , <i>Hakea arborescens</i> , <i>Livistona humilis</i> ; open grass cover of <i>Sorghum plumosum</i> , <i>Heteropogon contortus</i> as major species.
1c	Rises	<ul style="list-style-type: none"> • Low scarps and short steep slopes, mostly on lateritic material. • Gradient 5-20%, relief 5-20m. • Extensive outcrop and surface stone (30-60% cover) 	Rudosol. Shallow gravelly lithosols. Coarse textured. 50-70% stone and gravel throughout. Rapidly drained.	Woodland. Dominant species are generally thin <i>Eucalyptus miniata</i> , <i>E. bleeseri</i> with <i>E. tetradonta</i> , <i>E. tectifera</i> , <i>E. foelscheana</i> as associated species; open shrub understory of <i>Xanthostemon paradoxus</i> , <i>Terminalia ferdinandiana</i> , <i>Buchanania obovata</i> , <i>Cycas armstrongii</i> , <i>Livistona humilis</i> ; open grass cover with <i>Sorghum plumosum</i> , <i>Eriachne avenacea</i> , <i>Chrysopogon latifolius</i> , <i>Heteropogon contortus</i> as major species.
2a1	Rises	<ul style="list-style-type: none"> • Low rises and associated upper slopes. • Gradient 0.5-4%. • Extensive surface gravels (commonly flaky siltstone and quartz). Small areas with quartz outcrop. 	Rudosol. Gravelly lithosols, usually shallow with some moderately deep occurrences. Loamy sand or sandy loam surface to sandy clay loam subsoil. 20-40% gravels in surface, 30-60% gravels in subsoil. Well drained.	Open woodland, minor woodland. Predominantly thin <i>Eucalyptus miniata</i> , <i>E. tetradonta</i> , or <i>E. foelscheana</i> , <i>E. confertiflora</i> , <i>E. tectifera</i> with associated <i>E. bleeseri</i> , <i>Erythrophleum chlorostachys</i> , <i>Xanthostemon paradoxus</i> ; open shrub understory includes <i>Buchanania obovata</i> , <i>Grevillea decurrens</i> , <i>Calytrix exstipulata</i> , <i>Petalostigma quadriloculare</i> ; medium to dense grass cover including <i>Schizachyrium fragile</i> , <i>Chrysopogon latifolius</i> , <i>Heteropogon triticeus</i> , <i>Themeda australis</i> , <i>Eragrostis sp.</i> and annual sorghum.




ID	Descriptor	Landform	Soil	Vegetation
2a2	Rises	<ul style="list-style-type: none"> • Low rises, generally adjacent to or within estuarine flats. • Gradient 1-2.5%. • 20-30% laterite outcrop, 10-30% surface gravels. 	Leptic Rudosol. Shallow gravelly lithosols. Sandy loams and sandy clay loams. 20-50% gravels throughout profile. Well drained.	Tall Shrubland or Open Forest; variable composition with <i>Eucalyptus polycarpa</i> , <i>E. papuana</i> , <i>Canarium australianum</i> , <i>Alstonia actinophylla</i> ; with dense shrub layer consisting of <i>Acacia spp.</i> , <i>Cycas armstrongii</i> , <i>Planchonia careya</i> , <i>Grevillea pteridifolia</i> ; and sparse grass cover.
2b1	Low hills	<ul style="list-style-type: none"> • Gentle side slopes to low hills. • Gradient 2-5%. • Extensive surface gravel, commonly flaky siltstone. 	Kandosol. Moderately deep gravelly yellow massive earths, minor shallow lithosols. Sandy loam surface to sandy clay loam or light clay at depth. 10-20% gravel in surface, 30-60% gravel in subsoil. Well drained.	Open woodland to woodland. Variable dominants including <i>Eucalyptus miniata</i> , <i>E. tetradonta</i> , <i>E. foelscheana</i> , <i>E. tectifera</i> and associated species <i>E. bleeseri</i> , <i>E. confertiflora</i> , <i>Erythrophleum chlorostachys</i> ; scattered shrubs <i>Buchanania obovata</i> , <i>Planchonia careya</i> , <i>Petalostigma quadriloculare</i> , <i>Livistona humilis</i> ; medium to dense grass cover with <i>Sorghum plumosum</i> , <i>Chrysopogon latifolius</i> , <i>Schizachyrium fragile</i> , <i>Aristida browniana</i> and annual sorghum in dense patches.
2b2	Rises	<ul style="list-style-type: none"> • Gentle side slope. • Gradient 2-5%. • Common rock outcrop (mostly ferricrete), extensive surface gravels. 	Kandosol. Shallow gravelly massive earths, minor lithosols. Loamy sand surface over a sandy loam to light sandy loam subsoil. 30-60% gravel throughout. Moderately well drained.	Low open woodland to open woodland. Dominant trees include <i>Eucalyptus miniata</i> , <i>E. tetradonta</i> , <i>Erythrophleum chlorostachys</i> , <i>C. polysciada</i> , <i>E. foelscheana</i> , <i>E. tectifera</i> ; sparse understorey of <i>Cycas sp.</i> and <i>Livistona humilis</i> ; sparse grass cover.
3a	Plains	<ul style="list-style-type: none"> • Flat to very gently undulating upland surface. • Gradient 0-2%. • Very minor amounts of ferruginous gravel. 	Kandosol. Deep red massive earths, minor yellow massive earths. Sandy loam surface over sandy clay loam grading to light clay at depth. Deep subsoil occasionally has up to 10% ferruginous gravel. Well drained.	Open forest. Large <i>Eucalyptus tetradonta</i> , <i>E. miniata</i> dominants with minor associated <i>Erythrophleum chlorostachys</i> , <i>Eucalyptus confertiflora</i> , <i>E. foelscheana</i> ; scattered shrubs including <i>Cycas armstrongii</i> , <i>Livistona humilis</i> , <i>Syzygium suborbiculare</i> , <i>Planchonia careya</i> ; dense grasses, including <i>Heteropogon triticeus</i> , <i>Chrysopogon latifolius</i> . Small area of Woodland associated with yellow earths in south of survey area with <i>Eucalyptus foelscheana</i> , <i>E. miniata</i> , <i>Erythrophleum chlorostachys</i> and dense grasses.




ID	Descriptor	Landform	Soil	Vegetation
3b	Plains	<ul style="list-style-type: none"> • Flat to very gently undulating upland surface. • Gradient 0-2.5%. • Common ferruginous gravels (10-30% surface cover) 	Kandosol. Moderately deep to deep, gravelly yellow massive earths (usually overlaying friable weathered material), minor red massive earths. Sandy loam surface grading to sandy clay loam subsoil and light clay at depth. 5-15% ferruginous gravels in surface, 10-30% in subsoil. Well drained.	Woodland to open forest. Generally large <i>Eucalyptus miniata</i> , <i>E. tetradonta</i> and minor associated <i>E. porrecta</i> , <i>E. foelscheana</i> , <i>E. confertiflora</i> , <i>Erythrophleum chlorostachys</i> ; with open to medium shrub understory including <i>Terminalia ferdinandiana</i> , <i>Xanthostemon paradoxus</i> , <i>Livistona humilis</i> , <i>Petalostigma pubescens</i> ; dense grasses, including <i>Sorghum intrans</i> , <i>S. plumosum</i> , <i>Eriachne avenacea</i> , <i>Chrysopogon latifolius</i> , <i>Panicum mindanaense</i> .
3c	Plains	<ul style="list-style-type: none"> • Flat to very gently undulating upland surface. • Gradient 1-3%. • Extensive ferruginous gravels (40-80% surface cover) small areas of laterite outcrop. 	Kandosol. Shallow to moderately deep gravelly yellow massive earths, minor lateritic lithosols. Loamy sand to sandy loam surface grading into sandy clay loam subsoil. 20-40% ferruginous gravel in surface, 30-50% in subsoil. Well drained.	Woodland, minor open woodland. Moderately large <i>Eucalyptus miniata</i> , <i>E. tetradonta</i> and associated <i>E. bleeseri</i> , <i>E. foelscheana</i> , <i>Erythrophleum chlorostachys</i> ; frequently well-developed shrub layer with <i>Terminalia ferdinandiana</i> , <i>Xanthostemon paradoxus</i> , <i>Planchonia careya</i> common throughout; generally dense grasses including <i>Sorghum intrans</i> , <i>S. plumosum</i> , <i>Triodia pungens</i> , <i>Eriachne avenacea</i> , <i>Chrysopogon latifolius</i> , <i>Panicum mindanaense</i> , <i>Themeda australis</i> .
3e	Plains	<ul style="list-style-type: none"> • Drainage areas within gently undulating upland surface. • Gradient 0.5-2%. 	Hydrosol. Hard-setting deep mottled yellow massive earths. Sandy loam or light sandy clay loam surface grading to light clay subsoil. Imperfectly drained; high wet-season water table.	Woodland, minor open forest. Large <i>Eucalyptus polycarpa</i> , <i>Erythrophleum chlorostachys</i> as dominant with patches of <i>Lophostemon lactifluus</i> , associated <i>Eucalyptus miniata</i> , <i>Syzygium suborbiculare</i> ; patches of dense shrubs including <i>Pandanus spiralis</i> , <i>Grevillea pteridifolia</i> ; dense grasses including <i>Ectrosia leporina</i> , <i>Sorghum plumosum</i> , <i>Aristida browniana</i> and sedges.
4c	Plains	<ul style="list-style-type: none"> • Gentle lower slopes. • Gradient 0.5-1.5%. 	Hydrosol. Hard-setting deep mottled yellow massive earths. Sandy loam or light sandy clay loam surface grading to light clay subsoil. Minor ferruginous gravel in subsoil. Imperfectly drained; high water table in wet-season.	Open forest, minor woodland. Large mixed species including <i>Eucalyptus tetradonta</i> , <i>E. papuana</i> , <i>Erythrophleum chlorostachys</i> , <i>Eucalyptus polycarpa</i> , <i>E. miniata</i> , <i>Lophostemon lactifluus</i> ; dense shrub layer, including <i>Pandanus spiralis</i> , <i>Verticordia cunninghamii</i> ; medium to dense grasses including <i>Mnesithea rottboellioides</i> , <i>Sorghum plumosum</i> , <i>Chrysopogon latifolius</i> , <i>Heteropogon triticeus</i> , <i>Eriachne trisetata</i> .




ID	Descriptor	Landform	Soil	Vegetation
5a	Alluvial plains	<ul style="list-style-type: none"> Narrow alluvial plains within upland terrain. Gradient <1.0%. 	Hydrosol. Hard-setting apedal mottled yellow duplex soils. Fine sandy loam or loam overlaying light clay to medium clay subsoil. Minor subsoil ferruginous gravels. Imperfectly drained.	Grassland with scattered trees, including <i>Eucalyptus polycarpa</i> , <i>E. papuana</i> , <i>E. alba</i> and patches of <i>Eugenia bleeseri</i> and <i>Melaleuca nervosa</i> ; grasses predominantly <i>Sorghum stipoideum</i> , <i>Eriachne burkittii</i> , <i>Paspalum scrobiculatum</i> and <i>Panicum mindanaense</i> .
5b1	Drainage systems	<ul style="list-style-type: none"> Narrow drainage floors within upland terrain, non-incised. Gradient <1.0%. 	Hydrosol. Mottled grey massive earths and yellow massive earths. Fine sandy loam, loam or sandy clay loam grading to clay loam or light clay at depth. Frequently 10-70% ferruginous gravel in subsoil. Moderately well drained.	Open forest to woodland occasionally shrubland. Trees include <i>Lophostemon lactifluus</i> , <i>Eucalyptus papuana</i> , <i>Melaleuca viridiflora</i> ; extensive dense <i>Pandanus spiralis</i> with <i>Grevillea pteridifolia</i> ; grasses include <i>Germania grandiflora</i> , <i>Imperata cylindricus</i> , <i>Mnesithea rottboellioides</i> .
5b2	Drainage systems	<ul style="list-style-type: none"> Narrow drainage floors with incised drainage lines. Gradient <1.5%. 	Hydrosol. Deep hard-setting mottled grey massive earths. Fine sandy loam or loam grading to fine sandy clay loam subsoil. 10-30% ferruginous gravels in deep subsoil. Imperfectly drained.	Open woodland to open shrubland. Trees include <i>Eucalyptus polycarpa</i> , <i>Melaleuca spp.</i> , <i>Eucalyptus alba</i> ; shrubs <i>Eugenia bleeseri</i> , <i>Melaleuca viridiflora</i> ; dense grasses and sedges including <i>Eriachne burkittii</i> , <i>E. avenacea</i> , <i>Sorghum plumosum</i> , <i>S. stipoideum</i> and <i>Rhynchospora sp.</i>
6a2	Drainage systems	<ul style="list-style-type: none"> Broad lowland plains. Gradient <1%. 	Hydrosol. Hard-setting apedal mottled yellow duplex soils, pulverulent surface. Fine sandy loam over medium clay subsoil. Minor ferruginous gravels in subsoil. Poorly drained; high wet-season water tables.	Open woodland or woodland. Small <i>Lophostemon lactifluus</i> , <i>Eucalyptus polycarpa</i> , <i>E. alba</i> ; with open shrub layer <i>Melaleuca viridiflora</i> common with <i>Pandanus spiralis</i> , <i>Grevillea pteridifolia</i> , <i>Eugenia bleeseri</i> ; dense grasses including <i>Eriachne burkittii</i> , <i>Pseudopogonatherum contortus</i> , <i>Germania grandiflorum</i> and sedges.
6b	Drainage system	<ul style="list-style-type: none"> Broad drainage floors and creek margins. Gradient <1.5%. Debil debil surface is common. 	Hydrosol. Shallow to moderately deep siliceous and earthy sands, minor sandy massive earths. Coarse textured sands to sandy loams. 0-10% gravel in surface, 5-40% gravel in subsoil. Well drained.	Tall shrubland to low open woodland, minor open woodland. Dominant species are <i>Grevillea pteridifolia</i> , <i>G. decurrens</i> , <i>Melaleuca nervosa</i> , <i>M. viridiflora</i> , <i>Eugenia bleeseri</i> , <i>Pandanus sp.</i> , <i>Lophostemon lactifluus</i> , <i>Gardenia megasperma</i> , <i>Petalostigma pubescens</i> and in Open Woodland areas <i>Acacia auriculiformis</i> , <i>E. polycarpa</i> and <i>E. papuana</i> occur; grass species include annual sorghum, <i>Heteropogon triticeus</i> , <i>Aristida sp.</i> , <i>Eragrostis sp.</i> and <i>Eriachne sp.</i>


ID	Descriptor	Landform	Soil	Vegetation
7a	Alluvial plains	<ul style="list-style-type: none"> • Fringes and levees of major channels. • Gradient 0.5-2%, backslopes up to 50% where large channels • are deeply incised. • Small areas of outcrop. 	Brown Kandosol. Deep hard-setting yellow massive earths. Sandy loam or light sandy clay loam grading to sandy clay loam or light clay. Moderately well drained.	Variable open woodland with <i>Eucalyptus miniata</i> , <i>Erythrophleum chlorostachys</i> ; occasionally <i>Melaleuca sp.</i> or <i>Lophostemon sp.</i> Low Woodland with <i>Acacia spp.</i> ; dense grass cover, including <i>Mnesithea rottboellioides</i> , <i>Sorghum plumosum</i> , <i>Themeda australis</i> .
8b	Swamps	<ul style="list-style-type: none"> • Swamp depressions on upland surface. • Gradient negligible, generally <0.5%. 	Hydrosol. Friable apedal mottled yellow duplex soils. Organic loam surface over a light clay or sandy clay subsoil. Very poorly drained.	Open to closed forest of <i>Melaleuca spp.</i>



APPENDIX B EASEMENT LAND UNIT ASSESMENT SITES

Land unit	Sites	Description	Site photo
1b	EA36	Easement cleared and surrounding woodland disturbed. Weeds present: Gamba Grass (<i>Andropogon gayanus</i>) and Annual Mission Grass (<i>Cenchrus pedicellatus</i>)	 EA36
1c	EA35	Easement cleared and surrounding area highly disturbed.	No picture
2a1	EA32, EA33, EA34	Easement cleared, with some resprouting trees. Surrounding woodland with small upper story. High ground with poor soil and low water. Sorghum sp. (annual) dominant. Weeds present: Gamba Grass (<i>Andropogon gayanus</i>), Hyptis (<i>Hyptis suaveolens</i>) and Annual Mission Grass (<i>Cenchrus pedicellatus</i>)	 EA33
2b1	EA28, EA29, EA30	Easement cleared. Surrounding woodland mostly with good structure, some highly disturbed. <i>Eucalyptus miniata</i> Weeds present: Gamba Grass (<i>Andropogon gayanus</i>), Flannel Weed (<i>Sida cordifolia</i>)	 EA28



2b2	EA26	Easement cleared. General area very disturbed with some intact woodland.	 <p>EA26</p>
3a	EA24, EA25	Totally modified Introduced species: Palms and African Mahogany (<i>Khaya senegalensis</i>)	-
3b	EA18, EA19, EA20, EA21, EA22, EA23	Easement cleared. Surroundings extensively cleared, with some woodland areas. Not inundated country.	-
3c	EA14, EA15, EA16, EA17	Easement cleared. Surround area variably cleared or woodland. Flooded country. Weeds present: Gamba Grass (<i>Andropogon gayanus</i>), Hyptis (<i>Hyptis suaveolens</i>) and Annual Mission Grass (<i>Cenchrus pedicellatus</i>)	 <p>EA14</p>  <p>EA17</p>

3e	EA13	Seasonally waterlogged	-
4c	EA12	Easement highly modified. Weeds present: Annual Mission Grass (<i>Cenchrus pedicellatus</i>)	-
5a	-	-	-
5b1	EA10, EA11	Easement modified but surrounding forest good condition. Weeds present: Gamba Grass (<i>Andropogon gayanus</i>), Annual Mission Grass (<i>Cenchrus pedicellatus</i>) and Paspalum (<i>Paspalum</i> sp.)	 EA11
5b2	EA8, EA9	Woodlands, including surrounds, from good to poor condition. <i>Melaleuca</i> sp. and <i>Pandanus spiralis</i> present. Drainage system. Weeds present: Gamba Grass (<i>Andropogon gayanus</i>)	 EA8
6a2	EA4, EA5, EA6, EA7, EA28	Highly disturbed – poor upper story condition to all trees cleared. <i>Pandanus spiralis</i> , <i>Melaleuca</i> sp., <i>Eucalyptus</i> sp. and <i>Sorghum</i> sp. (annual - dominant) Seasonally inundated Weeds present: Gamba Grass (<i>Andropogon gayanus</i>)	 EA6
7a	VS06, PS12	See tables below	See tables below

8b	EA1	Swamp country. No weeds observed.	 <p>EA1</p>
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Land unit: 7a		Site: VS06	
Vegetation type: Riparian creek verge		Date: 17/11/2022	
Strata	Dominant species	Height (m)	Cover (%)
Upper	<i>Acacia auriculiformis</i>	12-14	30
	<i>Melaleuca argentea</i>	12-14	20
	<i>Timonius timon</i>	8-12	25
	<i>Khaya senegalensis</i> *	8-10	10
Mid	<i>Pandanus spiralis</i>	3-8	5
	<i>Carpentaria acuminata</i>	4-8	5
	<i>Carallia brachiata</i>	5-8	5
	<i>Terminalia microcarpa</i>	3-8	10
Ground	<i>Andropogon gayanus</i> *		5
	<i>Breynia cernua</i>		<1
			
Landform: Slope 5% south-south-east aspect			
Soil: Dark grey-black loamy clay			
Groundcover (%):			
Vegetation	5	Soil	5
Litter	90	Rock	0
Gravel	0		
Fire: No recent fire			
Weeds: Gamba grass (<i>Andropogon gayanus</i>) and African Mahogany (<i>Khaya senegalensis</i>)			
Ferals: None observed			
Other: Wire fence through site and site adjacent to bitumen road.			

*Introduced species

Land unit: 7a	Site: PS12
	Date: 17/11/2022
	



APPENDIX C WTP LAND UNIT ASSESMENT SITES



Land unit: 3a		Site: VS05	
Vegetation type: <i>Eucalyptus Erythrophleum</i> (Ironwood) woodland over sparse shrubland and open grassland		Date: 17/11/2022	
Strata	Dominant species	Height (m)	Cover (%)
Upper	<i>Eucalyptus miniata</i>	10-14	25
	<i>Erythrophleum chlorostachys</i>	10-14	10
	<i>Eucalyptus tetradonta</i>	8-10	5
Mid	<i>Erythrophleum chlorostachys</i>	2-4	10
	<i>Livistona humilis</i>	2-4	<2
	Juvenile upper <i>Eucalyptus</i> spp.	3-6	5
	<i>Brachychiton megaphyllus</i>	1-2	<5
Ground	<i>Sorghum</i> sp. (annual)		20
	<i>Heteropogon triticeus</i>		10
	Juvenile upper spp. as well as <i>Alphitonia excelsa</i> , <i>Acacia difficilis</i> , <i>Buchanania obovata</i> & <i>Planchonia careya</i>		20








Landform: Gentle sloping plain <1 % west-south-west aspect									
Soil: Red-brown clay loam sand with sparse gravel									
Groundcover (%):									
Vegetation	50	Soil	<5	Litter	45	Rock	0	Gravel	<1
Fire: Not burnt in 2022									
Weeds: None observed									
Ferals: None observed									
Other: Historic WWII disturbance in general area									



Land unit: 3a	Site: PS09 – LTC (large tree & Cycad assessment)
Large trees: Most trees <40 cm DBH. Some larger trees in vicinity Cycads: Sparse	Date: 17/11/2022
	



Land unit: 3c –woodland		Site: VS03	
Vegetation type: <i>Eucalyptus</i> woodland over sparse shrubland and open grassland		Date: 17/11/2022	
Strata	Dominant species	Height (m)	Cover (%)
Upper	<i>Eucalyptus miniata</i>	8-12	30
	<i>Eucalyptus tetradonta</i>	10	<5
	<i>Erythrophleum chlorostachys</i>	12	<5
Mid	<i>Terminalia ferdinandiana</i>	3-6	<5
	<i>Livistona humilis</i>	2-4	<5
	<i>Planchonia careya</i>	2-3	<5
	<i>Cycas armstrongii</i>	-	-
Ground	<i>Sorghum</i> sp. (annual)		20
	Juvenile upper spp.		20
	<i>Heteropogon triticeus</i>		<1
	<i>Alloteropsis semialata</i>		<1
			
Landform: Side slope 1-3 % west-south-west aspect			
Soil: Brown-grey sandy clay loam with surface gravel			
Groundcover (%):			
Vegetation	40	Soil	35
		Litter	20
		Rock	0
		Gravel	5
Fire: Burnt in 2022			
Weeds: None observed			
Ferals: None observed			
Other: Small raised mounds throughout site are possible historic human disturbance			



Land unit: 3c - woodland	Site: PS01 – LTC (large tree & Cycad assessment)
Large trees: All <40 cm dbh Cycads: Sparse	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS02 – TH (known <i>Typhonium</i> habitat)
	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS03 – LTC (large tree & Cycad assessment)
Large trees: All <40 cm DBH Cycads: Sparse	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS04 – LTC (large tree & Cycad assessment)
Large trees: Mostly <40 cm dbh. Some large trees in vicinity Cycads: Sparse	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS05 – TH (known <i>Typhonium</i> habitat)
	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS08 – LTC (large tree & Cycad assessment)
<p> Large trees: Mostly <40 cm DBH. Some large trees in distance Cycads: Sparse – few more specimens than observed elsewhere on site, still much less than prescribed high densities </p>	Date: 17/11/2022
	



Land unit: 3c - woodland	Site: PS10
	Date: 17/11/2022
	

Land unit: 3c – open woodland		Site: VS04							
Vegetation type: <i>Eucalyptus</i> open woodland over sparse shrubland and open grassland		Date: 17/11/2022							
Strata	Dominant species	Height (m)	Cover (%)						
Upper	<i>Eucalyptus tetradonta</i>	10-12	5-10						
	<i>Buchanania obovata</i>	6-10	<2						
	<i>Corymbia bleeseri</i>	8-12	<5						
Mid	<i>Terminalia ferdinandiana</i>	3-8	<5						
	<i>Livistona humilis</i>	2-4	5						
	<i>Acacia latescens</i>	2-4	5						
	<i>Terminalia</i> sp. (<i>T. pterocarya</i> or <i>T. canescens</i>)	2-3	<1						
	Juvenile upper spp.	2-5	<2						
Ground	<i>Triodia</i> sp.		15						
	<i>Acacia latescens</i>		15						
	<i>Petalostigma quadriloculare</i>		15						
	<i>Heteropogon triticeus</i>		5						
									
Landform: Side slope <2 % west aspect									
Soil: Grey-brown sandy clay loam with surface gravel									
Groundcover (%):									
Vegetation	50	Soil	15	Litter	20	Rock	0	Gravel	15
Fire: Burnt in 2022									
Weeds: None observed									
Ferals: None observed									
Other: Historic human disturbance throughout area									



<p>Land unit: 3c – open woodland</p>	<p>Site: PS06 – LTC (large tree & Cycad assessment)</p>
<p>Large trees: Patch of <i>Eucalyptus tetradonta</i> approaching 40 cm and 50 cm dbh with hollows. Cycads: Sparse</p>	<p>Date: 17/11/2022</p>
	


<p>Land unit: 3c – open woodland</p>	<p>Site: PS07 – LTC (large tree & Cycad assessment)</p>
<p>Large trees: <i>Eucalyptus tetradonta</i> approaching 40 cm dbh with some hollows. Cycads: Very sparse</p>	<p>Date: 17/11/2022</p>
	

Land unit: 6b		Site: VS01	
Vegetation type: Drainage - <i>Melaleuca</i> open woodland over open shrubland and open grassland		Date: 17/11/2022	
Strata	Dominant species	Height (m)	Cover (%)
Upper	<i>Melaleuca nervosa</i>	4-8	5-10
	<i>Corymbia polysciada</i>	8	<5
	<i>Pandanus spiralis</i>	4-6	<5
Mid	<i>Verticordia cunninghamii</i>	2-4	25-30
	<i>Grevillea pteridifolia</i>	2-4	<5
	<i>Livistona humilis</i>	2-3	5
	<i>Pandanus spiralis</i>	2-4	<5
Ground	<i>Sorghum</i> sp. (annual)		15
	<i>Verticordia cunninghamii</i>		10
	Other spp.		<1
			
Landform: Gentle slope <2 % west-north-west aspect			
Soil: Grey-brown sandy clay loam with surface gravel, some debil debils			
Groundcover (%):			
Vegetation	25	Soil	50
		Litter	15
		Rock	0
		Gravel	10
Fire: Partially burnt in 2022 – burnt to east, unburnt to west.			
Weeds: None observed			
Ferals: None observed			
Other: Historical WWII disturbance			

Land unit: 6b		Site: VS02	
Vegetation type: Drainage - <i>Corymbia</i> open woodland over open shrubland and sparse grassland		Date: 17/11/2022	
Strata	Dominant species	Height (m)	Cover (%)
Upper	<i>Corymbia polysciada</i>	6-10	<5
	<i>Corymbia polycarpa</i>	6-10	<5
Mid	<i>Livistona humilis</i>	2-4	5
	<i>Verticordia cunninghamii</i>	2-3	15
	<i>Grevillea pteridifolia</i>	3-5	<5
	<i>Melaleuca nervosa</i>	3-5	<2
	<i>Pandanus spiralis</i>	2-4	<5
Ground	<i>Sorghum</i> sp. (annual)		10
	<i>Heteropogon triticeus</i>		<5
	<i>Verticordia cunninghamii</i>		<5
	<i>Fimbristylis</i> spp.		<2
			
Landform: Gentle slope <2 % west-north-west aspect			
Soil: Grey-brown sandy clay loam with surface gravel, some debil debils			
Groundcover (%):			
Vegetation	20	Soil	50
		Litter	10
		Rock	0
		Gravel	20
Fire: Burnt in 2022.			
Weeds: None observed			
Ferals: None observed			
Other: Historical WWII disturbance			

<p>Land unit: 6b</p>	<p>Site: EA2</p>
<p><i>Calytrix</i> sp. (Dominant), <i>Melaleuca</i> sp., <i>Grevillea pteridifolia</i> and <i>Pandanus spiralis</i>. Seasonally inundated Not sandsheet heath.</p>	<p>Date: 23/03/2022</p>
	

<p>Land unit: 6b</p>	<p>Site: EA3</p>
<p><i>Calytrix</i> sp. (Dominant), <i>Hakea</i> sp., <i>Melaleuca</i> sp., <i>Pandanus spiralis</i> and <i>Grevillea pteridifolia</i>. Seasonally inundated</p>	<p>Date: 20/03/2022</p>
	

Land unit: Disturbed easement	Site: PS11
	Date: 17/11/2022
	

APPENDIX D WEED RECORD LOCATIONS

Weed records from 2022 survey within the project area

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
African Mahogany	<i>Khaya senegalensis</i>	50	4	AM50-4	131.1320710	-12.83778400	E
African Mahogany	<i>Khaya senegalensis</i>	50	4	AM50-4	131.1325120	-12.83737500	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	20	2	AMG20-2	131.0813052	-12.67841614	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	20	2	AMG20-2	131.0884984	-12.70237560	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	20	2	AMG20-2	131.1087577	-12.75802740	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	20	2	AMG20-2	131.1161494	-12.77828508	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	20	3	AMG20-3	131.0829555	-12.68545420	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	50	2	AMG50-2	131.1042184	-12.74556340	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	50	2	AMG50-2	131.1260975	-12.79993990	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	50	3	AMG50-3	131.0889958	-12.70372076	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	50	3	AMG50-3	131.1260286	-12.80062280	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	2	AMG100-2	131.0931783	-12.71518518	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	2	AMG100-2	131.1097508	-12.76055873	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	2	AMG100-2	131.1219473	-12.78379387	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	2	AMG100-2	131.1255971	-12.80292542	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	3	AMG100-3	131.1091202	-12.75915848	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	3	AMG100-3	131.1194667	-12.78205224	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	4	AMG100-4	131.1069090	-12.75296343	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	4	AMG100-4	131.1117911	-12.76610789	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	4	AMG100-4	131.1119117	-12.76646986	E
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	5	AMG100-5	131.1085526	-12.75744977	E

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
Annual Mission Grass	<i>Cenchrus pedicellatus</i>	100	5	AMG100-5	131.1078044	-12.75541039	E
Calopo	<i>Calopogonium mucunoides</i>	20	2	C20-2	131.1347556	-12.83412071	E
Calopo	<i>Calopogonium mucunoides</i>	50	2	C50-2	131.1349252	-12.83387514	E
Calopo	<i>Calopogonium mucunoides</i>	50	3	C50-3	131.1260286	-12.80062280	E
Calopo	<i>Calopogonium mucunoides</i>	100	2	C100-2	131.1097508	-12.76055873	E
Calopo	<i>Calopogonium mucunoides</i>	100	2	C100-2	131.1258891	-12.80095914	E
Calopo	<i>Calopogonium mucunoides</i>	100	2	C100-2	131.1358371	-12.83255076	E
Calopo	<i>Calopogonium mucunoides</i>	100	5	C100-5	131.1085526	-12.75744977	E
Calopo	<i>Calopogonium mucunoides</i>	100	5	C100-5	131.1078044	-12.75541039	E
Flannel Weed	<i>Sida cordifolia</i>	20	2	FW20-2	131.1159429	-12.77768311	E
Flannel Weed	<i>Sida cordifolia</i>	50	2	FW50-2	131.1355955	-12.82624623	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0813052	-12.67841614	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0847225	-12.69152630	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0845127	-12.69074578	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0851715	-12.69306689	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0861950	-12.69606912	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0849846	-12.69246934	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1113773	-12.76545041	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1153981	-12.77620466	E
Gamba Grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1180146	-12.78104168	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1161494	-12.77828508	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1248449	-12.78582453	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1253350	-12.80476603	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1332160	-12.82212797	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1323336	-12.82062024	E

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1361982	-12.83065128	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1345841	-12.83505891	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.1345839	-12.83468914	E
Gamba grass	<i>Andropogon gayanus</i>	20	2	GG20-2	131.0736180	-12.66834700	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0738115	-12.66569666	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0738017	-12.66894278	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0733694	-12.67016117	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0732942	-12.67036674	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0715412	-12.66940888	W
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.1346130	-12.83572101	E
Gamba grass	<i>Andropogon gayanus</i>	20	3	GG20-3	131.0736970	-12.67068400	W
Gamba grass	<i>Andropogon gayanus</i>	50	2	GG50-2	131.0877154	-12.70022789	E
Gamba grass	<i>Andropogon gayanus</i>	50	2	GG50-2	131.0895090	-12.70513340	E
Gamba Grass	<i>Andropogon gayanus</i>	50	2	GG50-2	131.1358371	-12.83255076	E
Gamba grass	<i>Andropogon gayanus</i>	50	2	GG50-2	131.0735040	-12.67135200	W
Gamba grass	<i>Andropogon gayanus</i>	50	3	GG50-3	131.0893450	-12.70461897	E
Gamba grass	<i>Andropogon gayanus</i>	50	3	GG50-3	131.0900380	-12.70655948	E
Gamba grass	<i>Andropogon gayanus</i>	50	3	GG50-3	131.0889958	-12.70372076	E
Gamba grass	<i>Andropogon gayanus</i>	50	3	GG50-3	131.1129491	-12.76938129	E
Gamba grass	<i>Andropogon gayanus</i>	50	3	GG50-3	131.1260286	-12.80062280	E
Gamba grass	<i>Andropogon gayanus</i>	50	4	GG50-4	131.1321300	-12.83776300	E
Gamba grass	<i>Andropogon gayanus</i>	50	4	GG50-4	131.1330810	-12.83786200	E
Gamba grass	<i>Andropogon gayanus</i>	50	4	GG50-4	131.1325180	-12.83736900	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.0867339	-12.69757783	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.0931783	-12.71518518	E

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.1097508	-12.76055873	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.1219473	-12.78379387	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.1258891	-12.80095914	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.1255971	-12.80292542	E
Gamba grass	<i>Andropogon gayanus</i>	100	2	GG100-2	131.1352372	-12.82572414	E
Gamba grass	<i>Andropogon gayanus</i>	100	3	GG100-3	131.0903589	-12.70754037	E
Gamba grass	<i>Andropogon gayanus</i>	100	3	GG100-3	131.1091202	-12.75915848	E
Gamba grass	<i>Andropogon gayanus</i>	100	3	GG100-3	131.1234471	-12.78484313	E
Gamba grass	<i>Andropogon gayanus</i>	100	4	GG100-4	131.1103960	-12.76232373	E
Gamba grass	<i>Andropogon gayanus</i>	100	4	GG100-4	131.1194667	-12.78205224	E
Gamba grass	<i>Andropogon gayanus</i>	100	4	GG100-4	131.1119117	-12.76646986	E
Gamba grass	<i>Andropogon gayanus</i>	100	5	GG100-5	131.1085526	-12.75744977	E
Hymenachne	<i>Hymenachne sp.</i>	20	5	Hym20-5	131.0734980	-12.67132100	W
Hyptis	<i>Mesosphaerum suaveolens</i>	20	2	Hypt20-2	131.0813052	-12.67841614	E
Hyptis	<i>Mesosphaerum suaveolens</i>	20	2	Hypt20-2	131.0884984	-12.70237560	E
Hyptis	<i>Mesosphaerum suaveolens</i>	20	2	Hypt20-2	131.1265842	-12.79590535	E
Hyptis	<i>Mesosphaerum suaveolens</i>	20	2	Hypt20-2	131.1347556	-12.83412071	E
Hyptis	<i>Mesosphaerum suaveolens</i>	20	2	Hypt20-2	131.0735820	-12.66832900	W
Hyptis	<i>Mesosphaerum suaveolens</i>	20	3	Hypt20-3	131.0829555	-12.68545420	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	2	Hypt50-2	131.0895090	-12.70513340	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	2	Hypt50-2	131.1355955	-12.82624623	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	2	Hypt50-2	131.1345841	-12.83505891	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	2	Hypt50-2	131.1345839	-12.83468914	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	2	Hypt50-2	131.1349252	-12.83387514	E
Hyptis	<i>Mesosphaerum suaveolens</i>	50	3	Hypt50-3	131.1260286	-12.80062280	E

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
Hyptis	<i>Mesosphaerum suaveolens</i>	50	3	Hypt50-3	131.1346268	-12.83553902	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	2	Hypt100-2	131.1258891	-12.80095914	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	2	Hypt100-2	131.1255971	-12.80292542	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	2	Hypt100-2	131.1352372	-12.82572414	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	3	Hypt100-3	131.1097508	-12.76055873	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	3	Hypt100-3	131.1091202	-12.75915848	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	3	Hypt100-3	131.1361518	-12.83153248	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	3	Hypt100-3	131.1361982	-12.83065128	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	4	Hypt100-4	131.1069090	-12.75296343	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	4	Hypt100-4	131.1117911	-12.76610789	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	4	Hypt100-4	131.1119117	-12.76646986	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	4	Hypt100-4	131.1358371	-12.83255076	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	4	Hypt100-4	131.1354245	-12.83338197	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	5	Hypt100-5	131.1085526	-12.75744977	E
Hyptis	<i>Mesosphaerum suaveolens</i>	100	5	Hypt100-5	131.1078044	-12.75541039	E
Neem	<i>Azadirachta indica</i>	20	2	N20-2	131.0735986	-12.67050091	W
Neem	<i>Azadirachta indica</i>	100	2	N100-2	131.1097508	-12.76055873	E
Paspalum	<i>Paspalum sp.</i>	20	2	P20-2	131.1087577	-12.75802740	E
Paspalum	<i>Paspalum sp.</i>	20	2	P20-2	131.1085526	-12.75744977	E
Paspalum	<i>Paspalum sp.</i>	100	5	P100-5	131.1078044	-12.75541039	E
Sida	<i>Sida acuta</i>	20	3	Sida20-2	131.0829555	-12.68545420	E
Sida	<i>Sida acuta</i>	50	2	Sida50-2	131.1358371	-12.83255076	E
Sida	<i>Sida acuta</i>	50	3	Sida50-3	131.1260286	-12.80062280	E
Snake Weed	<i>Stachytarpheta spp.</i>	20	2	SW20-2	131.1349252	-12.83387514	E
Snake Weed	<i>Stachytarpheta spp.</i>	50	3	SW50-3	131.1260286	-12.80062280	E

Common name	Scientific name	Patch diameter (m)	Weed density code	Code	Longitude	Latitude	Location (E=easement, W=WTP)
Snake Weed	<i>Stachytarpheta</i> spp.	50	3	SW50-3	131.1358371	-12.83255076	E
Stylo	<i>Stylosanthes</i> sp.	20	2	Stylo20-2	131.0736270	-12.66826600	W

APPENDIX E THREATENED SPECIES LIKELIHOOD OF OCCURRENCE ANALYSIS

- Threatened species records from the latest version of the [NT Atlas](#) were clipped to the two bioregions – Darwin Coastal and Pine Creek – intersected by the project area. Bioregions give a broad area with largely similar habitat characteristics and species assemblages. Clipping data to them ensures all potential species are captured in order to undertake a project-specific 'likelihood of occurrence' assessment.
- A [EPBC Protected Matters Search Tool](#) (PMST) report was generated using a 10 km buffer from the project area – generated on 6 December 2022. This PMST is an online enquiry tool managed by the Commonwealth Department of the Environment and Energy which interrogates a range of existing flora and fauna data, as well as predictive modelling to speculate on the presence of species within a search area.
- For each threatened species identified above, the likelihood of it occurring within the project area was assessed from desktop information and field surveys. Considerations included habitat requirements and availability on site, distribution (including [NT Government modelling](#)) and the number and dates of proximate records (obtained from NT Atlas and/or the field surveys discussed in Section 3). Likelihood ratings are defined below. Marine and coastal species were excluded because there is no marine or coastal habitat within the project area.

Ratings of threatened species likelihood to occur in the project area

Rating	Definition
HIGH	It is expected that this species occurs within the project area because there is core habitat and recent (post-2000) proximate records or knowledge that the species occurs in the local area.
MEDIUM	Species may occur within the project area because there is suitable habitat; however, there is evidence that lowers its likelihood of occurrence (known range contraction of the species in the region, no recent records within or close to the project area, substantial loss of habitat within the project area since previous records, species is naturally-rare or occurs at a low density etc.).
LOW	Species may occur, as a vagrant, within the project area; only marginally-suitable habitat is expected.
NONE	There is strong evidence that this species will not occur within the project area (i.e. there is no suitable habitat and/or the species is considered to be regionally-extinct).

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
BIRDS				
White-throated Grasswren <i>Amytornis woodwardi</i>	VU	VU	Habitat: Confined to hummock grasslands, sometimes with open shrubland or woodland overstorey, mixed among dense boulder fields or sandstone pavements (Schodde 1982; Noske 1992) and escarpment drainage lines. Distribution: NT only – patchily distributed from Nitmiluk National Park to western Arnhem Land (Noske 1992).	NONE <ul style="list-style-type: none"> • No suitable habitat • Outside of known distribution – all recent records located in or east of Kakadu.
	Noske, R. (1992). The status and ecology of the white-throated grass-wren <i>Amytornis woodwardi</i> . <i>Emu</i> , Vol. 92, pp. 39-51. Schodde, R. (1982). <i>The fairy-wrens - A monograph of the Maluridae</i> . Landsdowne Editions, Melbourne.			
Yellow Chat (Alligator River subspecies) <i>Epthianura crocea tunneyi</i>	EN	EN	Habitat: Grassy floodplain depressions and channels, concentrating around refugial waterholes at the end of the dry season (Armstrong 2004). Distribution: Top End of the NT, where restricted to a small number of sites in the floodplains from the Adelaide River to the East Alligator River (Woinarski & Armstrong 2006).	LOW <ul style="list-style-type: none"> • No suitable habitat • Nearest recent record 30 km to the north-west at Knuckey Lagoons Conservation Reserve in 2019.
	Armstrong, M. (2004). <i>The yellow chat Epthianura crocea tunneyi in Kakadu National Park</i> . Report to Parks Australia (North), NT Department of Infrastructure Planning and Environment, Darwin. Woinarski, J. and Armstrong, M. (2006). <i>Threatened Species of the Northern Territory - Yellow Chat (Alligator River subspecies) - Epthianura crocea tunneyi</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0019/206344/yellow-chat.PDF [Accessed 1 May 2018]. Schodde, R. and Mason, I.J. (1999). <i>The Directory of Australian Birds: Passerines</i> . CSIRO Publishing, Melbourne.			
Red Goshawk <i>Erythrotriorchis radiatus</i>	VU	VU	Habitat: Prefers tall, open Eucalypt forest and riparian areas. Nests in large trees, frequently the tallest and most massive in a tall stand, nest trees are invariably within 1 km of permanent water (Debus & Czechura 1988; Aumann & Baker-Gabb 1991). Rarely breeds in areas with fragmented native vegetation (Aumann & Baker-Gabb 1991; Czechura 2001). Home range of up to 200 km ² (Czechura & Hobson 2000). Distribution: Solitary and secretive hawk that is sparsely distributed across much of northern Australia, from the Kimberley in WA to south-eastern Qld. Within this range, generally confined to taller forests characteristic of higher rainfall coastal and sub-coastal areas (Debus 1998), but there are some isolated records of wandering birds from central Australia (Woinarski 2006).	LOW <ul style="list-style-type: none"> • No suitable nesting habitat, but suitable foraging habitat • Nearest recent record 17 km south-east of the project area at Adelaide River in 2018 • Rarely recorded in the Darwin region • Potential for occasional flyover
	Aumann, T. and Baker-Gabb, D. (1991). <i>A Management Plan for the Red Goshawk</i> . RAOU Report 75, Royal Australasian Ornithologists Union, Melbourne. Czechura G.V. and Hobson R.G. (2000). <i>The Red Goshawk Erythrotriorchis radiatus in northern Queensland: status and distribution</i> . Report to Queensland Parks and Wildlife Service. Czechura G.V. (2001). <i>The status and distribution of the Red Goshawk Erythrotriorchis radiatus on Cape York Peninsula, Queensland</i> . Unpublished report to Birds Australia. Debus, S. and Czechura, G. (1988). Field identification of the Red Goshawk <i>Erythrotriorchis radiatus</i> . <i>Australian Bird Watcher</i> , Vol. 12, pp. 154-159. Debus, S. (1998). <i>The Birds of Prey of Australia</i> . Oxford University Press, Melbourne. Woinarski, J. (2006). <i>Threatened Species of the Northern Territory - Red Goshawk - Erythrotriorchis radiatus</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0018/206352/red-goshawk.pdf [Accessed 1 May 2018].			

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
Gouldian Finch <i>Erythrura gouldiae</i>	EN	VU	<p>Habitat: Prefers areas with an adequate supply of seed from annual and perennial grasses (especially <i>Sorghum</i>), a nearby source of surface water and – in the breeding season – unburnt, hollow-bearing Eucalyptus trees (especially <i>E. tintinnans</i>, <i>E. brevifolia</i> and <i>E. leucophloia</i>) (Tidemann 1996; O'Malley 2006).</p> <p>Distribution: Patchily distributed across northern Australia from the Kimberley to north-central Qld (Dostine 1998; Franklin et al. 1999; Barrett et al. 2003; Franklin et al. 2005). In the NT, most known breeding populations occur in the Top End. Non-breeding birds disperse widely (Garnett et al. 2011), greatly increasing the possible range of this species.</p>	<p>LOW</p> <ul style="list-style-type: none"> • No preferred nesting habitat, but suitable foraging habitat • Nearest recent record 9 km west of the project area at Berry Springs in 2019 • Rarely recorded in the Darwin region • Potential for occasional sightings
<p>Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). <i>The New Atlas of Australian Birds</i>. Royal Australian Ornithologists Union, Melbourne, Victoria.</p> <p>Dostine, P. (1998). <i>Gouldian Finch Recovery Plan Erythrura gouldiae</i>. Gouldian Finch Recovery Team and Parks & Wildlife Commission NT, Darwin.</p> <p>Franklin, D.C., Burbidge, A.H. and Dostine, P.L. (1999). The harvest of wild birds for aviculture: an historical perspective on finch trapping in the Kimberley with special emphasis on the Gouldian Finch. <i>Australian Zoologist</i>, Vol. 31, pp. 92-109.</p> <p>Franklin, D.C., Whitehead, P.J., Pardon, G., Matthews, J., McMahon, P. and McIntyre, D. (2005). Geographic patterns and correlates of the decline of granivorous birds in northern Australia. <i>Wildlife Research</i>, Vol. 32, pp. 399-408.</p> <p>Garnett, S.T., Szabo, J.K. and Dutton, G. (2011). <i>The Action Plan for Australian Birds 2010</i>. CSIRO Publishing. Collingwood, Australia.</p> <p>O'Malley, C. (2006). <i>National Recovery Plan for the Gouldian Finch (Erythrura gouldiae)</i>. WWF-Australia, Sydney and Parks and Wildlife NT, Department of Natural Resources, Environment and the Arts, NT Government, Palmerston.</p> <p>Tidemann, S.C. (1996). Causes of the decline of the Gouldian Finch <i>Erythrura gouldiae</i>. <i>Biological Conservation International</i>, Vol. 6, pp. 49-61.</p>				
Grey Falcon <i>Falco hypoleucos</i>	-	VU	<p>Habitat: A generally solitary desert falcon that occurs in areas of lightly-timbered lowland plains, typically on inland drainage systems, where the average annual rainfall is less than 500 mm (Ward 2012).</p> <p>Distribution: Sparsely distributed through much of the arid and semi-arid regions of Australia but has been recorded from all mainland states and territories. In the NT, the majority of records are from the southern half, but there are records all the way up to Darwin (Ward 2012). A study of breeding records from 2003 to 2011 documented 38 breeding events – all within the hottest climate classes of Australia – with the northern-most record occurring south of Daly Waters (Schoenjahn 2013).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No recent or proximate records – nearest record 26 km east of the project area in 2002 • Naturally rare and rarely recorded in the Darwin region • Not known to breed north of Daly Waters
<p>Schoenjahn, J. (2013), A hot environment and one type of prey: investigating why the Grey Falcon (<i>Falco hypoleucos</i>) is Australia's rarest falcon, <i>Emu</i>, Vol. 113, pp. 19-25.</p> <p>Ward, S. (2012). <i>Threatened Species of the Northern Territory - Grey Falcon - Falco hypoleucos</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0020/206354/grey-falcon.pdf [Accessed 1 May 2018].</p>				
Crested Shrike-tit (northern subspecies)	VU	-	<p>Habitat: Recorded in eight different woodland types in northern Australia, mainly those dominated by <i>Eucalyptus miniata</i>, <i>E. tetradonta</i> or <i>E. bleeseri</i> (Robinson & Woinarski 1992). Nests have been found in the canopy of <i>E. tectifera</i>, <i>C. grandifolia</i> and <i>C. latifolia</i> at >12 m above the ground in open woodland habitat (Ward et al. 2009).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No proximate records – nearest records are > 100 km east of the project area.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
<i>Falcunculus frontatus whitei</i>			<p>Distribution: North-western Australia from the Kimberley in WA, across the Top End of the NT to Borrooloola (TSSC 2016). In the NT, recorded in very low densities in many isolated sub-populations (Garnett & Crowley 2000) between north-east Arnhem Land and semi-arid Victoria River District. Scarcity of records suggests that populations are at very low density (Woinarski 2004). Not known to have disappeared from any area where recorded historically (TSSC 2016).</p>	
<p>Garnett, S.T. and Crowley, G.M. (2000). <i>The Action Plan for Australian Birds 2000</i>. Environment Australia and Birds Australia, Canberra, ACT.</p> <p>Robinson, D. and Woinarski, J.C.Z. (1992). 'A review of records of the Northern Shrike-tit <i>Falcunculus frontatus whitei</i> in north-western Australia'. <i>South Australian Ornithologist</i>, Vol. 31, pp. 111-117.</p> <p>Threatened Species Scientific Committee (2016). <i>Approved Conservation Advice for Falcunculus frontatus whitei - crested shrike-tit (northern)</i>. Canberra: Department of the Environment. In effect under the EPBC Act from 02-May-2016. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/26013-conservation-advice-05052016.pdf [Accessed 1 May 2018].</p> <p>Ward, S.J., Berghout, M. & Baker, B. (2009). Notes on the form and habitat of nests of the Northern Shrike-tit. <i>Northern Territory Naturalist</i>, Vol. 21, pp. 54-60.</p> <p>Woinarski, J.C.Z. (2004). <i>National multi-species Recovery Plan for the Partridge Pigeon [eastern subspecies] Geophaps smithii smithii; crested shrike-tit [northern (sub)-species] Falcunculus (frontatus) whitei; masked owl [north Australian mainland subspecies] Tyto novaehollandiae kimberli; and masked owl [Tiwi Islands subspecies] Tyto novaehollandiae melvillensis, 2004-2008</i>. NT Department of Infrastructure Planning and Environment, Darwin.</p>				
<p>Partridge Pigeon (eastern subspecies) <i>Geophaps smithii smithii</i></p>	VU	VU	<p>Habitat: Open forests and woodlands with an understorey of grasses (Woinarski 2006). Prefers woodland dominated by <i>Eucalyptus tetradonta</i> and <i>E. miniata</i> (Braithwaite 1985; Garnett et al. 2011; Higgins & Davies 1996). According to Fraser (2001), favour a structurally-patchy savanna understorey at a relatively intricate scale. In all seasons, prefer to feed in areas that have an open ground layer (e.g. following fire); however, more likely to nest where there is dense vegetation cover. Require the seeds of certain perennial grasses and sedges that are available early in the wet season when seed is otherwise scarce, particular the perennial grass species <i>Alloteropsis semialata</i> and <i>Chrysopogon</i>. The presence of these grasses may be crucial for survival at this time (Fraser 2001). Largely sedentary; however, can travel distances of 5 to 10 km in the wet season in search of food and water resources (Fraser 2001). Home ranges vary seasonally between 8 – 31 hectares Fraser (2001).</p> <p>Distribution: Historically, across the Top End (from Kununurra in WA to Borrooloola in the NT). Since early 20th century a severe range contraction from the western, eastern and southern parts of the former distribution (Higgins & Davies 1996; Woinarski et al. 2007). Currently, distribution is limited to sub-coastal NT from Yinberrie Hill in the south, Litchfield NP in the west and (western) Arnhem Land in the east (Garnett et al. 2011).</p>	<p>MEDIUM</p> <ul style="list-style-type: none"> • Suitable habitat within the project area • Records relative to the project area: 3.5 km west in 2017 and 5 km east in 2015 • Not recorded in any recent surveys in the Greater Darwin region except in areas contiguous with extensive savannah woodland (which is not the case for this project area)
<p>Braithwaite, R.W. (1985). <i>The Kakadu fauna survey: an ecological survey of Kakadu National Park</i>. Australian National Parks & Wildlife Service, Canberra.</p> <p>Fraser, F. (2000). Species profile: Partridge Pigeon <i>Geophaps smithii</i>. <i>Northern Territory Naturalist</i> 16, 38-39.</p>				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Fraser, F., Lawson V., Morrison S., Christophersen P., McGregor S. and Rawlinson M. (2003). Fire management experiment for the declining partridge pigeon, Kakadu National Park. <i>Ecological Management and Restoration</i> 4, 94–102.</p> <p>Garnett, S.T., Szabo, J.K. and Dutton, G. (2011). <i>The Action Plan for Australian Birds 2010</i>. Birds Australia, CSIRO Publishing, Melbourne.</p> <p>Higgins, P.J. and Davies S.J.J.F. (eds) (1996). <i>Handbook of Australian, New Zealand and Antarctic Birds. Volume Three: Snipe to Pigeons</i>. Oxford University Press. Melbourne, Victoria.</p> <p>Woinarski, J.C.Z. (2006). <i>Threatened Species of the Northern Territory - Partridge Pigeon (eastern subspecies) - Geophaps smithii</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0003/206355/partridge-pigeon.pdf [Accessed 1 May 2018].</p> <p>Woinarski, J., Pavey, C., Kerrigan, R., Cowie, I. and Ward, S. (Eds) (2007). <i>Lost from Our Landscape: Threatened Species of the Northern Territory</i>. Northern Territory Government, Darwin.</p>	
Painted Honeyeater <i>Grantiella picta</i>	VU	VU	<p>Habitat: Acacia and Eucalyptus-dominated woodlands and open forest, preferring habitats with more mature trees that host more mistletoe. Breeding times and seasonal movements (south to north) likely governed by the fruiting of mistletoe (Garnett et al. 2011).</p> <p>Distribution: Across eastern and northern parts of the country – but nowhere very numerous (Ward 2012). Many birds move after breeding to semi-arid regions such as north-eastern SA, central and western Qld, and central NT (TSSC 2015). Few NT records – most from the Barkly Tablelands – but no evidence of a breeding population in the NT, and the records are likely irregular visitors from south-eastern Australia (Ward 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • Vagrant to the NT • No proximate records – nearest > 200 km away at Nitmiluk NP
			<p>Garnett, S.T., Szabo, J.K. and Dutton, G. (2011). <i>The Action Plan for Australian Birds 2010</i>. CSIRO Publishing, Collingwood, Australia.</p> <p>Threatened Species Scientific Committee (TSSC) (2015). <i>Approved Conservation Advice for Grantiella picta (Painted Honeyeater)</i>. Canberra: Department of the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf [Accessed 1 May 2018].</p> <p>Ward, S. (2012). <i>Threatened Species of the Northern Territory – Painted Honeyeater - Grantiella picta</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0009/373554/painted-honeyeater.pdf [Accessed 1 May 2018].</p>	
Masked Owl (northern subspecies) <i>Tyto novaehollandiae kimberli</i>	VU	VU	<p>Habitat: Mainly in <i>Eucalyptus</i> tall open forests (especially those dominated by <i>Eucalyptus miniata</i> and <i>E. tetradonta</i>), but also roosts in monsoon rainforests and forages in more open vegetation types, including grasslands (Woinarski & Ward 2012). Usually nests in tree hollows, within patches of closed forest (Garnett et al. 2011). Little else known about the subspecies, but the species in general is resident in pairs within a territory up to 3,000 hectares (Debus 2009). Nest in large hollows with an entrance more than 20 cm wide and that is greater than 10 m above the ground (Debus 2009). Breeding poorly known, but thought to occur between March and October (DEWHA 2010).</p> <p>Distribution: Poorly known, with few records from across a broad range in northern Australia. In the NT, records from the Top End, Kakadu, Coburg Peninsula (majority of records) and south-west Gulf country (Woinarski & Ward 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • Suitable habitat within the project area • No recent proximate records – nearest record from 26 km east of the project area in 2012 • Despite substantial survey effort in the Greater Darwin region there are no recent records
			<p>Garnett, S.T., Szabo, J.K. and Dutton, G. (2011). <i>The Action Plan for Australian Birds 2010</i>. CSIRO Publishing, Collingwood, Australia.</p>	

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
Woinarski, J.C.Z. and Ward, S. (2012). <i>Threatened Species of the Northern Territory - Masked Owl (north Australian mainland subspecies) - Tyto novaehollandiae kimberli</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/data/assets/word_doc/0008/373553/masked-owl-mainland-top-end.docx [Accessed 1 May 2018].				
Australian Painted Snipe <i>Rostratula benghalensis australis</i>	EN	VU	<p>Habitat: Fringes of permanent and temporary wetlands, swamps and inundated grasslands (Taylor et al. 2013).</p> <p>Distribution: Nomadic and scattered across Australia with no predictable occurrence (Rogers 2001), but could occur at any wetland or inundated grassland across its distribution, including nearly all of the NT and Qld (Garnett et al. 2011).</p>	<p>LOW</p> <ul style="list-style-type: none"> • Potentially suitable foraging habitat within project area, but unlikely to provide core habitat • Dispersive nomad, rare in the Top End • No recent proximate records – 2006 record 12 km north of the project area at McMinns Lagoon
<p>Garnett, S.T., Szabo, J.K. and Dutton, G. (2011). <i>The Action Plan for Australian Birds 2010</i>. CSIRO Publishing. Collingwood, Australia.</p> <p>Rogers, D. (2001). Painted Snipe. <i>Wingspan</i>, Vol. 11 (No. 4), pp. 6-7.</p> <p>Taylor, R., Chatto, R. and Woinarski, J.C.Z. (2013). <i>Threatened Species of the Northern Territory - Australian painted snipe - Rostratula australis</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/data/assets/pdf_file/0018/206361/australian-painted-snipe.pdf [Accessed 1 May 2018].</p>				
MAMMALS (TERRESTRIAL)				
Fawn Antechinus <i>Antechinus bellus</i>	VU	EN	<p>Habitat: Mostly in open forests and woodlands dominated by <i>Eucalyptus miniata</i> and/or <i>E. tetradonta</i>, particularly where these forests have a relatively dense shrubby understorey (Friend 1985; Friend & Taylor 1985). Declines in areas with frequent intense fires (Corbett et al. 2003) but not necessarily common in areas where fire has been excluded for long periods (>20 years; Woinarski et al. 2004). Breeding occurs mid-June to late August, after which a synchronous male die-off occurs (TSSC 2015).</p> <p>Distribution: Restricted to the Top End of the NT (Watson & Calaby 2008), with one record from Melville Island. Recent surveys have failed to record it across central and eastern Arnhem Land (TSSC 2015).</p>	<p>LOW</p> <ul style="list-style-type: none"> • Suitable habitat within the project area • No recent proximate records – 2002 record 6 km north-east of the project area • Despite substantial survey effort in the Greater Darwin region there are no recent records
<p>Corbett L. K., Andersen, A.N. and Muller, W.J. (2003). Terrestrial vertebrates. In: Andersen, A.N., Cook, G.D. and Williams, R.J. (eds.). <i>Fire in Tropical Savannas: The Kapalga Experiment</i>. Springer-Verlag, New York: pp. 126–152.</p> <p>Friend, G.R. and Taylor, J.A. (1985). Habitat preferences of small mammals in tropical open-forest of the Northern Territory. <i>Australian Journal of Ecology</i>, Vol. 10, pp. 173-185.</p> <p>Friend, G.R. (1985). Ecological studies of a population of <i>Antechinus bellus</i> (Marsupalia: Dasyuridae) in tropical Australia. <i>Australian Wildlife Research</i>, Vol. 12 (No. 2), pp. 151-162.</p> <p>Threatened Species Scientific Committee (2015). <i>Approved Conservation Advice for Antechinus bellus – Fawn Antechinus</i>. Canberra: Department of the Environment. In effect under the EPBC Act from 03-Dec-2015. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/344-conservation-advice-2015123.pdf [Accessed 1 May 2018].</p> <p>Watson, M.L. and Calaby, J.H. (2008). Fawn Antechinus: <i>Antechinus bellus</i>. In: Van Dyck, S. and Strahan, R. (eds.). <i>The Mammals of Australia: 3rd Edition</i>. Reed New Holland, Sydney.</p> <p>Woinarski, J.C.Z., Risler, J. and Kean, L. (2004). The response of vegetation and vertebrate fauna to 23 years of fire exclusion in a tropical Eucalyptus open forest, Northern Territory, Australia. <i>Austral Ecology</i>, Vol. 29, pp. 156–176.</p>				
Northern Quoll <i>Dasyurus hallucatus</i>	EN	CR	<p>Habitat: Wide range of habitats, but since the arrival of Cane Toads generally restricted to the most suitable habitats which are rocky upland areas with numerous crevices and rock piles (Van Dam et al. 2002). Prime habitat in the NT consists of rocky sandstone escarpments and outliers (Braithwaite & Griffiths 1994). Home range varies from 35 to 100 ha</p>	<p>LOW</p> <ul style="list-style-type: none"> • Suitable habitat, but no rocky refuge areas • Species has suffered a range decline since the introduction of Cane Toads

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>(Oakwood 2002). Breeding occurs in May and June, with male die-off occurring shortly afterwards (Oakwood 2000).</p> <p>Distribution: Historically occurred in the NT from Borroloola in the south-east as far west as the NT/WA border (Woinarski et al. 2007), and extends into the Kimberley and Pilbara regions of WA. Dramatic range contraction and population crash associated with Cane Toad invasion. Now occurs across northern Australia in five regional populations – including the Top End in the NT.</p>	<ul style="list-style-type: none"> No recent proximate records – 2001 record 6 km north-west of the project area.
<p>Braithwaite, R.W. and Griffiths, A.D. (1994). Demographic variation and range contraction in the Northern Quoll, <i>Dasyurus hallucatus</i> (Marsupialia: Dasyuridae). <i>Wildlife Research</i>, Vol. 21, pp. 203-218.</p> <p>Oakwood, M. (2000). Reproduction and demography of the northern quoll, <i>Dasyurus hallucatus</i>, in the lowland savanna of northern Australia. <i>Australian Journal of Zoology</i>. 48:519-539.</p> <p>Oakwood, M. (2002). Spatial and social organization of a carnivorous marsupial, <i>Dasyurus hallucatus</i>. <i>Journal of Zoology</i>, London. 257:237-248.</p> <p>Van Dam, R.A., Walden, D.J. and Begg, G.W. (2002). <i>A preliminary risk assessment of cane toads in Kakadu National Park</i>. Supervising Scientist Report 164, Darwin, Northern Territory.</p> <p>Woinarski, J.C.Z., Rankmore, B.R., Fisher, A. and Milne, D. (2007). <i>The natural occurrence of northern quolls Dasyurus hallucatus on islands of the Northern Territory: assessment of refuges from the threat posed by cane toads Bufo marinus</i>. Report to Natural Heritage Trust.</p>				
Northern Brush-tailed Phascogale <i>Phascogale pirata</i>	VU	EN	<p>Habitat: No detailed studies, but ecology is probably similar to that reported for phascogales in southern Australia (Rhind 1998). Most records are from tall open forests dominated by <i>Eucalyptus miniata</i> and <i>E. tetradonta</i> (Rhind et al. 2008). Brush-tailed Phascogales are primarily arboreal and seldom feed on the ground.</p> <p>Distribution: Probably occurs naturally in low densities (Woinarski et al. 2014). Very few records exist; reported from West Island, east Arnhem Land, Coburg Peninsula, Kakadu, Litchfield and the Tiwi Islands. In the last 10 years only recorded from Kakadu, Coburg Peninsula and the Tiwi Islands, despite many extensive wildlife surveys across regions of the Top End during that time (Woinarski et al. 2014).</p>	<p>LOW</p> <ul style="list-style-type: none"> Suitable habitat within the project area No recent proximate records - nearest record 46 km south-west of the project area in 2004. This species now appears to be restricted to Cobourg Peninsula and Kakadu National Park on the mainland.
<p>Rhind, S.G. (1998). <i>Ecology of the brush-tailed phascogale in jarrah forest of south-western Australia</i>. PhD thesis, Murdoch University, Perth, Western Australia.</p> <p>Rhind, S.G., Woinarski, J. and Aplin, K.P. (2008). Brush-tailed Phascogale. In: Van Dyck, S. and Strahan, R. (eds). <i>The Mammals of Australia</i>. Reed New Holland, Chatswood, NSW.</p> <p>Woinarski, J., Burbidge, A. and Harrison, P. (2014). <i>The Action Plan for Australian Mammals 2012</i>. CSIRO Publishing: pp. 125-127.</p>				
Arnhem Leaf-nosed Bat <i>Hipposideros inornatus</i>	EN	VU	<p>Habitat: Caves or abandoned mine sites in cool draughty areas, close to water (Churchill 1998; Corbett & Richards 2002). Reported as foraging in riparian areas and in Eucalypt tall open forests (Woinarski & Milne 2015).</p> <p>Distribution: Restricted to the NT and only known to occur on the western Arnhem Land sandstone massif (Deaf Adder Gorge and upper South Alligator River area) and from one site – Tolmer Falls – in Litchfield National Park (McKean & Hertog 1979) where population appears to be disappearing (Woinarski & Milne 2015).</p>	<p>LOW</p> <ul style="list-style-type: none"> Potential foraging habitat, but no caves/abandoned mine sites in the project area All records east of Nitmiluk National Park, with the exception of one 57 km south-west at Litchfield National Park in 1978.
<p>Churchill, S. (1998). <i>Australian Bats</i>. Reed New Holland, Sydney.</p>				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Corbett, L. and Richards, G. (2002). <i>Bat survey: Gunlom land trust area</i>. Report to Parks Australia North, EWL Sciences, Darwin.</p> <p>McKean, J.L. and Hertog, A.L. (1979). Extension of range in the horseshoe bat. <i>Northern Territory Naturalist</i>, Vol. 1, p. 5.</p> <p>Woinarski, D. and Milne, D. (2015). <i>Threatened Species of the Northern Territory – Arnhem Leaf-nosed Bat – Hipposideros inornata</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0018/205524/arnhem-leaf-nosed-bat.pdf [Accessed 1 May 2018].</p>	
<p>Northern Leaf-nosed Bat <i>Hipposideros stenotis</i></p>	-	VU	<p>Habitat: Prefers rocky outcrops. Often found in shallow caves, boulder piles and old mine sites. It is an obligate cave rooster, most caves being small, shallow overhangs or splits in sandstone cliffs (Churchill 2008). Forages in a wide range of habitats including monsoon vine thickets, woodlands and open grasslands (Milne 2012).</p> <p>Distribution: In the NT – recorded in few locations. Often associated with and found in close proximity to rocky outcrops and escarpment country (Milne et al. 2005). Recorded throughout parts of the Kimberley, WA and in the Mt Isa region of north-western Qld. (Woinarski et al. 2014).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No roosting habitat within project area • No proximate records – the nearest record is > 100 km away at Nitmiluk National Park
			<p>Churchill, S. (2008) <i>Australian Bats</i>. 2nd edition. Allen & Unwin, Crows Nest NSW.</p> <p>Milne, D. (2012). <i>Threatened Species of the Northern Territory - Northern Leaf-nosed Bat - Hipposideros stenotis</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0016/205513/northern-leafnosed-bat.pdf [Accessed 1 May 2018].</p> <p>Milne, D.J., Armstrong, M., Fisher, A., Flores, T. and Pavey, C.R. (2005) Structure and environmental relationships of insectivorous bat assemblages in tropical Australian savannas. <i>Austral Ecology</i>, Vol. 30, pp. 906-919.</p> <p>Woinarski, J., Burbidge, A. and Harrison, P. (2014). <i>The Action Plan for Australian Mammals 2012</i>. CSIRO Publishing, pp. 501-503.</p>	
<p>Ghost Bat <i>Macroderma gigas</i></p>	VU	-	<p>Habitat: Ranging from the arid Pilbara of WA to tropical savanna woodlands and north Qld. rainforests (TSSC 2016). Permanent roost sites are generally deep natural caves or disused mines (TSSC 2016).</p> <p>Move between a number of caves seasonally or as dictated by weather conditions, and require a range of cave sites (Hutson et al. 2001). Most breeding sites are caves with multiple entrances (TSSC 2016).</p> <p>Distribution: Geographically-disjunct colonies occur in the Pilbara and Kimberley in WA, NT north of approximately 17° latitude (including Elcho Island and Groote Eylandt), the Gulf of Carpentaria, eastern Qld from Cape York to near Rockhampton, and western Qld (including Riversleigh and Camooweal districts) (TSSC 2016). Distribution likely influenced by the availability of suitable caves and mines for roost sites (Ward & Milne 2016). Only 14 breeding sites known (Worthington Wilmer 2012). Disperse widely when not breeding (TSSC 2016). In arid Australia, including southern NT until the early 1960's (Ward & Milne 2016).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No roosting habitat within the project area • Undated record 1.5 km east of the project area • Most recent proximate record 57 km south-west from 2011
			<p>Hutson, A. M., Mickleburgh, S. P. & Racey, P. A. (2001) <i>Microchiropteran Bats - Global Status Survey and Conservation Action Plan</i>. IUCN/SSC Chiroptera Specialist Group, Gland, Switzerland and Cambridge, U.K.</p> <p>Milne, D. and Ward, S. (2016). <i>Threatened Species of the Northern Territory – Ghost Bat - Macroderma gigas</i>. Northern Territory Department of Environment and Natural Resource. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0010/376138/ghost-bat.pdf [Accessed 1 May 2018].</p>	

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			Threatened Species Scientific Committee (2016). <i>Approved Conservation Advice for Macroderma gigas (ghost bat)</i> . Canberra: Department of the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf [Accessed 1 May 2018]. Worthington Wilmer, J. (2012). Ghost Bat <i>Macroderma gigas</i> . In: Curtis et al. (eds.). <i>Queensland's Threatened Animals</i> . CSIRO, Canberra: pp. 382-383.	
Bare-rumped Sheathtail Bat <i>Saccolaimus saccolaimus (nudicluniatus)</i>	VU	-	Habitat: In the NT, specimens have been collected from Pandanus woodland fringing the sedgelands of the South Alligator River and Eucalypt tall open forests (Friend & Braithwaite 1986; Churchill 1998) with more recent records from Howard Springs (Milne et al 2009). Most records occur within near-coastal habitats with one recent exception (Jasper Gorge) 150 km inland (Woinarski et al. 2014). Distribution: Widely distributed from India through south-east Asia to the Solomon Islands including north-eastern Qld and the NT. The north-eastern Australian population is described as the subspecies <i>S. s. nudicluniatus</i> , although it is not clear whether this should be applied to NT populations (Milne & Woinarski 2006).	MEDIUM <ul style="list-style-type: none"> • Suitable habitat within project area • Most recent proximate record 25 km south-west from 2014 • Despite substantial survey effort in the Greater Darwin region there are few recent records
			Churchill, S. (1998). <i>Australian Bats</i> . Reed New Holland, Sydney. Friend, G.R. and Braithwaite, R.W. (1986). Bat fauna of Kakadu National Park, Northern Territory. <i>Australian Mammalogy</i> , Vol. 9, pp. 43-52. Milne, D.J., Jackling, F.C., Sidhu, M., and Appleton, B.R. (2009). Shedding new light on old species identifications: morphological and genetic evidence suggest a need for conservation status review of the critically endangered bat, <i>Saccolaimus saccolaimus</i> . <i>Wildlife Research</i> 36: 496–508. Milne, D. and Woinarski, J. (2006). <i>Threatened Species of the Northern Territory - Bare-rumped Sheathtail Bat - Saccolaimus saccolaimus</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/data/assets/pdf_file/0007/376117/bare-rumped-sheathtail-bat.pdf [Accessed 1 May 2018]. Woinarski, J., Burbidge, A. and Harrison, P. (2014). <i>The Action Plan for Australian Mammals 2012</i> . CSIRO Publishing: pp. 511-514.	
Golden Bandicoot <i>Isoodon auratus (auratus)</i>	VU	EN	Habitat: Mainly in heathland and shrubland on sandstone sheets, avoiding vegetation with greater tree cover (Palmer et al. 2012; Southgate et al. 1996). Distribution: Formerly across most of northern, central and western Australia (across a broad range of habitats), but now only recorded population on mainland Australia is within the Kimberley. In the NT, confined to the offshore islands of Arnhem Land. The only records from mainland NT are from the north-east corner of Arnhem Land between 1950 and 1980 (Palmer et al. 2012). Now extinct on the mainland except in a few locations in the north-west Kimberley (TSSC 2015).	NONE <ul style="list-style-type: none"> • Considered extinct on mainland NT
			Palmer, C., Woinarski, J. and Hill, B. (2012). <i>Threatened Species of the Northern Territory - Golden Bandicoot - Isoodon auratus</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/data/assets/pdf_file/0017/205505/golden-bandicoot.pdf [Accessed 1 May 2018]. Southgate, R., Palmer, C., Adams, C., Masters, M., Triggs, B. and Woinarski, J. (1996). Population and habitat characteristics of the Golden Bandicoot (<i>Isoodon auratus</i>) on Marchinbar Island, Northern Territory. <i>Wildlife Research</i> , Vol. 23, pp. 647-664. Threatened Species Scientific Committee (TSSC) (2015). <i>Approved Conservation Advice for Isoodon auratus auratus (golden bandicoot (mainland))</i> . Canberra: Department of the Environment. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66665-conservation-advice-01102015.pdf [Accessed 1 May 2018].	

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
Brush-tailed Rabbit-Rat <i>Conilurus penicillatus</i>	VU	EN	<p>Habitat: Largely restricted to mixed <i>Eucalypt</i> open forest and woodland, or on dunes with <i>Casuarina</i> – seeming to prefer habitats that are not burnt annually, that have an understorey of predominantly perennial grasses and a sparse-to-moderate middle storey (Firth et al. 2006; Firth 2007; Kemper & Firth 2008).</p> <p>Distribution: Formerly widespread across northern Australia, but has declined extensively from Qld and lower rainfall areas of the Kimberley in WA and the Top End in the NT. No recent records from much of the historically-recorded NT range between near the mouth of Victoria River (in the west) and Sir Edward Pellew island group (in east). Most recently known from Cobourg Peninsula, Tiwi Islands, Groote Eylandt and a small area within Kakadu National Park (Woinarski & Hill 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> This species now appears to be restricted to Cobourg Peninsula and Kakadu National Park on the mainland
<p>Firth, R.S.C. (2007). <i>Ecology and conservation status of the brush-tailed rabbit-rat Conilurus penicillatus</i>. PhD thesis, Charles Darwin University, Darwin, Northern Territory.</p> <p>Firth, R.S.C., Woinarski, J.C.Z. and Noske, R.A. (2006). Home range and den characteristics of the brush-tailed rabbit-rat <i>Conilurus penicillatus</i> in the monsoonal tropics of the Northern Territory, Australia. <i>Wildlife Research</i>, Vol. 33, pp. 397-408.</p> <p>Kemper, C.M. and Firth, R.S.C. (2008). Brush-tailed Rabbit-rat. In: Van Dyck, S. and Strahan, R. (eds). <i>The Mammals of Australia</i>. Reed New Holland, Chatswood, NSW.</p> <p>Woinarski, J.C.Z. and Hill, B. (2012). <i>Threatened Species of the Northern Territory - Brush-tailed rabbit-rat, Brush-tailed tree-rat - Conilurus penicillatus</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0016/205504/brush-tailed-rabbit-rat.pdf [Accessed 1 May 2018].</p>				
Black-footed Tree-rat (Kimberley and mainland NT subspecies) <i>Mesembriomys gouldii gouldii</i>	EN	VU	<p>Habitat: Woodlands and open forests with large trees and a moderately diverse mid-storey in near-coastal areas. Generally, require fruit and seed resources including <i>Pandanus</i> fruits, and fruiting trees and shrubs (Rankmore 2006). Shelters in tree hollows and occasionally <i>Pandanus</i> (Hill 2012). Thought to be more prevalent in woodlands with infrequent and low intensity fires (Price et al. 2005).</p> <p>Distribution: Top End of NT, Kimberley region of WA and Cape York Peninsula south to Townsville in Qld. (Hill 2012). Has remained relatively abundant in the Darwin rural area and there are some recent records from Gunn Point (Price et al. 2005), the Lee Point Area and Middle Arm.</p>	<p>LOW</p> <ul style="list-style-type: none"> Suitable habitat within project area Most recent proximate record 5 km west of the WTP from 2017 None detected during camera trapping undertaken at the WTP
<p>Hill, B. (2012). <i>Threatened Species of the Northern Territory- Black-footed Tree-rat - Mesembriomys gouldii</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0018/205515/black-footed-tree-rat.pdf [Accessed 1 May 2018].</p> <p>Price, O., Rankmore, B., Milne, D.J., Brock, C., Tynan, C., Kean, L. and Roger, L. (2005). Regional patterns of mammal abundance and their relationships to landscape variables in eucalypt woodlands near Darwin, northern Australia. <i>Wildlife Research</i>, Vol. 32, pp. 435-446.</p> <p>Rankmore, B.R. 2006. <i>Impacts of Habitat Fragmentation on the Vertebrate Fauna of the Tropical Savannas of Northern Australia; with Special Reference to Medium-sized Mammals</i>. PhD Thesis, Charles Darwin University, Darwin.</p>				
Golden-backed Tree-rat	VU	CR	<p>Habitat: In the NT, little known of the ecology apart that all three records were from riverine vegetation. In the Kimberley, known to occur in open Eucalypt forests with tussock grass understorey, rainforest patches, sandstone screes, beaches, and black soil plains (Woinarski et al. 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> Now only known to occur in some areas of the north-western Kimberley

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
<i>Mesembriomys macrurus</i>			<p>Distribution: Historically, known to have occurred in three localities in the NT (Parker 1973) with no new records in the last 30 years. In 1993, reportedly spotted in Kakadu National Park; however, further surveys of suitable habitats in the NT failed to locate the species (Lee 1995). Now only known to occur in some areas of the north-western Kimberley and associated offshore islands (Palmer et al. 2003).</p>	
<p>Lee, A.K. (1995). <i>The Action Plan for Australian Rodents</i>. Australian Nature Conservation Agency, Endangered Species Program, Canberra.</p> <p>Palmer, C., Taylor, R. and Burbidge, A. (2003). <i>Recovery plan for the Golden Bandicoot <i>Isodon auratus</i> and golden-backed tree-rat <i>Mesembriomys macrurus</i> 2004-2009</i>. Northern Territory Department of Infrastructure Planning and Environment, Darwin.</p> <p>Parker, S.A. (1973). An annotated checklist of the native land mammals of the Northern Territory. <i>Records of the South Australian Museum</i>, Vol. 16, pp. 1-57.</p> <p>Woinarski, J.C.Z., Palmer, C. and Hill, B. (2012). <i>Threatened Species of the Northern Territory - Golden-backed tree-rat - <i>Mesembriomys macrurus</i></i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0006/205476/golden-backed-tree-rat.pdf [Accessed 1 May 2018].</p>				
Northern Hopping-Mouse <i>Notomys aquilo</i>	VU	VU	<p>Habitat: Most often sandy substrates, seemingly favouring coastal sand dunes and sand sheets with a cover of tussock grass or heath. Also shrubland, Eucalypt open forest, and the margins of coastal rainforest thickets (Woinarski 2004; Woinarski & Flannery 2008).</p> <p>Distribution: Restricted to the NT – mostly Groote Eylandt, but also central north-east Arnhem Land (Woinarski & Ward 2012). No confirmed records from the Australian mainland for at least 10 years (Woinarski et al. 2014).</p>	<p>NONE</p> <ul style="list-style-type: none"> • Project area is outside of this species known distribution
<p>Woinarski, J., Burbidge, A. and Harrison, P. (2014). <i>The Action Plan for Australian Mammals 2012</i>. CSIRO Publishing: pp. 609-611.</p> <p>Woinarski, J.C.Z. and Flannery, T.F. (2008). Northern Hopping-mouse. in Van Dyck, S. & Strahan, R. (eds.) <i>The Mammals of Australia, 3rd Edition</i>. Reed New Holland, Sydney.</p> <p>Woinarski, J.C.Z. (2004). <i>National Multi-species Recovery Plan for the Carpentarian <i>Antechinus Pseudantechinus mimulus</i>, Butler's Dunnart <i>Sminthopsis butleri</i> and Northern Hopping-mouse <i>Notomys aquilo</i>, 2004 - 2008</i>. Department of the Environment and Heritage, ACT. [online] Available at: https://www.environment.gov.au/system/files/resources/dfb8a0ed-9e3e-4315-9e35-e28236ee96ba/files/p-mimulus-s-butleri-n-aquilo.pdf [Accessed 1 May 2018].</p> <p>Woinarski, J. and Ward, S. (2012). <i>Threatened Species of the Northern Territory – Northern Hopping Mouse – <i>Notomys aquilo</i></i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0019/205516/northern-hopping-mouse.pdf [Accessed 1 May 2018].</p>				
Nabarlek (Top End subspecies) <i>Petrogale concinna canescens</i>	CR	EN	<p>Habitat: Isolated and rocky areas consisting of both sandstone and granite escarpments (Churchill 1997; Telfer et al. 2008). Shelters in caves and crevices during the day (Churchill 1997) and may move from these to forage in adjacent flat areas (Sanson et al. 1985).</p> <p>Distribution: Restricted to the Top End of the NT in scattered populations from sandstone cliffs bordering the Arafura Swamp (Arnhem Land) in the east, to the Daly River catchment in the west (Ward & Woinarski 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No escarpment habitat within the project area • No proximate or recent records – nearest most recent record 65 km south of project area towards Litchfield National Park from 1990.
<p>Churchill, S. (1997). Habitat use, distribution and conservation status of the Nabarlek, <i>Petrogale concinna</i>, and sympatric rock-dwelling mammals, in the Northern Territory. <i>Australian Mammalogy</i>, Vol. 19, pp. 297-308.</p> <p>Sanson, G.D., Nelson, J. and Fell, P. (1985). Ecology of <i>Peradorcas concinna</i> in Arnhem Land in a wet and a dry season. <i>Proceedings of the Ecological Society of Australia</i>, Vol. 13, pp. 65-72.</p> <p>Telfer, W.R., Griffiths, A.D. and Bowman, D.M.J.S. (2008). The habitat requirements of four sympatric rock-dwelling macropods of the Australian monsoon tropics. <i>Austral Ecology</i>, Vol. 33, pp. 1033-1044.</p>				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
	Ward, S. and Woinarski, J. (2012). <i>Threatened Species of the Northern Territory - Nabarlek - Petrogale concinna</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0017/205523/nabarlek.pdf [Accessed 1 May 2018].			
Pale Field-rat <i>Rattus tunneyi</i>	-	VU	<p>Habitat: Historically occurred in a wide range of habitats, but now primarily in dense vegetation along creeks (Aplin et al. 2008). Fire regime seems to have little effect on population numbers; instead, the level of groundwater irrigating the riparian system and, to a lesser extent, current rainfall have a much stronger influence (Braithwaite & Griffiths 1996).</p> <p>Distribution: Higher rainfall areas of northern Australia, extending from Kimberley in WA to south-eastern Qld, including the Top End of the NT (Cole & Woinarski 2002, Braithwaite & Griffiths 1996). Previously widespread and patchily abundant, particularly in the north-west of the Top End, the Pale Field-rat appears to have declined in lower rainfall areas (Woinarski 2000).</p>	<p>HIGH</p> <ul style="list-style-type: none"> • Suitable riparian habitat within the project area • Most recent proximate record in the Darwin area is 22 km to the north-west from 2014 • Detected during camera trapping undertaken at the WTP.
	<p>Aplin, K., Braithwaite, R. and Baverstock, P. (2008). Pale Field-rat: <i>Rattus tunneyi</i>. In: Van Dyck, S. and Strahan, R. (eds.). <i>The Mammals of Australia (3rd Edition)</i>. Reed New Holland, Sydney, NSW.</p> <p>Braithwaite, R. and Griffiths, A. (1996). The paradox of <i>Rattus tunneyi</i>: endangerment of a native pest. <i>Wildlife Research</i>, Vol. 23, pp. 1-21.</p> <p>Cole, J. and Woinarski, J. (2002). <i>Field Guide to the Rodents and Dasyurids of the Northern Territory</i>. Surrey Beatty & Sons, Chipping Norton, NSW.</p> <p>Woinarski, J.C.Z. (2000). The conservation status of rodents in the monsoonal tropics of the Northern Territory. <i>Wildlife Research</i>, Vol. 27, pp. 421-435.</p>			
Northern Brushtail Possum <i>Trichosurus vulpecula arnhemensis</i>	VU	NT	<p>Habitat: In Northern Australia, mainly tall eucalypt open forests with large, hollow-bearing trees, some mangrove communities, rainforests and semi-urban areas (TSSC 2001). Found in higher abundance when shrub density is high, particularly shrubs that bear large, fleshy fruits (Stobo-Wilson 2019. Kerle 1985, Friend et al 1985).</p> <p>Distribution: Occurs from the Gulf of Carpentaria, NT to the Kimberley, WA. Also occurs on many NT islands, but not on any WA islands. Within its range, distribution is patchy (TSSC 2021). Recently, there have been broad-scale losses and reduction in extensive areas of the NT range (Woinarski 2004; Woinarski et al. 2011; Gibson & McKenzie 2012; Ziembicki et al. 2013; Stobo-Wilson et al. 2019).</p>	<p>HIGH</p> <ul style="list-style-type: none"> • Suitable habitat within the project area • Detected during camera trapping undertaken at the WTP.
	<p>Friend G & Taylor J (1985) Habitat preferences of small mammals in tropical open-forest of the Northern Territory. <i>Australian Journal of Ecology</i> 10, 173-185.</p> <p>Gibson L & McKenzie N (2012) Occurrence of non-volant mammals on islands along the Kimberley coast of Western Australia. <i>Records of the Western Australian Museum supplement</i> 81, 15-39</p> <p>Kerle J (1985) Habitat preference and diet of the northern brushtail possum <i>Trichosurus arnhemensis</i> in the Alligator Rivers Region, N.T. <i>Proceedings of the Ecological Society of Australia</i> 13, 161-176.</p> <p>Kerle, J., Foulkes, J., Kimber, R. and Papenfus, D. (1992). The decline of the brushtail possum, <i>Trichosurus vulpecula</i> (Kerr 1798), in arid Australia. <i>Rangelands Journal</i>, Vol. 14, pp. 107-127.</p> <p>Stobo-Wilson A, Murphy B, & Cremona T (2019) Contrasting patterns of decline in two arboreal marsupials from Northern Australia. <i>Biodiversity Conservation</i> 28, 2951</p> <p>Threatened Species Scientific Committee (2021). <i>Conservation Advice Trichosurus vulpecula arnhemensis Northern Brushtail Possum</i>. Canberra: Department of Agriculture, Water and the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/83091-conservation-advice-11052021.pdf [Accessed 27 January 2022].</p> <p>Woinarski, J.C.Z. (2004). In a land with few possums, even the common are rare: ecology, conservation and management of possums in the Northern Territory. In: Goldingay, R. and Jackson, S. (eds.). <i>The biology of Australian possums and gliding possums</i>. Surrey Beatty & Sons, Sydney: pp.51- 62.</p> <p>Woinarski J, Ward S, Mahney T, Bradley J, Brennan K, Ziembicki M & Fisher A (2011) The mammal fauna of the Sir Edward Pellew Islands, Northern Territory: refuge and death-trap. <i>Wildlife Research</i> 38, 307-322.</p>			

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
	Ziembicki M, Woinarski J & Mackey B (2013) Evaluating the status of species using Indigenous knowledge: novel evidence for major native mammal declines in northern Australia. <i>Biological Conservation</i> 157, 78-92.			
False Water Rat <i>Xeromys myoides</i>	VU	-	<p>Habitat: Utilises both intertidal and freshwater habitats, with most records from mangrove forests, saltmarsh, sedgeland, clay pans and freshwater <i>Melaleuca</i> wetlands (DoE 2017).</p> <p>Distribution: Three regions of coastal Australia: the NT, central south Qld and south-east Qld (DoE 2017). In the NT, known only from coastal Top End with ten records at six sites – South Alligator River in 1903, Daly River floodplain in 1972, two sites on the Tomkinson River in 1975, Melville Island in 1975 and Glyde River floodplain in 1998 and 1999 (Cole & Woinarski 2002, Woinarski 2006).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No suitable habitat within project area • No recent proximate records – nearest most recent record 156 km east from 2014.
<p>Cole, J. and Woinarski, J. (2002). <i>Field Guide to the Rodents and Dasyurids of the Northern Territory</i>. Surrey Beatty & Sons, Chipping Norton, NSW.</p> <p>Department of the Environment (2017). <i>Xeromys myoides - Water Mouse, False Water Rat, Yirrkoo</i>. Species Profile and Threats Database, Department of the Environment, Canberra. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66 [Accessed 1 May 2018].</p> <p>Woinarski, J.C.Z. (2006). <i>Threatened Species of the Northern Territory - False water-rat, Water mouse - Xeromys myoides</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0008/376136/false-water-rat.pdf [Accessed 1 May 2018].</p>				
Arnhem Rock-rat <i>Zyzomys maini</i>	VU	VU	<p>Habitat: Rugged sandstone environments, typically where there are many caves, crevices or boulders. Occupies environments in association with monsoonal rainforest, typically those areas which are floristically-rich and provide the fleshy fruits and seeds that form its principal food item (Begg et al. 1980).</p> <p>Distribution: Endemic to the sandstone massif of western Arnhem Land in the NT (Woinarski 2004). Commonly found throughout parts of Kakadu National Park and Warddeken Indigenous protected area (Woinarski et al. 2014).</p>	<p>NONE</p> <ul style="list-style-type: none"> • Restricted to the sandstone massif of Western Arnhem Land.
<p>Begg, R.J. and Dunlop, C.R. (1980). Security eating, and diet in the large rock-rat, <i>Zyzomys woodwardi</i> (Rodentia: Muridae). <i>Australian Wildlife Research</i>, Vol. 7, pp. 63-70.</p> <p>Woinarski, J., Burbidge, A. and Harrison, P. (2014). <i>The Action Plan for Australian Mammals 2012</i>. CSIRO Publishing: pp. 652-654.</p> <p>Woinarski, J.C.Z. (2004). <i>Threatened plants and animals in Kakadu National Park: a review and recommendations for management</i>. Darwin, Northern Territory DIPE.</p>				
REPTILES (TERRESTRIAL)				
Plains Death Adder <i>Acanthophis hawkei</i>	VU	VU	<p>Habitat: Floodplains in the Top End and cracking soil plains inland (Webb et al. 2002).</p> <p>Distribution: Habitat mapping suggests the potential geographic range extends from western Qld, across the sub-coastal north of the NT to the north-eastern Kimberley of WA. Fragmented populations occur in the Mitchell Grass Downs of western Qld, the Barkly Tablelands on the NT/Qld border and east of Darwin (Fogg Dam) in the NT (TSSC 2012; Wuster et al. 2005). Susceptible to ingesting toxic Cane Toads (Phillips et al. 2009).</p>	<p>LOW</p> <ul style="list-style-type: none"> • Limited drainage areas – not floodplains – in the project area • Recent proximate record 3 km west of the project area from 2018 – identified by the public on a rural block driveway not near floodplains, possibly a misidentification • The majority of records are from floodplains to the east, with the most recent proximate record 25 km east from 2017.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Phillips, B.L., Greenlees, M.J., Brown, G.P. and Shine R (2010). Predator behaviour and morphology mediates the impact of an invasive species: cane toads and death adders in Australia. <i>Animal Conservation</i>, Vol. 13, pp. 53-59.</p> <p>Webb, J.K., Christian, K.A. and Fisher, P. (2002). Fast growth and early maturation in a viviparous sit-and-wait predator, the northern death adder (<i>Acanthophis praelongus</i>) from tropical Australia. <i>Journal of Herpetology</i>, Vol. 36, no. 3, pp. 505-509.</p> <p>Wuster, W., Dumbrell, A.J., Hay, C., Pook, C.E., Williams, D.J. and Fry, B.G. (2005). Snakes across the Strait: trans-Torresian phylogeographic relationships in three genera of Australasian snakes (Serpentes: Elapidae: <i>Acanthophis</i>, <i>Oxyuranus</i>, and <i>Pseudechis</i>). <i>Molecular Phylogenetics and Evolution</i>, Vol. 34, pp. 1-14.</p> <p>Threatened Species Scientific Committee (2015). <i>Approved Conservation Advice – Acanthophis hawkei – Plains Death Adder</i>. Canberra: Department of the Environment. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/83821-conservation-advice.pdf [Accessed 1 May 2018].</p>	
Yellow-snouted Gecko <i>Lucasium occultum</i>	EN	VU	<p>Habitat: Prefers areas with well-developed leaf litter and grasses (King et al. 1982; Johansen 2006) in open forests dominated by <i>Eucalyptus miniata</i> and <i>E. tetradonta</i>. Commonly found in sandy red-loam substrates. Has been recorded in areas consisting of moderate to sparse Gamba grass (Beggs et al. 2012).</p> <p>Distribution: Endemic to the NT with known populations from north-west of Kakadu National Park and Wildman Reserve (King et al. 1982).</p>	<p>LOW</p> <ul style="list-style-type: none"> • Suitable habitat within project area • Project area is outside of known distribution – nearest records 70 km east of the project area.
			<p>Beggs, K., Armstrong, M., Woinarski, J. and Ward, S. (2012). <i>Threatened Species of the Northern Territory - Yellow-Snouted Gecko - Lucasium occultum</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0007/206458/yellow-snouted-gecko.pdf [Accessed 1 May 2018].</p> <p>Johansen, T. (2006). <i>The yellow-snouted gecko (Diplodactylus occultus), a little known endemic species of northern Australia</i>. Report to NT Department of Natural Resources Environment and the Arts.</p> <p>King, M., Braithwaite, R.W. and Wombey, J.C. (1982). A new species of <i>Diplodactylus</i> (Reptilia: Gekkonidae) from the Alligator Rivers region - Northern Territory. <i>Transactions of the Royal Society of South Australia</i>, Vol. 106, pp. 15-18.</p>	
Oenpelli Python <i>Simalia (Morelia) oenpelliensis</i>	-	VU	<p>Habitat: Shelters in cracks, caves and crevices of rugged sandstone escarpments and gorges; or in large shady trees. Within this environment, reported from monsoon rainforest patches, riparian areas, woodlands, open heathlands and bare rock pavements (Woinarski & Ward 2012).</p> <p>Distribution: Restricted to the sandstone massif of Western Arnhem Land in the NT. Reported in the upper catchments of the Cadell, also in the South and East Alligator River systems (Woinarski & Ward 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • Restricted to the sandstone massif of Western Arnhem Land.
			<p>Woinarski, J. and Ward, S. (2012). <i>Threatened Species of the Northern Territory - Oenpelli Python - Morelia oenpelliensis</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0008/206459/oenpelli-python.pdf [Accessed 1 May 2018].</p>	
Mertens' Water Monitor <i>Varanus mertensi</i>	-	VU	<p>Habitat: Semi-aquatic, occupying edges of freshwater watercourses and lagoons, but seldom seen far from water (Christian 2004).</p> <p>Distribution: Across far northern Australia from the western Cape York Peninsula in Qld to the Kimberley in WA (Christian 2004). Widespread in the NT, occupying all of the Top End river systems (Ward et al. 2006). Few records for the Darwin region. Susceptible to ingesting toxic Cane Toads resulting in reduced abundance (Griffiths & McKay 2007).</p>	<p>HIGH</p> <ul style="list-style-type: none"> • Suitable habitat in the project area. • Most recent proximate record 300 m east of the project area (south end of the easement) in 2020. Smattering of other records in this area.
			<p>Christian, K. (2004). <i>Varanus mertensi</i>. In: Pianka et al. (eds.). <i>Varanoid lizards of the world</i>. Indiana University Press, Bloomington, Indianapolis.</p>	

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			Griffiths, A.D. and McKay (2007). Cane toads reduce the abundance and site occupancy of Merten's water monitor (<i>Varanus mertensi</i>). <i>Wildlife Research</i> , Vol. 34, pp. 609-615. Ward, S., Woinarski, J., Griffiths, T. and McKay, L. (2006). <i>Threatened Species of the Northern Territory - Mertens Water Monitor - Varanus mertensi</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0018/206460/mertens-water-monitor.pdf [Accessed 1 May 2018].	
Mitchell's Water Monitor <i>Varanus mitchelli</i>	-	VU	Habitat: Semi-aquatic and often arboreal, inhabiting margins of freshwater watercourses, swamps and lagoons (Shine 1986). Distribution: Top End of the NT and Kimberley in WA (Schultz & Doody 2004). In the NT, recorded in most catchments flowing into the Timor Sea, Arafura Sea and the Gulf of Carpentaria (Ward 2012). Susceptible to ingesting toxic Cane Toads resulting in reduced abundance (Doody et al. 2009).	LOW <ul style="list-style-type: none"> • No recent proximate records – 1978 record at Manton Dam and record 15 km west of project area from 1973. • Severe decline in occurrence post-Cane Toads
			Doody, J.S., Green, B., Rhind, D., Castellano, C., Sims, R. and Robinson, T. (2009). Population-level declines in Australian predators caused by an invasive species. <i>Animal Conservation</i> , Vol. 12, pp. 46-53. Schultz, T. and Doody, S. (2004). <i>Varanus mitchelli</i> . In: Pianka et al. (eds.). <i>Varanoid lizards of the world</i> . Indiana University Press, Bloomington, Indianapolis. Shine, R. 1986. Food habits, habitats and reproductive biology of four sympatric species of varanid lizards in tropical Australia. <i>Herpetologica</i> , Vol. 42, pp. 346-360. Ward, S. (2012). <i>Threatened Species of the Northern Territory - Mitchell's Water Monitor - Varanus mitchelli</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0019/206461/mitchells-water-monitor.pdf [Accessed 1 May 2018].	
Floodplain Monitor <i>Varanus panoptes</i>	-	VU	Habitat: Broad range of habitats from coastal beaches to savannah woodlands (Christian 2004). Also common throughout floodplains grasslands and a variety of native woodlands (Ward et al. 2012). Distribution: Across northern Australia from the Kimberley in WA to Cape York Peninsula, and southwards through most of Qld. In the NT, recorded across most of the Top End and the Gulf Region (Christian 2004). Highly susceptible to cane toad poisoning (Ujvari & Madsen 2009), and has experienced significant declines (Doody et al. 2009).	MEDIUM <ul style="list-style-type: none"> • Suitable habitat within the project area • Most recent proximate record 11.5 km north-east of the project area from 2019 • Records from the early 1990's adjacent to the project area • Despite substantial survey effort in the Greater Darwin region there are few recent records
			Christian, K. (2004). <i>Varanus panoptes</i> . In: Pianka et al. (eds.). <i>Varanoid lizards of the world</i> . Indiana University Press, Bloomington, Indianapolis. Doody, J.S., Green, B., Rhind, D., Castellano, C., Sims, R. and Robinson, T. (2009). Population-level declines in Australian predators caused by an invasive species. <i>Animal Conservation</i> , Vol. 12, pp. 46-53. Ujvari, B. & Madsen, T. (2009). Increased mortality of naive varanid lizards after the invasion of non-native cane toads (<i>Bufo marinus</i>). <i>Herpetological Conservation and Biology</i> , Vol. 4, pp. 248-251. Ward, S., Woinarski, J., Griffiths, T. & McKay, L. (2012). <i>Threatened Species of the Northern Territory - Yellow Spotted Monitor, Northern Sand Goanna, Floodplain Monitor - Varanus panoptes</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0006/206466/floodplain-monitor.pdf [Accessed 1 May 2018].	
AMPHIBIANS				
Howard Springs Toadlet <i>Uperoleia daviesae</i>	-	VU	Habitat: Appears to be confined to seasonally inundated, low relief sandsheet heathland associated with drainage systems. Suitable habitat consists of shallowly inundated seepage areas with sedges and herbs on sandy substrates (Ward et al. 2012). Habitat may be reliant on a perched aquifer overlying a lateritic or clay layer, which is influenced by rainfall inputs and localised drainage.	LOW <ul style="list-style-type: none"> • No sandsheet heath habitat within the project area.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Distribution: Endemic to the Darwin region in the northern NT. Confined to sandsheet heathlands in the Howard and Elizabeth River catchments (Ward et al. 2012).</p> <p>Ward, S., Young, S. and Hill, B. (2012). <i>Threatened Species of the Northern Territory - Howard River Toadlet – Uperoleia daviesae</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0003/205527/howard-river-toadlet.PDF [Accessed 1 May 2018].</p>	
FISH				
<p>Northern River Shark <i>Glyphis garricki</i></p>	EN	EN	<p>Habitat: Little is known of the ecology, probably restricted to shallow, brackish reaches of large rivers (Ward & Larson 2012).</p> <p>Distribution: In Australia, there are few records, including in the NT from the Adelaide, East and South Alligator River systems. Also known from the Kimberley coast and King Sound in WA (Thorburn & Morgan 2004; Compagno et al. 2008). NT distribution does not extend into the Gulf of Carpentaria.</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area.
<p>Compagno, L.J.V., White, W.T. and Last, P.R. (2008). <i>Glyphis garricki</i> sp. nov., a new species of river shark (Carcharhiniformes: Carcharhinidae) from northern Australia and Papua New Guinea, with a redescription of <i>Glyphis glyphis</i> (Müller & Henle, 1839). In: Last et al. (eds.). <i>Descriptions of New Australian Chondrichthyans</i>. CSIRO Marine and Atmospheric Research Paper, 022: pp. 203-226.</p> <p>Thorburn, D.C. and Morgan, D.L. (2004). The northern river shark, <i>Glyphis</i> sp. C (Carcharhinidae) discovered in Western Australia. <i>Zootaxa</i>, Vol. 685, pp. 1-8.</p> <p>Ward, S. and Larson, H. (2012). <i>Threatened Species of the Northern Territory – Northern River Shark – Glyphis garricki</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0005/206384/northern-river-shark.pdf [Accessed 1 May 2018].</p>				
<p>Speartooth Shark <i>Glyphis glyphis</i></p>	CR	VU	<p>Habitat: Tropical fresh water and marine environments (Bradshaw et al. 2008). May be restricted to low salinity environments such as freshwater or brackish areas of rivers (DoE 2017).</p> <p>Distribution: Papua New Guinea and Northern Australia. Considered to be very rare in Australia as few specimens have been collected (Cavanagh et al. 2003). Three distinct geographical locations in the NT and northern Qld (DoE 2017). In the NT, recorded in the Alligator River region across to Adelaide River, and the Bizant River (Ward and Larson 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area.
<p>Bradshaw, C.J.A., Fitzpatrick, B.M., Steinberg, C.C., Brook, B.W. and Meekan, M.G. (2008). Decline in whale shark size and abundance at Ningaloo Reef over the past decade: the world's largest fish is getting smaller. <i>Biological Conservation</i>, Vol. 141, pp. 1894–1905.</p> <p>Cavanagh, R., Kyne, P., Fowler, S., Musick, J. and Bennett, M. (eds.) (2003). <i>The Conservation Status of Australian Chondrichthyans</i>. Report of the IUCN Shark Specialist Group Australia and Oceania Red List Workshop. The University of Queensland, School of Biomedical Sciences, Brisbane, Australia.</p> <p>Department of the Environment (2017). <i>Glyphis glyphis - Speartooth Shark</i>. Species Profile and Threats Database, Department of the Environment, Canberra. [online] Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82453 [Accessed 1 May 2018].</p> <p>Ward, S. and Larson, H. (2012). <i>Threatened Species of the Northern Territory - Speartooth Shark - Glyphis glyphis</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0009/206388/speartooth-shark.pdf [Accessed 1 May 2018].</p>				
<p>Dwarf Sawfish <i>Pristis clavata</i></p>	VU	VU	<p>Habitat: Tropical marine and estuarine habitats, entering estuarine or fresh waters to breed during the wet season and moving into marine waters following the wet season (Peverell 2005).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Distribution: Indonesia, South-East Asia and northern Australia (Cavanagh et al. 2003). In the NT, known to occur around Darwin (including Buffalo Creek and Rapid Creek), in Kakadu National Park (Alligator River), Keep River and Victoria River (Thorburn et al. 2003).</p>	
			<p>Cavanagh, R., Kyne, P., Fowler, S., Musick, J. and Bennett, M. (eds.) (2003). <i>The Conservation Status of Australian Chondrichthyans</i>. Report of the IUCN Shark Specialist Group Australia and Oceania Red List Workshop. The University of Queensland, School of Biomedical Sciences, Brisbane, Australia.</p> <p>Peverell, S.C. (2005). Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on their ecology. <i>Environmental Biology of Fishes</i>, Vol. 73, pp. 391-402.</p> <p>Thorburn, D.C., Peverell, S., Stevens, S., Last, J.D. and Rowland, A.J. (2003). <i>Status of freshwater and estuarine elasmobranchs in Northern Australia</i>. Report to Natural Heritage Trust, Canberra.</p>	
<p>Freshwater or Largetooth Sawfish <i>Pristis pristis</i></p>	VU	VU	<p>Habitat: Tropical marine and estuarine habitats, entering estuarine or fresh waters to breed during the wet season and moving into marine waters following the wet season (Peverell 2005). Of the four <i>Pristis</i> species reported to occur in Australia, is the one most often associated with freshwater, and has been recorded several hundred kilometres upstream (Thorburn et al. 2003).</p> <p>Distribution: Circumtropical, with distinct populations in the eastern Atlantic, western Atlantic, eastern Pacific and Indo-West Pacific – including northern Australia (TSSC 2014). In the NT, reported in Adelaide, Victoria, Daly, East and South Alligator, Goomadeer, Roper, McArthur, Wearyan and Robinson Rivers (TSSC 2014). May potentially occur in all large rivers of northern Australia from the Fitzroy River, WA, to the western side of Cape York Peninsula, Qld (DoE 2018).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area.
			<p>Department of the Environment (DoE) (2018). <i>Pristis pristis in Species Profile and Threats Database</i>, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. [Accessed 1 May 2018].</p> <p>Peverell, S.C. (2005). Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on their ecology. <i>Environmental Biology of Fishes</i>, Vol. 73, pp. 391-402.</p> <p>Threatened Species Scientific Committee (2014). <i>Approved Conservation Advice - Pristis pristis (largetooth sawfish)</i>. Canberra: Department of the Environment. In effect under the EPBC Act from 11-April-2014. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf [Accessed 1 May 2018].</p>	
<p>Green Sawfish <i>Pristis zijsron</i></p>	VU	VU	<p>Habitat: Tropical waters – including marine inshore waters, river mouths, estuaries and lagoons – but not freshwater (Thorburn et al. 2003). Enters estuarine to breed during the wet season and moves back into marine waters following the wet season (Peverell 2005).</p> <p>Distribution: Northern Australia, South-East Asia and the Indian Ocean (Cavanagh et al. 2003). Most frequently encountered of the sawfish species in Australian waters (Last & Stevens 1994). Most commonly known from the Gulf of Carpentaria (Stevens et al. 2005). In the NT specimens have only been collected from Buffalo Creek in Darwin (Stirrat et al. 2006).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area.
			<p>Cavanagh, R., Kyne, P., Fowler, S., Musick, J. and Bennett, M. (eds.) (2003). <i>The Conservation Status of Australian Chondrichthyans</i>. Report of the IUCN Shark Specialist Group Australia and Oceania Red List Workshop. The University of Queensland, School of Biomedical Sciences, Brisbane, Australia.</p> <p>Last, P.R. and Stevens, J.D. (1994). <i>Sharks and Rays of Australia</i>. CSIRO, Melbourne.</p>	

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Peverell, S.C. (2005). Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on their ecology. <i>Environmental Biology of Fishes</i>, Vol. 73, pp. 391-402</p> <p>Stirrat, S., Larson, H. and Woinarski, J. (2006). <i>Threatened Species of the Northern Territory - Green Sawfish - Pristis zijsron</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0006/206394/green-sawfish.pdf [Accessed 1 May 2018].</p> <p>Thorburn, D.C., Peverell, S., Stevens, S., Last, J.D. and Rowland, A.J. (2003). <i>Status of freshwater and estuarine elasmobranchs in Northern Australia</i>. Report to Natural Heritage Trust, Canberra.</p>	
INVERTEBRATES				
Atlas Moth <i>Attacus wardi</i>	-	VU	<p>Habitat: Coastal monsoon vine forest, where the larval stages feed on the plant <i>Croton habrophyllus</i> at the edges of the forest (Lane et al. 2010).</p> <p>Distribution: The Top End of the NT, with records from Tiwi and Melville Islands, Darwin, Black Point and Cobourg Peninsula. Also records from Lesuer Island in WA (Braby & Nielsen 2011).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No coastal monsoon vine forest within the project area
			<p>Braby, M.F. and Nielsen, J. (2011). Review of the conservation status of the Atlas Moth, <i>Attacus wardi</i> Rothschild, 1910 (Lepidoptera: Saturniidae) from Australia. <i>Journal of Insect Conservation</i>, Vol. 15, pp. 603-608.</p> <p>Lane, D., Martin, G. and Weir, R.P. (2010). The life history of <i>Attacus wardi</i> Rothschild (Lepidoptera: Saturniidae) from the Northern Territory, Australia. <i>Australian Entomology</i>, Vol. 37, pp. 115-127.</p>	
Victoria's Land Snail <i>Trachioopsis victoriana</i>	-	VU	<p>Habitat: Found in leaf litter at the base of large limestone boulders in a marshy sink. Also recorded buried in soil in open <i>Eucalyptus</i> woodlands (Solem 1985).</p> <p>Distribution: Reported in and around a limestone sinkhole adjacent to the Victoria Highway, 86 km south-west of Katherine (Solem 1985). Possibly naturally extremely restricted in range.</p>	<p>LOW</p> <ul style="list-style-type: none"> • No recent or proximate records – record 45 km to north-west from 1985. • All other records >160 km south.
			<p>Solem, A. (1985). <i>Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae) - V Remaining Kimberley genera and addenda to the Kimberley</i>. Records of the Western Australian Museum Supplement 20, pp. 707-981.</p> <p>Wilson, C., Woinarski, J., Kessner, V. and Braby, M. (2006). <i>Threatened Species of the Northern Territory - Victoria's Land Snail - Setobaudinia victoriana</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0007/206539/setobaudinia-victoriana.pdf [Accessed 1 May 2018].</p>	
FLORA				
a shrub <i>Acacia praetermissa</i>	VU	VU	<p>Habitat: Upper to lower slopes with various aspects in stony, skeletal or sandy soils on sandstone or laterite substrates with <i>Eucalyptus miniata</i> and <i>E. tetradonta</i> (NTH 2020). Several sites are on the slopes of a tertiary plateau remnant; others are on ridge slopes (Cowie & Kerrigan 2012). Flowers recorded between Jan-Sept, and fruits from Jan-Mar and Jul-Oct (Holmes et al. 2007).</p> <p>Distribution: Endemic to the NT, collected from two roadside localities along 25 km of the Stuart Highway; near Emerald Springs and Hayes Creek (Dunlop et al. 1995). Some targeted searches have been conducted and considerable survey has been conducted in the wider region, suggesting that existing records reflect this species' restricted distribution and abundance (Cowie & Kerrigan 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • Outside of known distribution • Species has not been recorded north of Hayes Creek area.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Cowie, I. and Kerrigan, R. (2012). <i>Threatened Species of the Northern Territory - Acacia praetermissa</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/data/assets/pdf_file/0018/208404/acacia-praetermissa.pdf [Accessed 1 May 2018].</p> <p>Dunlop, CR., Leach, GJ. and Cowie, ID. (1995). <i>Flora of the Darwin Region</i>. Vol 2. Conservation Commission of the Northern Territory, Darwin.</p> <p>Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to the Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i>. WWF-Australia, Ultimo, NSW.</p> <p>Northern Territory Herbarium (NTH). (2020). FloraNT - Northern Territory flora online. Department of Land Resource Management. [accessed 27 October 2020].</p>	
a shrub <i>Atalaya brevialata</i>	CR	-	<p>Habitat: Restricted to foot-slope sites with more open vegetation on deeper, coarser sandy soils, mostly along a specific, distinct geological boundary (Cowie 2014).</p> <p>Distribution: Endemic to the NT; found south of Darwin, near Elizabeth River at Virginia, and its tributary – Amy’s Creek (Cowie 2014). Few targeted survey and there is uncertainty as to the taxonomic distinctness of the species. Extent of occurrence is 7.6 km², with a high degree of confidence as it occurs within one of the most heavily-surveyed areas in the NT (Cowie 2014).</p>	<p>LOW</p> <ul style="list-style-type: none"> • The project area intersects ~ 0.5 ha of modelled potential habitat in the western portion of the WTP • High likelihood habitat occurs 680 m north of the project area (WTP) • Habitat found to be not suitable during field surveys.
			<p>Cowie, I. (2014). <i>Threatened Species of the Northern Territory - Atalaya brevialata</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/data/assets/pdf_file/0008/376262/atalaya-brevialata.pdf [Accessed 1 May 2018].</p>	
a herb <i>Cleome insolata</i>	-	VU	<p>Habitat: Inundated sedge land growing on silty loam with coverage of laterite gravels in close proximity to a river catchment (Short 2010). Low open woodlands with <i>Grevillea pteridifolia</i>, <i>Melaleuca viridiflora</i>, <i>M. nervosa</i>, <i>Verticordia cunninghamii</i> and <i>Pandanus</i> over <i>Dapsilanthus</i>, <i>Eriachne burkittii</i>; <i>Sorghum</i> and <i>Alloteropsis</i>; on seasonally waterlogged sandy soils. Flowering Jan-Apr (NTH 2020).</p> <p>Distribution: Endemic to the NT, known from a population located near Humpty Doo, three populations in Lloyd Creek; from the Noonamah - Amys Creek area; Wishart Rd; near Shoal Bay and in the Darwin rural area (Westaway & Cowie 2012; EcOz records). A species-specific survey has not been carried out (Westaway & Cowie 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No sandsheet heath habitat within the project area.
			<p>Short, P.S. (2010). New species of <i>Cleome</i> L. (Cleomaceae) from the Northern Territory, Australia. <i>The Beagle</i>, Records of the Museum and Art Galleries of the Northern Territory, 2010, Vol. 26, pp. 1–12. [online] Available at: https://dtc.nt.gov.au/data/assets/pdf_file/0011/254954/Short.pdf [Accessed 1 May 2018].</p> <p>Northern Territory Herbarium (NTH). (2020). FloraNT - Northern Territory flora online. Department of Land Resource Management. [accessed 27 October 2020].</p> <p>Westaway, J. and Cowie, I. (2012). Threatened Species of the Northern Territory - <i>Cleome insolata</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/data/assets/pdf_file/0006/208428/cleome-insolata.pdf [Accessed 1 May 2018].</p>	
an orchid <i>Crepidium marsupichila</i>	-	VU	<p>Habitat: Prefers protected shady areas and moist soils rich in leaf litter along the margins of monsoon rainforest and littoral rainforest (Kerrigan & Cowie 2006).</p> <p>Distribution: An Australian endemic with known populations from north-eastern Qld and the NT. In the NT, only known from one locality, Gunn point</p>	<p>NONE</p> <ul style="list-style-type: none"> • No rainforest within the project area • In the NT, only known from Gunn Point

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			(Kerrigan & Cowie 2006). Limited amount of recent survey in the area, though extensive surveys in the 1980's of rainforest areas failed to find the species (Kerrigan & Cowie 2006).	
			Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Malaxis marsupichila</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0007/208690/malaxis-marsupichila.pdf [Accessed 1 May 2018].	
Darwin Cycad <i>Cycas armstrongii</i>	-	VU	<p>Habitat: Open grassy woodland where adequate drainage appears to be a limiting factor (Kerrigan et al. 2006). Prime habitat has deep loamy soil (Liddle 2009). Separate male and female plants, with male microsporophylls flowering in August, and female megasporophylls from March-Nov (Holmes et al. 2007)</p> <p>Distribution: Restricted to the Top End of the NT – from Gunn Point to Hayes Creek, west to within 50km of the coastline and east to the Wildman River catchment (Kerrigan et al. 2006). Also on the Tiwi Islands and Cobourg Peninsula.</p>	<p>HIGH</p> <ul style="list-style-type: none"> • Low numbers found throughout the project area.
			<p>Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to the Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i>. WWF-Australia, Darwin.</p> <p>Kerrigan, R., Cowie, I. and Liddle, D. (2006). <i>Threatened Species of the Northern Territory - Cycas armstrongii</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0017/208430/cycas-armstrongii.pdf [Accessed 1 May 2018].</p> <p>Liddle, D.T. (2009). Management Program for Cycads in the Northern Territory of Australia 2009-2014. Northern Territory Department of Natural Resources, Environment, the Arts and Sport, Darwin. http://www.territorystories.nt.gov.au/jspui/bitstream/10070/265358/1/Management%20program%20for%20cycads%20in%20the%20Northern%20Territory%20of%20Australia%202009%20to%202014.pdf [Accessed 1 May 2018].</p>	
a ground orchid <i>Dienia montana</i>	-	VU	<p>Habitat: Wet (spring-fed) rainforest (Kerrigan et al. 2013).</p> <p>Distribution: Northern Qld, and one population in the NT, near Munmarlary in Kakadu National Park. A targeted search in 2003 failed to record any plants at this locality (Kerrigan et al. 2013).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No rainforest in the project area • In the NT, only known from Kakadu National Park.
			Kerrigan, R., Cowie, I. and Ward S. (2013). <i>Threatened Species of the Northern Territory - Dienia montana</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0007/208474/dienia-montana-malaxis-latifolia.pdf [Accessed 1 May 2018].	
a sedge <i>Eleocharis retroflexa</i>	VU	-	<p>Habitat: On plateaux, in the margins of seasonal swamps and watercourses with <i>Melaleuca</i>, <i>Eucalyptus</i> and <i>Corymbia</i> species and grasses (Cowie & Kerrigan 2006).</p> <p>Distribution: Northern Qld near Cairns and in the NT in Nitmiluk National Park near Katherine (TSSC 2008).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No plateaux in the project area • Only known from locations over 200 km from the project area.
			<p>Cowie, I. and Kerrigan, R. (2006). <i>Threatened Species of the Northern Territory - Eleocharis retroflexa</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0010/376264/eleocharis-retroflexa.pdf [Accessed 1 May 2018].</p> <p>Threatened Species Scientific Committee (2008). Commonwealth Conservation Advice on <i>Eleocharis retroflexa</i>. Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/23672-conservation-advice.pdf [Accessed 1 May 2018].</p>	
Native Walnut	-	VU	<p>Habitat: Well-developed spring-fed rainforests on swampy or very wet substrates along creek margins (Kerrigan & Cowie 2006).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No rainforest habitat within the project area

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
<i>Endiandra limnophila</i>			<p>Distribution: Endemic to Australia – far north of Cape York Peninsula in Qld, and the Tiwi Islands and Channel point in the NT (Kerrigan & Cowie 2006). In the NT, recorded at approximately 22 locations with no more than 6 individuals at any one locality (Liddle et al. 1994). Extensive survey of the Tiwi Islands in 2000-02 yielded no further populations (Woinarski et al. 2003).</p>	<ul style="list-style-type: none"> On the mainland, only known from Channel Point.
<p>Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Endiandra limnophila</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0003/208434/endiandra-limnophila.pdf [Accessed 1 May 2018].</p> <p>Liddle, D.T., Russell-Smith, J., Brock, J., Leach, G.J. and Connors, G.T. (1994). <i>Atlas of the vascular rainforest plants of the Northern Territory</i>. Flora of Australia Supplementary Series No. 3, Australian Biological Resources Study, Canberra.</p> <p>Woinarski, J., Brennan, K., Cowie, I., Kerrigan, R., and Hempel, C. (2003). <i>Biodiversity conservation on the Tiwi islands, Northern Territory. Part 1. Plants and environments</i>. Department of Infrastructure Planning and Environment, Darwin.</p>				
Narrow-leaf Climbing Pandan <i>Freycinetia excelsa</i>	-	VU	<p>Habitat: Wet lowland rainforest and spring-fed rainforests in sandstone gullies (Kerrigan & Cowie 2006).</p> <p>Distribution: Known from Papua New Guinea, coastal Qld, and in the NT from seven locations between Bathurst Island and the Arafura Swamp (Kerrigan & Cowie 2006).</p>	<p>NONE</p> <ul style="list-style-type: none"> No rainforest habitat in the project area No proximate records – nearest records 55 km north at Gunn Point from 2004
<p>Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Freycinetia excelsa</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0018/208440/freycinetia-excelsa.pdf [Accessed 1 May 2018].</p>				
a herb <i>Goodenia quadrifida</i>	VU	-	<p>Habitat: Ecology not well known. Recorded growing in grassland on the upper parts of estuarine floodplains on poorly-drained grey clays or silty soils (Cowie & Kerrigan 2006). Grows on cracking clay soils on plains (NTH 2020). Flowering and fruiting from March to May (Cowie & Kerrigan 2006).</p> <p>Distribution: Endemic to the Top End of the NT. Rare. Known from the upper Adelaide River and Hardies Creek (a tributary of the Mary River) (Cowie & Kerrigan 2006).</p>	<p>LOW</p> <ul style="list-style-type: none"> No suitable habitat in the project area Only known from the Mary River and upper Adelaide River floodplains
<p>Cowie, I. and Kerrigan, R. (2006). <i>Threatened Species of the Northern Territory - Goodenia quadrifida</i>. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0006/376269/goodenia-quadrifida.pdf [Accessed 1 May 2018].</p> <p>Northern Territory Herbarium (NTH). (2020). FloraNT - Northern Territory flora online. Department of Land Resource Management. [accessed 27 October 2020].</p>				
a ground orchid <i>Habenaria rumphii</i>	-	EN	<p>Habitat: Occurs in open forest and woodland, on poorly drained sites which are partly inundated during the wet season. One NT collection was from a sandplain adjacent to the edge of a spring jungle. Flowers and fruits in Feb (NTH 2020).</p> <p>Distribution: Known from the northern parts of Australia, Papua New Guinea, and South-East Asia. Known in NT from the upper Howard River, south-east of Darwin, Litchfield NP and in the Wildman River area (DEPWS 2021).</p>	<p>LOW</p> <ul style="list-style-type: none"> Potentially suitable habitat within the project area No recent proximate records – nearest recent record 50 km south-west from 2016 Most proximate record 15 km north-east, but old record from 1989.
<p>Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to the Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i>. WWF-Australia, Darwin.</p>				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
Department of Environment, Parks and Water Security (2021). <i>Threatened species of the Northern Territory - Habenaria rumphii</i> . [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0004/208444/habenaria-rumphii.pdf [Accessed 5 December 2022].				
a shrub <i>Helicteres macrothrix</i>	EN	EN	<p>Habitat: Woodland dominated by <i>Eucalyptus tectifica</i>, <i>E. tetradonta</i> and <i>E. miniata</i> on sandy loam and rocky siltstone slopes or granitic rocks (Cowie et al. 2012). Absent from the laterite country predominant in the region (DoE 2017).</p> <p>Distribution: Restricted to the Top End of the NT where only three populations known – Mt Bundey, Batchelor/Glenluckie Creek and Lake Bennett (DoE 2017). While it is possible that extensive targeted searches may uncover additional subpopulations, there is a high degree of confidence in the broader distributional data (Cowie et al. 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • The project area intersects ~ 5 ha of modelled high likelihood habitat in the south half of the easement • Habitat verified as unsuitable during field surveys.
Cowie, I., Kerrigan, R. and Stuckey, B. (2012). <i>Threatened species of the Northern Territory - Helicteres Sp. Glenluckie Creek</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0005/208445/helicteres-macrothrix.pdf [Accessed 1 May 2018]. Department of the Environment (2017). <i>Helicteres macrothrix</i> . Species Profile and Threats Database, Department of the Environment, Australian Government, Canberra. http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=86586 .				
a sub-shrub <i>Hibbertia tricornis</i>	-	VU	<p>Habitat: Sandy scree among sandstone escarpments (Westaway & Cowie 2012).</p> <p>Distribution: Known only from one location at Mount Brockman on the central western escarpment on the Arnhem land plateau. This population is located within the Kakadu National Park south of Jabiru (Westaway & Cowie 2012). High level of general survey in the area suggests that substantial increases are unlikely (Westaway & Cowie 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No sandstone escarpment in the project area • Known only from the West Arnhem Land plateau.
Westaway, J. and Cowie, I. (2012). <i>Threatened Species of the Northern Territory - Hibbertia tricornis</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0019/208450/hibbertia-tricornis.pdf [Accessed 1 May 2018].				
a shrub <i>Hibiscus brennanii</i>	VU	VU	<p>Habitat: Sandstone cliffs, in gullies and on broken sandstone (Kerrigan & Cowie 2006).</p> <p>Distribution: Endemic to the NT, with restricted population in the Mt Brockman area to the west of Arnhem Land (Kerrigan & Cowie 2006). Considered adequately surveyed (Kerrigan & Cowie 2006).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No sandstone country in the project area • Restricted to Mt Brockman area.
Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Hibiscus brennanii</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0003/208452/hibiscus-brennanii.pdf [Accessed 1 May 2018].				
a shrub <i>Jacksonia divisa</i>	-	VU	<p>Habitat: Associated with shrubland on sandy kaolinite clay on ledges around the escarpment of a tertiary plateau (Cowie & Westaway 2012).</p> <p>Distribution: Endemic to the NT; found on the edges of a gorge on the eroding western margin of the Marrawal Plateau at Bloomfield Springs in southern Kakadu National Park (Cowie & Westaway 2012). An intensive</p>	<p>NONE</p> <ul style="list-style-type: none"> • No plateau habitat within the project area • Only known from Kakadu National Park.

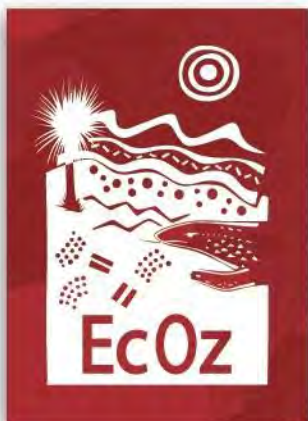
Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			survey of adjoining Nitmiluk National Park in 1999- 2001 failed to find additional subpopulations (Cowie & Westaway 2012).	
Cowie, I. and Westaway, J. (2012). <i>Threatened Species of the Northern Territory - Jacksonia divisa</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0011/208469/jacksonia-divisa.pdf [Accessed 1 May 2018].				
Pink Myrtle <i>Lithomyrtus linariifolia</i>	-	VU	Habitat: Heaths or eucalypt woodlands on sandstone, in sandy or skeletal soils, often along the margins of <i>Allosyncarpia ternata</i> forest and almost always growing amongst <i>Triodia microstachya</i> (Kerrigan & Cowie 2006). Distribution: Endemic to the NT; found within Kakadu National Park and Arnhem Land (Kerrigan & Cowie 2006). Considered adequately surveyed.	NONE <ul style="list-style-type: none"> • No suitable habitat in the project area • Only known from Kakadu National Park and Arnhem Land.
Kerrigan, R. (2004). <i>Kakadu Threatened Flora Report</i> . Volume 2. Results of a threatened flora survey 2004. NT Department of Infrastructure Planning and Environment, Darwin. Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Lithomyrtus linariifolia</i> . Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/_data/assets/pdf_file/0003/208470/lithomyrtus-linariifolia.pdf [Accessed 1 May 2018].				
Luisia Orchid <i>Luisia corrugata</i>	-	VU	Habitat: An epiphyte that commonly grows on trees with scaly bark and prefers the areas of bright light (non-shaded area). Within the NT, collected from the margins of monsoon rainforests. Elsewhere, more common in coastal and near coastal habitats (Kerrigan & Cowie 2012). Distribution: Appears to be endemic to the NT with known populations from Melville Island and the mainland (Bankers Jungle and Crocodile Creek in Black Jungle Conservation Reserve) (Kerrigan & Cowie 2012). It is likely that the existing collections accurately reflect the abundance and distribution of this species (Kerrigan & Cowie 2012).	LOW <ul style="list-style-type: none"> • No monsoon forest edge or coastal habitats in the project area • Closest record 30 km north-east of the project area at Bankers Jungle in 2018.
Kerrigan, R. and Cowie, I. (2012). <i>Threatened Species of the Northern Territory - Luisia corrugata</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0005/208472/luisia-corrugata.pdf [Accessed 1 May 2018].				
Arrowleaf Monochoria <i>Monochoria hastata</i>	-	VU	Habitat: Grows in floating mat vegetation in permanent to near-permanent back-swamps, drainage channels and billabongs (Kerrigan & Cowie 2006). Inflorescence of 25-60 flowers occurs from March-June, and capsule fruits from April-June (Holmes et al. 2007). Distribution: New Guinea, India, Sri Lanka, South-East Asia. In Australia, only found in the NT on the floodplains of the Finnis, Reynolds and Wildman Rivers (Kerrigan & Cowie 2006). There is a negative collection bias associated with the swampy habitat in which this species occurs. However, extensive coverage of floodplains in the Kakadu region detected this species at only one location in that region (Wildman River). Furthermore, it is considered that the extensive surveys of the Top End floodplain communities (Wilson et al. 1991) during the 1990s would have detected this species more often had it been more common or widespread (Kerrigan & Cowie 2006).	LOW <ul style="list-style-type: none"> • No swamp/billabong habitat within the project area • No proximate records – nearest records are 62 km from the project area.
Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to the Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i> . WWF-Australia, Darwin.				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory - Monochoria hastata</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0003/208479/monochoria-hastata.pdf [Accessed 1 May 2018].</p> <p>Wilson, B.A., Brocklehurst, P.S. and Whitehead, P.J. (1991). <i>Classification, distribution and environmental relationships of coastal floodplain vegetation, Northern Territory, Australia</i>. Technical Report 91/2. Conservation Commission of the Northern Territory, Darwin.</p>	
Darwin Palm <i>Ptychosperma macarthurii</i>	-	EN	<p>Habitat: Dense rainforests fed from lowland springs at the edges of tropical riverine floodplains. Common in deep organic loamy clay substrates without humus development (Liddle et al. 2006). Flowers occur in branched inflorescence from May-Dec, and red fleshy drupe fruits from Aug-Sept and Nov-Dec (Holmes et al. 2007).</p> <p>Distribution: Known from the NT, Cape York Peninsula and Papua New Guinea. Within the NT, known from eight locations on the western margin of the Adelaide River Floodplain (Liddle et al. 2006). Survey effort is not documented.</p>	<p>LOW</p> <ul style="list-style-type: none"> • No rainforest habitat in the project area.
			<p>Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to the Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i>. WWF-Australia, Darwin.</p> <p>Liddle, D.T., Brook, B., Matthews, J., Taylor, S.M. and Caley, P. (2006). Threat and response: A decade of decline in a regionally endangered rainforest palm affected by fire and introduced animals. <i>Biological Conservation</i>, Vol. 132, pp. 362-375.</p>	
a shrub / tree <i>Schoutenia ovata</i>	-	EN	<p>Habitat: Monsoonal vine thicket on both granite and limestone outcrops. Predominant on south-facing slopes within the Mt Bunday region (Cowie & Kerrigan 2012).</p> <p>Distribution: Occurs in three disjunct populations in the NT – two located at Mt Bunday and Mt Goyder and one near Tipperary Station (Liddle et al. 1994). The general habitat has been sufficiently well sampled across the Top End to indicate that its apparently highly restricted distribution in the NT is accurate (Cowie & Kerrigan 2012).</p>	<p>NONE</p> <ul style="list-style-type: none"> • No suitable habitat in the project area • Appears to be highly restricted and known only from three disjunct populations >50 km from the project area.
			<p>Cowie, I. and Kerrigan, R. (2012). <i>Threatened Species of the Northern Territory - Schoutenia ovata</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0006/208491/schoutenia-ovata.pdf [Accessed 1 May 2018].</p> <p>Liddle, D.T., Russell-Smith, J., Brock, J., Leach, G.J. and Connors, G.T. (1994). <i>Atlas of the vascular rainforest plants of the Northern Territory</i>. Flora of Australia Supplementary Series No. 3, ABRIS, Canberra.</p>	
a trigger plant <i>Stylidium ensatum</i>	EN	EN	<p>Habitat: Margins of drainage areas in damp heavy clay or peaty soil (Cowie & Westaway 2012). Occurs with sedges (e.g. <i>Fimbristylis furva</i>), perennial grasses such as <i>Eriachne burkittii</i>, herbs such as <i>Burmanna</i> spp. and shrubs such as <i>Osbeckia</i> spp. and scattered <i>Banksia dentata</i> (TSSC 2016). Associated with <i>Melaleuca viridiflora</i> and <i>Lophostemon lactifluus</i> (Holmes et al. 2007). Sites occupied are poorly drained sandy or loamy flats that are seasonally inundated and are damp well into the Dry season (June-Aug) (TSSC 2016). Flowering and fruiting June and July (Holmes et al. 2007; Cowie & Westaway 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • The project area intersects ~ 0.5 ha of high likelihood modelled habitat in the western portion of the WTP • Habitat verified as unsuitable during field surveys.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			<p>Distribution: Known from three localities – Shoal Bay, Girraween Rd, Hayes Creek. Other historical collections recorded; however, the exact locality for these collections is unknown. Populations at Girraween Rd. and Hayes Creek still exist based on NT Herbarium surveys in recent years. Only additional subpopulation has been located on Koolpinyah Station near Gunn Point Rd., despite several flora and biodiversity surveys in the Darwin region over the last ten years (but no systematic survey of potentially suitable habitat at an appropriate time of year). Substantial areas of potentially-suitable habitat south from Darwin towards Hayes Creek that are relatively poorly surveyed and it is likely that additional subpopulations exist (Cowie & Westaway 2012).</p>	
<p>Cowie, I. and Westaway, J. (2012). <i>Threatened species of the Northern Territory - Styliidium ensatum</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0009/208494/styliidium-ensatum.pdf [Accessed 1 May 2018].</p> <p>Holmes, J., Bisa, D., Hill, A. and Crase, B. (2007). <i>A Guide to Threatened, Near Threatened and Data Deficient Plants in the Litchfield Shire of the Northern Territory</i>. WWF-Australia, Darwin.</p> <p>Threatened Species Scientific Committee. 2016. Conservation Advice. <i>Styliidium ensatum</i>. Department of the Environment, Canberra.</p>				
<p>a herb <i>Typhonium praetermissum</i></p>	-	VU	<p>Habitat: Open woodland including relatively unshaded areas in red brown clay and shallow or gravelly lateritic soil (Cowie & Westaway 2012).</p> <p>Distribution: Endemic to the NT. Previously recorded at six locations in the Darwin/Litchfield area – Virginia, Karama, the Palmerston escarpment, Mandorah and Humpty Doo (Cowie & Westaway 2012). Two new sub-populations recorded in Lloyd Creek (EcOz records). Low number of fertile collections thought to be due to the species seasonality rather than its abundance. Targeted survey of potential habitat in the Darwin region is a priority for this species (Cowie & Westaway 2012). Targeted survey have been undertaken in the Darwin region in 2016 and additional sub-populations have been identified at both Gunn Point and the southern extent of Cox Peninsular (Green, Cuff 2016)</p>	<p>HIGH</p> <ul style="list-style-type: none"> • Suitable habitat within the project area • Detected in the WTP during field surveys.
<p>Cowie, I. and Westaway, J. (2012). <i>Threatened species of the Northern Territory - Typhonium praetermissum</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0017/208502/typhonium-praetermissum.pdf [Accessed 1 May 2018].</p> <p>Green, C. and Cuff, N. Threatened Species Distribution in the Greater Darwin Region – <i>Typhonium praetermissum</i> Population Status of <i>Typhonium praetermissum</i>, November 2015</p>				
<p>a herb <i>Typhonium taylori</i></p>	EN	EN	<p>Habitat: Seasonally-saturated sandy substrate in nutrient-deficient grass/sedge land (Kerrigan & Cowie 2006).</p> <p>Distribution: Endemic to the NT, with the only known population from the edge of the Howard River floodplain (Kerrigan & Cowie 2006). Targeted survey for this species in the Howard River Floodplain as part of a biodiversity assessment survey (Cowie 2002) did not relocate or uncover any additional populations of this species. Considered adequately surveyed, based on the strong survey effort in the area and the high profile of this</p>	<p>LOW</p> <ul style="list-style-type: none"> • No sandsheet heath habitat within the project area.

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
			genus amongst collectors. While more populations may exist, the paucity of collections of this species is considered to accurately reflect its very restricted distribution and abundance (Kerrigan & Cowie 2006).	
Cowie, I. D. (2002). <i>Preliminary report on a survey of Utricularia (Lentibulariaceae) in the Howard River – Shoal Bay area</i> . NT Department of Infrastructure Planning and Environment, Darwin. Kerrigan, R. and Cowie, I. (2006). <i>Threatened species of the Northern Territory - Typhonium taylori</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0019/208504/typhonium-taylori.pdf [Accessed 1 May 2018].				
a bladderwort <i>Utricularia dunstaniae</i>	-	VU	<p>Habitat: 'Sandsheet heath' type habitats with wet sand, often in shallow water, in paperbark (<i>Melaleuca nervosa</i>) woodland or Feather-flower (<i>Verticordia</i>) shrub land. Occurs in slightly wetter micro-habitats than other sympatric <i>Utricularia</i> species, frequently where water is percolating from the ground (Kerrigan & Cowie 2012).</p> <p>Distribution: Endemic to Australia, known from WA and the NT – where known from nine locations. Locations near Darwin are Noonamah, Howard Springs and the Howard River floodplain. Other sub-populations on the Cobourg Peninsula, near Murgendela and near Finnis River (Kerrigan & Cowie 2012). As apparently suitable habitat within the extent of occurrence remains unsurveyed, it is likely that additional, undiscovered subpopulations exist (Kerrigan & Cowie 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No sandsheet heath habitat within the project area.
Kerrigan, R. and Cowie, I. (2012). <i>Threatened Species of the Northern Territory - Utricularia dunstaniae</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0020/208505/utricularia-dunstaniae.pdf [Accessed 1 May 2018].				
a bladderwort <i>Utricularia singeriana</i>	-	VU	<p>Habitat: Borders of seasonally-inundated grassland (Cowie & Kerrigan 2012) and low open woodland (Holmes et al. 2005). Dominant associated plants include Eriachne burkittii, Sorghum spp., Pseudopogonatherum spp. and sedges (Cowie & Kerrigan 2012). Also recorded growing near granite outcrops (Holmes et al. 2005). Often in shallow water (to 2 cm deep) on moist sandy or sandy loamy substrates (Holmes et al. 2005). Flowering between March and May, and fruiting begin in May (Cowie & Kerrigan 2012).</p> <p>Distribution: Endemic to the NT with known populations from five locations between Darwin and Katherine – the nearest Darwin being Finn Rd in Weddell. Other sites are the Edith River area, near the Finnis River, and the Marrawal Plateau east of Pine Creek. Port Darwin population (early 1900's record) no longer in existence (Kerrigan & Cowie 2012). As much apparently suitable habitat within the extent of occurrence remains unsurveyed, it is likely that additional undiscovered sub-populations exist (Kerrigan & Cowie 2012).</p>	<p>LOW</p> <ul style="list-style-type: none"> • No sandsheet heath habitat within the project area.
Cowie, I. and Kerrigan, R. (2012). <i>Threatened Species of the Northern Territory - Utricularia singeriana</i> . Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0003/208506/utricularia-singeriana.pdf [Accessed 1 May 2018].				

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
a ground orchid <i>Zeuxine oblonga</i>	-	VU	<p>Habitat: Grows in clusters in dark and moist situations in wet rainforest or in wet peaty areas near streams (Jones 1988).</p> <p>Distribution: Qld, NSW and in the NT, where known from five widely-spaced locations south and south-west of Darwin, from Keep River near the WA border to south-west of Adelaide River (Liddle et al. 1994). Not collected since 1992, despite efforts to relocate the Keep River population in 2000 and 2001 (Kerrigan & Cowie 2006). There is a negative collection bias associated with this species due to its ephemeral nature.</p>	<p>LOW</p> <ul style="list-style-type: none"> • Riparian vegetation at the south end of the easement maybe suitable • No recent or proximate records - not detected since 1992 and the nearest record 55 km south
<p>Jones, D.L. (1988). <i>Native Orchids of Australia</i>. Reed, Sydney.</p> <p>Kerrigan, R. and Cowie, I. (2006). <i>Threatened Species of the Northern Territory – Zeuxine oblonga</i>. Northern Territory Department of Environment and Natural Resources. https://nt.gov.au/_data/assets/pdf_file/0008/208691/zeuxine-oblonga.pdf [Accessed 1 May 2018].</p> <p>Liddle, D.T., Russell-Smith, J., Brock, J., Leach, G.J. and Connors, G.T. (1994). Atlas of the vascular rainforest plants of the Northern Territory. <i>Flora of Australia Supplementary Series No. 3</i>, Australian Biological Resources Study, Canberra.</p>				



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**APPENDIX C STAKEHOLDER ENGAGEMENT AND
COMMUNICATIONS PLAN**

Stakeholder Engagement and Communications Plan – Manton Dam Return to Service Project

Reference	D2022/188761
Marketing and Communications lead	Danna Irwin, Strategic Communications Consultant
Business unit lead	Trevor Durling, Senior Headworks Planning Engineer

Purpose

The purpose of this Stakeholder Engagement and Communications Plan is to identify the key stakeholders for the Manton Dam Return to Service (RTS) project and to outline an approach for how the project team will effectively engage with stakeholders to support the delivery of the project and communicate project information to the community.

Background

Built in the 1940s with a storage capacity of 14,000 megalitres (million litres), Manton Dam was Darwin's primary source of water until Darwin River Dam was commissioned in 1972. Darwin River Dam has been the main water supply source in the region ever since.

Manton Dam was opened for recreation use by the Northern Territory Government in the late 1980s and, since then, it has remained in 'care and maintenance' as a potential future water supply source.

Current situation

With demand for water in the Darwin region expected to more than double by 2050, Power and Water is working with the NT Government to deliver the Darwin Region Water Supply Infrastructure Program which will secure Darwin's water future for the next 30 years and beyond. This includes two major projects, Manton Dam return to service and the Adelaide River Off-stream Water Storage (AROWS). The Department of Industry, Tourism and Trade (DITT) are leading the overall stakeholder engagement and communications for the Infrastructure Program and the project development (pre-construction phase) for the AROWS project.

The infrastructure program is the result of several years of careful planning by Power and Water about the best ways to add new sources of water to our system and the development of a detailed business case in collaboration with the NT Government. The Infrastructure Program will roll out in two stages to deliver an extra 67,500 megalitres of water a year after completion.

Stage 1 Manton Dam Return to Service

The first stage is the return to service of Manton Dam into our supply network by 2025/26. On its return to service Manton Dam will supply 7,300 megalitres a year into the Darwin region water supply system.

Work is already underway by Power and Water and includes \$190 million of Australian Government investment in infrastructure through the National Water Grid Fund, including:

- a refurbished intake tower
- a new pumping station and pipeline; and
- a new water treatment plant.

Power and Water is leading project development, stakeholder and community engagement (including informing on heritage management and the ongoing management of recreation) and project delivery, in close collaboration with the Department of Industry, Tourism and Trade (DITT) and the Department of Environment, Parks and Water Security (DEPaWS).

Stage 2 Adelaide River Off-stream Water Storage project

The second stage is the Adelaide River Off-stream Water Storage (AROWS) project. AROWS will take advantage of a natural geological basin in the Murrakai region, south-east of Darwin, which will be filled with water pumped from the Adelaide River during the wet season. This project will take 7-10 years to deliver and will be a vital enabler of future economic growth in the NT.

DITT is leading communications and stakeholder engagement and project development for the AROWS project, in close collaboration with Power and Water.

Both the return to service of Manton Dam and the AROWS project will significantly add to our water security, ensuring we have enough supply to keep pace with projected demand and support economic and population growth – both in the short and long term.

Recreation use

Manton Dam is a popular spot for recreation activities including boating, water sports and fishing. In March 2022, the NT Government announced that recreational activities will continue once the dam is returned to service. Power and Water is installing additional treatment measures to ensure it meets stringent drinking water quality standards while also remaining an important recreational resource for the community.

In collaboration with DEPaWS, Power and Water is developing a Recreation Management Plan for Manton Dam and a contemporary legal agreement for the arrangement between the organisations.

Heritage infrastructure

During the 1990s, in recognition of the heritage value of some of the infrastructure at Manton Dam, Power and Water invested in the development of a 'heritage area', including signage, walkways and observation platforms.

Power and Water is now developing a Heritage Management Plan for Manton Dam. The plan is intended to secure and preserve the heritage assets, and to make them available to the public through potential initiatives including periodic public open days and guided tours.

Communication objectives

- Collaborate and consult with relevant NT Government agencies and key stakeholders to develop and deliver consistent messaging for the Manton Dam RTS project that is aligned with the overall messaging for the Infrastructure Program
- Engage with DEPaWS and key stakeholders over the continued recreational use at Manton Dam and the development of a Recreational Management Plan
- Engage with key stakeholders to develop and implement a Heritage Management Plan for Manton Dam
- Inform key stakeholders and community about the processes, potential impacts and project timelines
- Inform the community of project deliverables and celebrate success through media opportunities

Key stakeholders

A broad range of Power and Water, Government and non-government stakeholders have been identified as having interest and/or involvement in the project. A smaller group of recreation-specific and heritage-specific stakeholders have also been identified for targeted engagement.

The full list of stakeholders and the relevant engagement actions is below in the Engagement and Communications Actions table.

Key messages

Darwin Water Story

- Power and Water provides water supply services to around 135,000 people across the Darwin region, managing everything from how our water is sourced, stored and treated through to the infrastructure that delivers it to your home.
- We also play an important role in ensuring we have enough water to support population growth, new industry and other major developments for the Territory to prosper and contribute to the \$40 billion economy by 2030 target.
- Currently the Darwin region's water supply comes from two sources - the Darwin River Dam and McMinns and Howard East Borefields. These two sources currently supply enough water for our needs but more water will be needed to meet future demand as the region's population and economy grow and the climate changes.
- Power and Water is working in collaboration with the NT Government to deliver the **Darwin Region Water Supply Infrastructure Program** which will secure Darwin's water future for the next 30 years and beyond.
- The Infrastructure program will be delivered in two stages and includes the return to service of Manton Dam ~~return~~ and the Adelaide River Off-stream Water Storage (AROWS) project. These two major projects will supply an additional 67,500 megalitres of water per year into our water supply system.

Manton Dam Return to Service

- In March 2022*, the Australian Government's National Water Grid Authority announced \$300.6 million to deliver stage one of the Darwin Region Water Supply Infrastructure Program which includes the return to service of Manton Dam, the construction of a pipeline to supply water to industry at Middle Arm, and further project development and de-risking activities for AROWS. * *Replace with October 2022 once the funding is reconfirmed....*
- Manton Dam was originally built in the 1940s and remained as Darwin's primary source of water until Darwin River Dam was commissioned in 1972. The NT Government opened Manton Dam to recreation in the late 1980s and, since then, it has remained in a care and maintenance status as a potential future water supply source.
- Power and Water has been planning for the return to service of Manton Dam for many years. The project was first identified in the 2013 Darwin Region Water Supply Strategy and a significant body of preliminary work has been completed to inform the project's design and delivery.
- Planning and design work is already underway to return Manton Dam to service as an operational drinking water supply source. This includes \$190 million to build new infrastructure including a refurbished intake tower, a new pumping station and pipeline and a new water treatment plant.
- Once returned to service in 2025/26, Manton Dam will provide 7,300 megalitres a year of water into the Darwin region water supply system.
- Manton Dam is a popular spot for recreation activities including boating, water sports and fishing. In March 2022, the NT Government announced that recreational activities will continue once the dam is returned to service.
- Manton Dam will continue to be an important recreational resource for the community and Power and Water will apply additional treatment measures to ensure the dam meets stringent drinking water quality standards.
- Power and Water will work with the NT Government to manage recreational activities through the development of a contemporary Recreation Management Plan that recognises the reservoir's dual purpose.
- During the 1990s, in recognition of the heritage value of some of the infrastructure at Manton Dam, Power and Water invested in the development of a 'heritage area' which includes signage, walkways and observation platforms.
- Power and Water is working to develop a Heritage Management Plan for Manton Dam. The Plan is intended to secure and preserve the heritage assets around the dam, and to make them available to the public through periodic public open days.

Key Project Milestones

- Development of Heritage Management Plan – 30 December 2022
- Development of Recreation Management Plan – 30 March 2023
- Submission of environment referral – 30 March 2023
- Award of design and construction contract – 30 November 2023
- Project construction and commissioning complete – January 2026

Sensitivities

- The community may be concerned that continued recreation poses a risk to the drinking water supply. Power and Water will implement additional water treatment measures to ensure the quality of water supplied to customer remains at a high level.
- Restrictions will be imposed on recreation activities from time to time once Manton Dam is returned to service for operational reasons and the media may focus on this from a community aspect. Access to the reservoir is already restricted on occasion by DEPaWS due to crocodile sightings. Power and Water and DEPaWS will need to manage risks associated with fluctuating water levels in the reservoir due to operations and communicate relevant information to the community.
- Commuters that utilise Cox Peninsula Road will be effected by the construction of new intersection for the access to Strauss Water Treatment Plant. It is proposed that the selected contractor will construct the intersection over a period of three months. The intersection will be constructed under traffic management and the contractor will be required to minimise the interruption to commuters. A targeted communications plan will be developed and implemented prior to the commencement of and during construction. A traffic management plan will be prepared by the contractor and this will require approval by DIPL.
- There a number of road openings for the construction of the proposed pipeline. These road openings will affect local traffic, but disruption will be minimised through good planning and communication. Close consultation with local government and other targeted stakeholders will be required and advance notice provided to residents.
- The proposed pipeline will be constructed across private property (within existing PWC easements). This may disrupt private property owners and disturb existing fencing in a number of locations. Significant advance warning will be given to residents with notification provided through correspondence to property owners.
- It is likely that the existing intersection at Manton Dam will require modifications and this will have an effect on traffic on the Stuart Highway. It is proposed that forward notice will be provided to commuters prior to the works being undertaken.

Communications Products (*need to always acknowledge the NTG and Australian Government)

Tools and Tactics	Description	Responsible	Due	Assets/budget
Darwin Water Story	Introduction within the Darwin Water Story Communications plan (D2022/188768)	Corporate Affairs / Water Services	August 2022	N/A
Darwin River Dam Open Day	Inclusion within the Darwin River Dam Open Day. Pull up banner and Fact sheet	Corporate Affairs	28th August	N/A
Fact Sheets (Open Day)	A4/A5 factsheets from Open Day delivered to local libraries, councils and support event activities.	Corporate Affairs	28th August	Allow \$10,000 over the project timeline for fact sheets & pull up banners to be created/updated as the project progresses. (initial
Pull up banners (Open Day)	Pull up banners to be designed with campaign copy to be used at events/briefings.	Corporate Affairs	28 th August	

Tools and Tactics	Description	Responsible	Due	Assets/budget
				collateral designed for the DRD open day)
Website	Create Manton Dam RTS Project Page.	Corporate Affairs	December 2022	N/A
Website	Monthly / Quarterly project updates	Corporate Affairs / Water Services	Ongoing	N/A
Factsheets (3)	Project, Heritage Management Plan and Recreation Management Plan	Corporate Affairs / Water Services	December 2022, March 2023	Allow \$10,000 for design and printing. Updates will be required as the project progresses.
Education Video	Project overview video, to be housed on the website, shared on social and used for in-person engagement.	Corporate Affairs / Water Services	December 2022.	Allow \$10,000 for scripts and development of two videos over the project timeline.(initial video part of the water story budget)
Media	Contributions to local publications such as NT News and Territory Q. Including project milestones.	Corporate Affairs / Water Services	Ongoing	\$Allow \$8,000 over the project timeline. (one TQ and two NT News)
Media	Media Release for major project announcements	Corporate Affairs / Water Services	Ongoing	N/A
Social Media	Promote Manton Video and Project milestone / achievements	Corporate Affairs	Ongoing	Social calendar inclusion. Allow \$2,000 for design and paid promotion.
Signage	Project overview information signs onsite, on the Stuart Hwy and Cox Peninsula Road.	Water Services / Corporate Affairs	December 2022	Allow \$20,000 for design, printing and installation.

Stakeholder Participation Spectrum

The level of engagement with various stakeholders will vary depending on key interests and the level of stakeholder impact. The spectrum of involvement is detailed in the Table.

	Inform	Consult	Involve	Collaborate
Stakeholder participation goal	To provide the stakeholder with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions	To obtain stakeholder feedback on analysis alternatives and or decisions	To work directly with the stakeholder throughout the process to ensure that public concerns and aspirations are consistently understood and considered	To partner with the stakeholder in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Promise to the Stakeholder	We will keep you informed	We will keep you informed, listen to and acknowledge concerns and aspirations and provide feedback on how stakeholder feedback influenced the decision	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how stakeholder input influenced decisions	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible
Example Techniques	<ul style="list-style-type: none"> • Fact sheets • Correspondence / letter drop • Web Site • Education video • Open Days • Social media • Signage 	<ul style="list-style-type: none"> • Public comment • Focus groups • Surveys • Public meetings • Direct engagement • Web site 	<ul style="list-style-type: none"> • Workshops • Direct meetings • Direct engagement • Web survey 	<ul style="list-style-type: none"> • Advisory committees • Working Groups • Governance Committees • Participatory decision making

Engagement and Communications Actions

Stakeholder/s	Engagement objective	Engagement Tools/Method	Responsible	Due
Cabinet stakeholders				
Minister for Essential Services	Inform on project, collaborate on announcements, particularly milestones	<ul style="list-style-type: none"> Direct Engagement Media release/event 	CE / Corporate Affairs / Water Services	December 2022, ongoing, particularly at milestones
Treasurer	Inform on project, collaborate on announcements, particularly milestones	<ul style="list-style-type: none"> Direct Engagement Media release/event 	CE / Corporate Affairs / Water Services	December 2022, ongoing, particularly at milestones
Minister for Environment, Climate Change and Water Security	Inform on project, particularly recreation issues	<ul style="list-style-type: none"> Memo from Minister for Essential Services 	CE / Corporate Affairs / Water Services	December 2022
Minister for Tourism and Hospitality	Inform on project, particularly recreation and heritage issues	<ul style="list-style-type: none"> Memo from Minister for Essential Services 	CE / Corporate Affairs / Water Services	December 2022
Government stakeholders				
CEO Steering Committee	Inform on project, consult on recreation management	<ul style="list-style-type: none"> Presentation or oral update Paper/s as required 	CE / Trevor Durling	Ongoing, quarterly
NTG Program Working Group (PWG)	Inform on project	<ul style="list-style-type: none"> Presentation or oral update Paper/s as required 	Trevor Durling	Ongoing, quarterly
Department of Industry, Tourism and Trade	Inform on project including milestones in funding agreement, consult on key decisions, collaborate on funding, collaborate on stakeholder engagement and communications	<ul style="list-style-type: none"> Through NTG PWG Direct engagement 	Trevor Durling / Water Services	Ongoing, as required
Department of Infrastructure, Planning and Logistics	Inform on project, collaborate on land acquisition	<ul style="list-style-type: none"> Through NTG PWG Direct engagement 	Water Services	Ongoing, as required

Stakeholder/s	Engagement objective	Engagement Tools/Method	Responsible	Due
Department of Environment, Parks and Water Security	Inform on project, consult on environmental referral, collaborate on recreation management plan	<ul style="list-style-type: none"> Through NTG PWG Direct engagement 	Water Services	Ongoing, as required
Power and Water stakeholders				
Power and Water Board	Inform on project, consult on key decisions, collaborate on award of contract	<ul style="list-style-type: none"> Presentation or oral update Paper/s as required 	CE / Water Services	Ongoing, as required
Governance Committee (and by default, ELT)	Inform on project, involve on key decisions	<ul style="list-style-type: none"> Presentation or oral update Paper/s as required 	EGMWS / Trevor Durling / Project Manager / Water Services	Ongoing, as required
Water Services Management Team	Inform on project, involve on key decisions	<ul style="list-style-type: none"> Presentation or oral update Paper/s as required 	Trevor Durling / Project Manager / Water Services	Ongoing, as required
Employees	Inform on project	<ul style="list-style-type: none"> Intranet Internal email updates 	Corporate Affairs / Water Services	Ongoing, as required
External stakeholders				
Local Members – Darwin and rural areas	Inform on project	<ul style="list-style-type: none"> Direct Engagement Project factsheet 	Corporate Affairs / Water Services / DITT	February 2023
Coomalie Community Government Council	Inform on project	<ul style="list-style-type: none"> Direct Engagement Project factsheet 	Water Services / DITT	February 2023
Litchfield Shire Council	Inform on project	<ul style="list-style-type: none"> Direct Engagement Project factsheet 	Water Services / DITT	February 2023
Northern Land Council	Inform on project	<ul style="list-style-type: none"> Direct Engagement Project factsheet 	Corporate Affairs / Water Services / DITT	February 2023
Aboriginal Areas Protection Authority	Inform on project, collaborate on sacred sites certificate	<ul style="list-style-type: none"> Direct Engagement Project factsheet 	Water Services / Property	February 2023
Manton River downstream landowners	Inform on project	<ul style="list-style-type: none"> Letter Project factsheet 	Water Services	February 2023

Stakeholder/s	Engagement objective	Engagement Tools/Method	Responsible	Due
Pipeline affected landowners	Inform on project, consult on access for construction	<ul style="list-style-type: none"> Letter Project factsheet Direct Engagement 	Water Services / Property	February 2023
General community	Inform on project, recreation management, heritage management	<ul style="list-style-type: none"> DRD Open Day Project signage Project webpage Factsheets (project, recreation, heritage) Media 	Corporate Affairs / Water Services	August 2022 (open day), February 2023, ongoing as required
NT Media	Inform on project, particularly at milestones	<ul style="list-style-type: none"> Project webpage Direct Engagement 	Corporate Affairs	Ongoing, particularly at milestones
Heritage-specific stakeholders				
Darwin Military Museum	Consult on development of heritage management plan	<ul style="list-style-type: none"> Direct Engagement Heritage Management Plan and factsheet 	Corporate Affairs / Water Services	December 2022
Heritage NT	Consult on development of heritage management plan	<ul style="list-style-type: none"> Direct Engagement Heritage Management Plan and factsheet 	Corporate Affairs / Water Services	December 2022
Recreation-specific stakeholders				
NT Water Ski Association	Inform on project, consult on development of recreation management plan	<ul style="list-style-type: none"> Direct Engagement Recreation Management Plan and factsheet 	Corporate Affairs / Water Services	February 2023
Amateur Fishermen's Association of the NT	Inform on project, consult on development of recreation management plan	<ul style="list-style-type: none"> Direct Engagement Recreation Management Plan and factsheet 	Corporate Affairs / Water Services	February 2023

Budget

Water Services has allocated \$50,000 from the Manton Dam RTS project budget for stakeholder engagement and communications in 2022/23. Costs can be directed to work order 2770856, with purchase requisitions and invoices work flowed to lead project manager Liam Early for approval.

Approvals

Endorsed by Trevor Durling
Senior Headworks Planning Engineer

6 / 10 / 22

Approved by Steven Porter
Executive General Manager Water Services

7 / 10 / 22

Endorsed by Rebecca Cass
Senior Manager Corporate Affairs

10 / 10 / 22

Approved by John Pease
Executive General Manager, Organisational
Governance

11 / 10 / 2022

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STAKEHOLDER ENGAGEMENT REGISTER (as of 06 July 2023)

Date	Stakeholder 1	Stakeholder 2	Stakeholder 3	Person 1	Person 2	Person 3	Subject\Topic	Type	Ref	Outcome
5/07/2023	Heritage Branch	PWC	EcOz	Fiona Earl and Team	Adrian White	Britanny Crescentino	Heritage values from archeological survey	Meeting		Heritage values to be included in referral and for future discussion
14/06/2023	Parks and Wildlife	PWC Property	PWC Legal	Trevor Durling	Neva McCartney	Sheryl Murray	SLA with Parks for Recreation Management	Meeting		PWC to engage consultant to develop SLA for Recreation Management
8/06/2023	AAPA	PWC Property	DITT	Trevor Durling	Thomas Lorporto	Sheryl Murray	Hydrological modelling for Manton Dam RTS	Meeting	D2023/217621	1. PWC to discuss Manton River sacred site with DEPaWS in relation to their work on A/R WAP and indigenous engagement, 2. AAPA to organise site inspection for custodians and PWC/DITT reps
31/05/2023	NLC	DITT		Trevor Durling	Evan Tyrrell		Hydrological modelling for Manton Dam RTS	Meeting	D2023/217621	NLC to organise community meeting at Acacia Larrakia
30/05/2023	Media	DITT	PWC	Jane Dellow	Danna Irwin	Evan Tyrrell	Proposed Media Briefing	Presentation		No Media attended - Rescheduled - Prestation was gone through
27/05/2023	Community	DITT		Trevor Durling	Liam Early	Evan Tyrrell	Freds Pass Show - Manton Dam return to service, and AROWS	Stand		Positive feedback on project
26/05/2023	Potential Tenderers	PWC		Liam Early	Adrian White	Tim Jacobs	Site Visit with Tenderers	Site Visit	D2023/223993	Site Visit - Refer NWD00096-22 Addendum 2
25/05/2023	Potential Tenderers	DITT	PWC	Evan Tyrrell	David Rossi	Liam Early	Industry Briefing	Presentation	D2023/223993	Briefing to Industry - Refer NWD00096-22 Addendum 2
25/05/2023	PWC			Danna Irwin	Trevor Durling	Adrian White	Communications plan	Meeting		Meeting to discuss communications for the project and develop communications plan
18/05/2023	AAPA	PWC		Trevor Durling	Thomas Lorporto		Downstream Effect of Manton project	Email		Hydrological Data on spills and downstream flows
16/05/2023	DITT	PWC		Evan Tyrrell	Kisha Avellanos	Sheryl Murray	Update Land Tenure Matters	Meeting	D2023/19934	A White and T Durling - Update Licence and Crown Lease
10/05/2023	Land Owners	PWC		Liam Early			Letters to downstream Propert Owners	Letter	D2023/231343	No responses as yet
26/04/2023	DEPaWS	PWC		Ashley Nunn	Neva McCartney	Trevor Durling	Catchment and Recreational Management Plans	Site Visit		Review of operational and recreations areas to inform Management Plans
26/04/2023	Parks and Wildlife			Trevor Durling	Neva McCartney		Recreation Management Plan	Workshop	D2023/208251	GHD to draft Recreation Management Plan, PWC to set up stakeholder meetings
6/04/2023	Fisheries (DITT)	Parks and Wildlife		Trevor Durling	Jake Maynard	Neva McCartney	Manton Project Overview and Fish Stocking Program	Meeting	D2023/120161	PWC to engage consultant to develop Recreation Management Plan
5/04/2023	DEPaWS			Trevor Durling	Abbe Damrow		Operationalising extraction licence for Manton Dam	Meeting	D2023/136365	PWC to engage with downstream landowners over their water use
31/03/2023	CRG	DITT	PWC	Sarah Robinson	Trevor Durling	Liam Early	CRG Meeting Lake Bennett	Presentation	D2023/168202	L Early - Presentation to CRG - Minutes referenced
30/03/2023	DITT	CRG	DITT	Evan Tyrrell	Kisha Avellanos	Sarah Robinson	Manton Project Update	Presentation	D2023/121927	T Durling - Project Update to CRG
24/03/2023	AFANT			Trevor Durling	Liam Early		Manton Project Overview and Update	Meeting	D2023/104546	PWC to return with Recreation Management Plan consultants for additional engagement
28/02/2023	PWC Legal	PWC		Adrian White	Simon Fosterling		Major Works Contract	Email		Update to Major Works Contract
20/02/2023	Crown Lands	DITT	PWC Property	Kisha Avellanos	Evan Tyrrell	Sarah Robinson	Land Tenure Matters	Meeting		A Whie, T Durling Sheryl Murray - Tourism Bike path discussed, Crown Lease Status, total site boundaries
17/02/2023	Litchfield Shire Council			Trevor Durling	Liam Early		Manton Project Overview and Update	Meeting	D2023/72980	Positive feedback on project
16/02/2023	PWC Steering Committee			Liam Early			Update on Manton Project	Presentation		Update to Committee
10/02/2023	Coomalie Shire Council	DITT		Trevor Durling	Sharon Hillen	Evan Tyrrell	Program update - Manton and AROWS	Meeting		Request for info on Batchelor and Adelaide River water supply upgrades
24/01/2023	DITT	PWC		David Rossi	David Rossi	Evan Tyrrell	Review of proposed tender development	Meeting		Meeting to discuss proposed tender and program - Milestone payments
6/12/2022	DEPaWS	PWC	DITT	Darcy Brook	Trevor Durling		Land Tenure	Email	D2022/505820	Update and land tenure and proposed meetings with NLC
8/11/2022	Land Owners	PWC Property		Liam Early	Sheryl Murray		Letter to Land Owners - Update Manton Return To Service	Letter	D2022/462762	No Responses
7/11/2022	CRG	DITT	NTG Working Group	Sarah Robinson	Sheryl Murray	Evan Tyrrell	CRG Meeting Chrls Darwin Centre	Presentation	D2022/473861	Presentation to CRG - Minutes referenced
7/11/2022	Land Owners	PWC Property	PWC	Adrian White	Sheryl Murray	D Skewes	Update to Manton Project Review on site Issues	Site Visit		Reviewed pipeline alignment over Lot 7 and Lot 230 - Review of Telstra cable required
2/11/2022	DITT	PWC		Trevor Durling	Evan Tyrrell	Darcy Brook	Milestone Payments, Project Reporting, Milestone Reporting & Feedback from DITT on PMP	Meeting		Positive feedback on PMP, Milestones agreed at this date, and general discussion around reporting
2/11/2022	Coomalie Shire Council	DITT		Trevor Durling	Evan Tyrrell		Manton Project Overview and Update	Meeting		Update for Council
10/10/2022	Parks and Wildlife			Trevor Durling	Liam Early		Manton Project Overview and Recreation Management	Meeting	D2022/386152	PWC to engage consultant to develop Recreation Management Plan
29/09/2022	PWC Steering Committee	PWC		Trevor Durling			Update on Manton Project	Presentation	D2022/505448	Update to Committee
28/09/2022	NTG Working Group	PWC		Trevor Durling		Trevor Durling	Manton Project Update	Presentation	D2022/402592	Update of Manton Project Provided
20/07/2022	DEPaWS	PWC		Johnathon Vea	Trevor Durling		Update from CE Steering Committee	Email	D2022/300378	Decision that Parks will manage recreation at Manton Dam
12/07/2022	DITT	PWC		Adrian White	Darcy Brook		Review PMP requirements	Meeting		General discussion around PMP requirement including indigenous participation and NT Gov requirements
3/05/2022	Litchfield Shire Council	DITT		Trevor Durling	Evan Tyrrell	Darcy Brooke	Manton Project Overview and Update	Meeting	D2022/173106	Positive feedback on project
15/02/2022	Coomalie Shire Council	DITT		Trevor Durling	Evan Tyrrell		Manton Project Overview and Update	Presentation	D2022/57785	Update for Council
11/11/2021	DIPL	PWC	PWC Property	Nim Perera	Adrian White	Sheryl Murray	Seeking Approval of Intersection Design	Email	D2021/504241	Email Trail PWC/GHD seeking approval Intersection
13/11/2018	Land Owners	PWC		Liam Early			Letter to land owners pipeline inspection	Letter	D2018/452652	Inspections undertaken
18/06/2018	DEPaWS	PWC		Dean McAdam	Louise Kean	Johnathon Vea	Update Darwin Region Water Supply Strategy	Meeting	D2018/274759	T Durling Provided Update of the Manton Project
21/06/2016	PWC Board	PWC		Trevor Durling			Board Noting Paper	Noting Paper	D2016/231841	Preferred resource portfolio

WSD33012 - Manton Dam Return To Service
STAKEHOLDER ENGAGEMENT REGISTER (as of 06 July 2023)

Date	Stakeholder 1	Stakeholder 2	Stakeholder 3	Person 1	Person 2	Person 3	Subject\Topic	Type	Ref	Outcome
12/07/2022	DITT	PWC		Adrian White	Darcy Brook		Review PMP requirements	Meeting		General discussion around PMP requirement including indigenous participation and NT Gov requirements
3/05/2022	Litchfield Shire Council	DITT		Trevor Durling	Evan Tyrrell	Darcy Brooke	Manton Project Overview and Update	Meeting	D2022/173106	Positive feedback on project
15/02/2022	Coomalie Shire Council	DITT		Trevor Durling	Evan Tyrrell		Manton Project Overview and Update	Presentation	D2022/57785	Update for Council
11/11/2021	DIPL	PWC	PWC Property	Nim Perera	Adrian White	Sheryl Murray	Seeking Approval of Intersection Design	Email	D2021/504241	Email Trail PWC/GHD seeking approval Intersection
13/11/2018	Land Owners	PWC		Liam Early			Letter to land owners pipeline inspection	Letter	D2018/452652	Inspections undertaken
18/06/2018	DEPaWS	PWC		Dean McAdam	Louise Kean	Johnathon Vea	Update Darwin Region Water Supply Strategy	Meeting	D2018/274759	T Durling Provided Update of the Manton Project
21/06/2016	PWC Board	PWC		Trevor Durling			Board Noting Paper	Noting Paper	D2016/231841	Preferred resource portfolio

APPENDIX D GHG ASSESSMENT



Greenhouse Gas Report

Manton Dam Return to Service

Power and Water Corporation



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Appendices

Appendix A FullCAM Model Inputs
Appendix B GHG Estimate Results

1 INTRODUCTION

This document provides a preliminary estimate of Greenhouse Gas (GHG) emissions associated with the construction and operation of the Manton Dam Return to Service Project (MDRTS). Estimates of Scope 1 and Scope 2 emissions are required to be provided in a Referral to the Northern Territory Environment Protection Authority (NT EPA) under the *Environment Protection Act 2019* (the EP Act) and reporting requirements for GHG are also specified under the *National Greenhouse and Energy Reporting (NGER)* legislation.

1.1 MDRTS Project Overview

The Northern Territory Government (NTG) proposes to develop the Manton Dam Return to Service (MDRTS) project as part of the solution to secure a long-term water supply for Darwin.




Power and Water Corporation (PWC) propose to return Manton Dam to service as a water supply source, utilising new pipeline infrastructure, an upgrade of the existing pump station and the construction of a water treatment plant (WTP) at Strauss (Figure 1-1). Manton Reservoir, is located just west of the Stuart Highway and approximately 70 km south of Darwin in the Northern Territory (NT). It is within the upper reaches of Manton River, a tributary of the Adelaide River catchment.

The major infrastructure components of the MDRTS project are:

- Existing dam, upgrade to existing inlet tower
- Upgrade to pumping infrastructure at Manton Dam
- A new 21km pipeline from Manton dam to Strauss WTP
- A new water treatment plant at Strauss.



Legend

-  Principal road
-  Strauss Water Treatment Plant
-  Manton Dam RTS Pipeline Easement



0 0.5 1 2
Kilometres



MAP INFORMATION
 Scale: 1:100,000 @ A4
 Projection: GDA 1994 MGA Zone 52
 Date Saved: 15/02/2023
 Client: Power and Water
 Mapper: SR
DATA SOURCE
 Topographic data: Geoscience Aust.
 Project data: EZZ1257
 Imagery: NTLIS

Figure 1.1 MDRTS General Arrangement and Locality

1.2 Purpose

The purpose of this greenhouse gas (GHG) estimate is to identify and quantify the material sources of GHG emissions over the life of the project. The estimate will be used to inform project planning and design in relation to carbon abatement and offset options for the project, that align with the NT Government's target for net zero emissions by 2050. This estimate meets the requirements of the NT EPA *Draft Guidance for Environmental Factor: Atmospheric Processes*.

The intent is that as the project progresses the GHG estimate will be refined based on engineering design and project execution strategy and a Greenhouse Gas Management Plan will be prepared in accordance with the *NT EP Act*

To address these requirements, this report presents:

- The scope and boundary of the GHG estimate
- The inputs utilised in the GHG estimation
- Results of the GHG estimation
- A review of the emissions against relevant NT Government Policies.

2 ASSESSMENT BOUNDARY

A GHG assessment boundary encompasses all primary effects (intended change) and significant secondary effects (unintended change) caused by activities that are under operational control (owned or controlled by the project proponent). Sources of GHG emissions are classified into scope 1, 2 or 3 emissions. Scope 1 emissions are direct emissions from activities or aspects of the project, scope 2 emissions are indirect emissions from energy consumption and scope 3 emissions are indirect emissions other than scope 2. The inclusion and/or exclusion of emissions from activities and aspects in the GHG assessment boundary are determined by the proponent's level of operational control over those activities e.g., 3rd party logistics, travel and waste are outside of the proponent's operational control and therefore excluded from the GHG assessment boundary.

2.1 Project Boundary

The boundary for the MDRTS Project GHG estimate is detailed in Figure 1-1 and Figure 2-1 and includes all activities and aspects under operational control. The estimate details the scope 1 and scope 2 emissions of the construction (2 years), operation and maintenance (50 years) phases of the MDRTS project including elements described in section 2.2.1 and section 2.2.2. GHG estimate boundary inclusions are outlined in section 2.2.3 and exclusions are noted in section 2.2.4. Scope 3 emissions associated with embodied carbon in materials of construction as well as the supply and use of water are excluded from this estimate.

The estimate includes the emissions from the owner organisation as well as the engineering procurement and construction contractors including civil, construction and logistics sub-contractors.

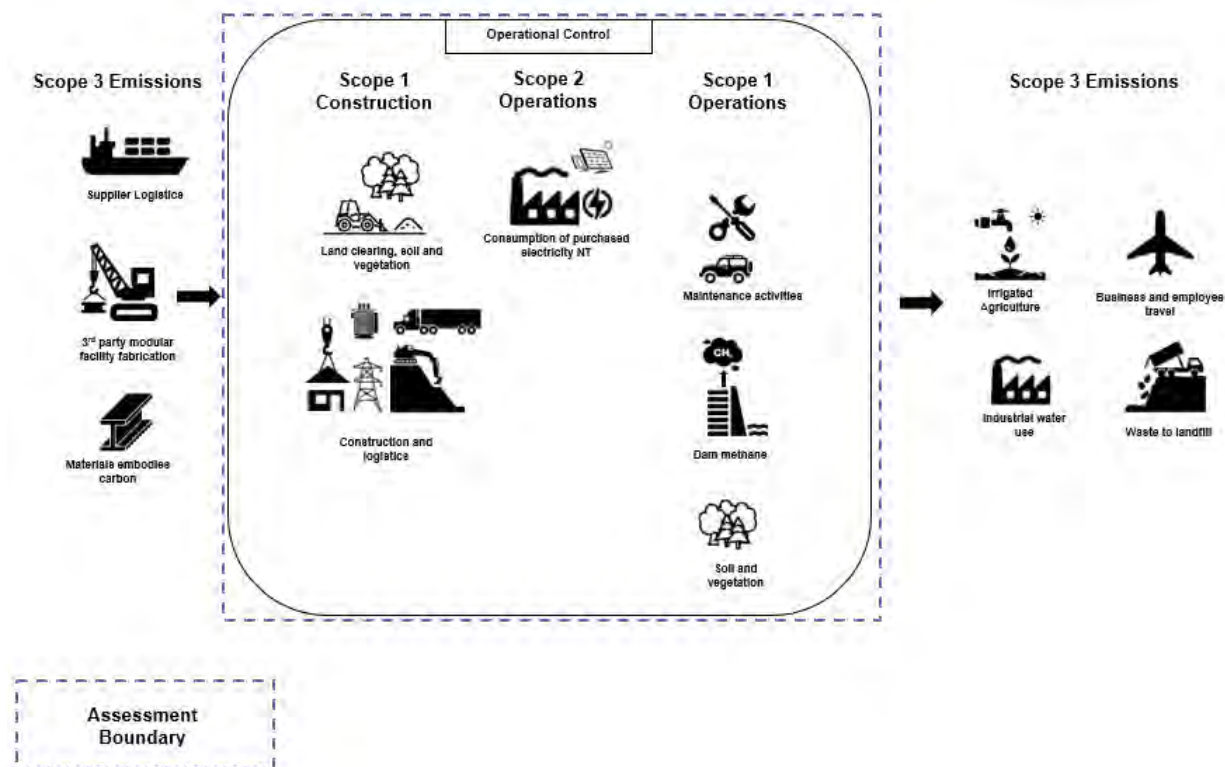


Figure 2-1. MDRTS Boundary of Assessment and Scope Categories

2.2 GHG Activities and Aspects

GHG emissions are estimated for the construction, operation and maintenance and decommissioning and revegetation phases of the project. A description of each of the activities and aspects included in each phase is provided below.

2.2.1 Construction

The construction of the MDRTS project infrastructure including the below elements.

- Civil and construction – Earthworks, machinery usage, drainage works, construction of dam walls, installation of mechanical and electrical equipment.
- Quarrying of Material – Quarrying and logistics of raw quarry materials for use in the concrete for foundations and drainage works.
- Vegetation and land use change – the reduction in carbon sequestration during the construction period associated with vegetation (trees, shrubs, etc), dead woody material, roots and change in soil carbon due to the project activities.
- Power generation – generation of power from diesel powered internal combustion engine electricity generators
- Cementing and Road work – the logistics and civil works associated with the construction and operation of the MDRTS project.
- Pipelines, Tankage and Strauss WTP construction and Logistics – civil, earthworks, logistics and construction machinery emissions associated with the construction of mains water pipelines, storage, and the Strauss WTP.

2.2.2 Operations

- Maintenance – Diesel consumed associated with the maintenance activities, i.e. vegetation management, infrastructure maintenance.
- Pumping and Extraction – Electricity consumed for the pumping and extraction of water from Manton Dam and distribution of water to Strauss WTP. Electricity is assumed to be sourced from the Darwin Katherine Interconnected System.
- Water treatment – Electricity consumed during the treatment of water to make it potable. Electricity is assumed to be sourced from the Darwin Katherine Interconnected System.
- Dam Methane (CH₄) emissions. Methane emissions evolve from decaying organic matter that breaks down in the lower anoxic layers of the dam. Carbon is broken down through biological activity in the absence of oxygen to form methane. This is absorbed into the water column and released from either the surface of the dam as water circulates or from the water removed from the dam for supply to the water users of MDRTS. The methane emissions are split into two categories within this estimate are two sources estimated in this report.
 - Upstream CH₄ emissions – These emissions are the diffuse methane emissions from the surface area of the dam.
 - Downstream CH₄ emissions as emissions occurring downstream of the large dam from the water offtake/spillway (not usually relevant to MDRTS) and degassing of water downstream of

dams. This emission occurs as the outlet of the dam typically sources water from the methane rich deeper waters. Surface waters are typically lower in methane concentration due to methanotropic activity in surface waters (Lima et al. 2007).

2.2.3 Inclusions

The construction and operation of the scope items noted in Table 2-1, and are the basis for the GHG estimate boundary. The GHG estimate include scope 1 and scope 2 emissions.

Table 2-1. GHG Estimate Inclusions

LOCATION	ITEM	ITEM DESCRIPTION (CHARACTERISTICS, LENGTH, AREA, MATERIALS ETC)
Manton dam to Strauss WTP	Pipeline	21000m x 600mm diameter, 3 work fronts, 18-month construction length or 292 days
Manton dam upgrade pump station	Upgraded pumpstation	Upgraded 280L/s 183kW pump station, 1 work front, 4-month construction time or 100 days
Manton Dam	Operations	3400 ha through put 20 ML/day
Manton Dam	Upgrade	Inlet tower, pump station and site works
Strauss WTP	Water treatment	20 ML/day treatment plant, 1 work front, 4-month construction time or 100 days
Manton Dam	Construction	2 years construction period phasing breakdown: 50% 1st year, 50% 2nd year
Manton Dam	Decommissioning	Earthworks and deconstruction emissions ~50% of construction emissions. Water supply assumed to be 100% renewable energy powered, to comply with Northern Territory Climate Change Response: Towards 2050'
Operations and Maintenance	All	The operations of 3 LV's during operations are included in the GHG estimate

2.2.4 Exclusions

Scope 3 emissions associated with the supply and use of water are excluded from this estimate. The downstream product of the MDRTS project is water supplied to residential, commercial, industrial and agricultural users, there are no tangible significant scope 3 emissions associated with the supply and use of water to these users.

Methane (CH₄) emissions from drinking water treatment sludge production at Strauss WTP has been excluded from this estimate because they are immaterial. The treatment of wastewater often results in methane emissions when organic material is treated in anaerobic environment and when untreated wastewater degrades anaerobically (US EPA 2019). Biologic oxygen demand (BOD) and chemical oxygen demand (COD) concentrations of sludge from drinking water treatment plants are used to model methane emissions. The BOD

and COD of MDRTS drinking water treatment sludge production would be extremely low since the sludge mainly consists of inorganic material (pers comm., Yan Yode, 1 December 2022) and therefore excluded from the GHG estimate.

Upstream embodied carbon emissions from the raw materials of the MDRTS project are excluded from this estimate. The upstream lifecycle emissions of the materials utilised in the construction and operation of the MDRTS project lay outside the scope of the environmental impact assessment under the NT EP Act and as such are excluded from this GHG estimate.

The scope items outlined in Table 2-2 are excluded from the scope of the GHG estimate as they do not form part of the MDRTS project.

Table 2-2. GHG Estimate Exclusions

LOCATION	ITEM	ITEM DESCRIPTION (CHARACTERISTICS, LENGTH, AREA, MATERIALS ETC)
Logistics associated with delivery of materials from Darwin Port and local quarries	Various	Various
Electricity transmission and substation	Electricity	Substation clearing assumed to be within existing cleared footprint of other elements. No data provided by SMEC on transmission extensions, assumed to be very minor emissions associated with footprint vegetation clearing for poles, cumulatively with other exclusions likely to be less than 5% of the total emissions.
Workers travel domestic and local	All	No information was available for this item. Including other noted exclusions, it is cumulatively likely to be less than 5% of the total emissions. The uplift to other items (construction scope 1 excluding vegetation and soil carbon emissions) has been applied to allow for this exclusion
Water use	All	Any scope 3 emissions associated with water use by third parties is excluded
Operations and Maintenance	All	Vegetations management, civil and mechanical inspection and repair is excluded as it is immaterial.
Decommissioning and rehabilitation	All	Given the uncertainty on facility life and end use carbon sequestration from the rehabilitation and revegetation of the MDRTS facilities and infrastructure, it is not included in this estimate

2.2.5 GHG Estimate Assumptions

The following assumptions have been made in the calculation of GHG estimates.

1. The NGERs location-based method emissions intensity was used, 0.57 TCO₂-e/MWh (NGERs 2021). This is a conservative estimate. DKIS emissions will drop as renewable penetration of the power generation system increases. Electricity is used to power pumps and Strauss WTP.

2. Methane emissions determined using the calculations published in Lima et al. 2007, instead of in field calculations.
3. Diesel use profile was provided by Power and Water Co (pers. Comm., James Whatley, 11 October 2022).
4. Manton Dam construction was assumed to be completed in 1942 for input into land use and vegetation changes calculations.
5. Manton Dam inundation area is assumed to be 3400 ha.

2.2.6 Data Uncertainty

There is uncertainty around specific engineering details of the project as it is in the design phase. Given the level of engineering detail underpinning the definition of scope within the boundary of the GHG estimate an uplift of 20% is applied to the construction and operation emissions associated with civil works, construction and maintenance. No uplift is applied to emissions estimates for scope 2 emissions, emissions from methane emissions from the MDRTS dam or land use change (soil carbon emissions and vegetation clearing for MDRTS and associated infrastructure), as these utilise a conservative set of assumptions on land use area and detailed vegetation and soil carbon data from the Australia Government FullCAM vegetation and soil carbon model. Given the uncertainty on facility life and end use carbon sequestration from the rehabilitation and revegetation of the MDRTS facilities and infrastructure is not included in this estimate.

2.2.7 Data Improvement

It is recommended that this estimate be revised during engineering definition of the project in line with the class of cost estimate to reduce uncertainty about GHG emissions and identify and implement GHG mitigation opportunities throughout design, construction and operation of the facility. It is recommended PWC engage their freshwater limnologist to develop assumptions for methane (CH₄) emissions from Manton Dam to quantify emissions from the breakdown of organic material within the dam and from discharged water, for a more accurate GHG estimate.

All exclusions and assumptions should be revisited and validated in future estimates.

3 CALCULATION METHODS

The approach used in this report aligns with the following legislation, regulations, standards and guidelines:

- ISO 14064 Greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas GHG emissions and removals.
- GHG Protocol a Corporate Accounting and Reporting Standard.
- National and Territory GHG Legislation, regulations, policy & guidance:
 - NT EPA *Draft Guidance for Environmental Factor: Atmospheric Processes*
 - *National Greenhouse and Energy Reporting Act 2007* (NGER Act).
 - *National Greenhouse and Energy Reporting Regulations 2008*.
 - *National Greenhouse and Energy Reporting (Measurement) Determination 2008*.
 - NT EPA *Greenhouse Gas Emissions Management for New and Expanding Large Emitters Policy* (DEWPS 2021)
- Full Carbon Accounting Model (FullCAM) see Appendix A for model inputs.

The approach is also aligned with the following guidance relating to offsets:

- NT GHG Offsets Policy and Technical Guidelines (DEPWS 2022)

The approach for calculating MDRTS GHG emissions followed the following steps:

1. Established a boundary for the GHG estimate.
2. Conducted a carbon calculation input scoping exercise to define GHG emissions sources within the boundaries of the estimate:
 - a. Defined the activities contributing to GHG emissions occurring within each aspect of the Project.
 - b. Define the required input data to calculate an estimate of GHG emissions from each activity or aspect.
 - c. Identify the source of the input data.
3. Source the input data and determine appropriate assumptions where data gaps or a lack of definition existed.
4. Construct a calculation based on the inputs and assumptions sourced.

The specific methodologies applied to calculating Scope 1 and Scope 2 emissions are outlined in the sections below.

3.1 Scope 1

3.1.1 Emissions from Fuel Use

The Emissions calculation methodology of carbon dioxide, methane and nitrous oxide from the combustion of diesel is taken from Section 2.20 of *National Greenhouse and Energy Reporting (Measurement) Determination 2008*.

$$E_{ij} = (Q_i \times EF_{ijoxec}) / 1000$$

Where:

- E_{ij} is the emissions of gas type (j), being carbon dioxide, methane or nitrous oxide, from each fuel type (i) released from the combustion of the product measured in CO₂-e tonnes.
- Q_i is the quantity of product (i) combusted measured in gigajoules.
- EF_{ijoxec} is the emission factor for each gas type (j) released during the year (which includes the effect of an oxidation factor) measured in kilograms CO₂-e per gigajoule of fuel.

Table 3-1. Emissions Factors for liquid fuels

Activity	Purpose	EF CO ₂ kgCO _{2-e} /GJ	EF CH ₄ kgCO _{2-e} /GJ	EF N ₂ O kgCO _{2-e} /GJ
Diesel Oil Consumption	Transport Fuel Emission	73.6	0.07	0.6

Note: All emission factors sourced from NGER (Measurement) Determination 2008, Compilation 13, Schedule 1 Emissions Factor (Items 38, 54)

3.1.2 Methane Emissions from MDRTS Project

The estimation methodology is taken from Lima et al. 2008. Both upstream and downstream emissions are included. Upstream related to the dam area evolved methane bubbling to the surface from sediment. Downstream related to evolved methane from dissolved methane concentrations in water extracted from the dam. Given the offtake arrangement and uncertainty in biological methane process in MDRTS an average water column concentration has been utilised representative of large tropical dam emissions.

$$E_{dj} \text{ (up)} = A_i \times EF_{dj} \times GHP_{CH_4}$$

Where:

- $E_{dj} \text{ (up)}$ is the fugitive emissions of methane (j) from dam type (d) being the MDRTS dam measured in CO₂-e tonnes/year.
- A_i is the area of the dam in ha
- EF_{dj} is the emission factor for methane 11.100015 tCO_{2e}/ha of a large tropical dam (Lima et al. 2008).
- GHP_{CH_4} is the greenhouse gas potential of methane which is 27.9 based on IPCC AR6

$$E_{dj} \text{ (down)} = Q_i \times EF_{dj} \times F_{dg} \times GHP_{CH_4} / 1000000$$

Where:

- $E_{dj} \text{ (down)}$ is the fugitive emissions of methane (j) from dam type (d) being the MDRTS dam measured in CO₂-e tonnes/year.
- Q_i is the volume of water discharged from the dam in m³ per year.
- EF_{dj} is the emission factor for methane 4g CH₄/m³ of a large tropical dam (Lima et al., 2008).

- F_{dg} is the degassing factor of the percentage of absorbed CH_4 degassed downstream of the MDRTS dam during use.
- GHP_{CH_4} is the greenhouse gas potential of methane which is 27.9 based on IPCC AR6

3.1.3 Change in Land Use Vegetation and Soil Carbon Emissions

The estimate utilises the Department of Industry Science Environment and Resources FullCAM model. Model inputs were aligned with advice from the Department of Industry Science Environment and Resources FullCAM group. The data inputs are summarised below and provided in full in Appendix A.

The FullCAM model utilised the Forest System including minerals with tree yield formula.

The simulation was set to run from 1/1020 to 12/2500 with monthly simulations with model output recorded annually.

The modelled location was averaged over a 100ha block located at (lat/long) -12.863 79; 131.181 66 with native species regeneration > -500mm rainfall.

The events modelled were initial conditions, a clearing event, clearing 100% of forest cover modelled on a theoretical date of 1 Jan 2024 Initial clearing: no product recovery – dam clearing.

It was assumed that 100% of material converted to CO_2 via oxidation. A sensitivity analysis was also conducted which converted 100% of the carbon from soil and vegetation to CH_4 via anerobic breakdown.

A revegetation planting event was simulated on 1 Jan 2128 with native species regeneration > -500mm rainfall, affecting the entire site.

Model outputs were provided in carbon per hectare and converted to either CO_2 via oxidation or methane via anerobic breakdown.

3.2 Scope 2

3.2.1 Electricity usage (Scope 2 Emissions)

$$Y = (Q \times EF) / 1000$$

Where:

- Y is the scope 2 emissions measured in CO_2 -e tonnes.
- Q is the quantity of electricity purchased from the electricity grid during the year and consumed from the operation of the facility measured in kilowatt hours.
- EF is the scope 2 emission factor, in kilograms of CO_2 -e emissions per kilowatt hour for the Darwin Katherine Interconnected System (DKIS):
 - Scope 2 GHG Emissions NGERs location-based method, NT 2021 basis of 0.57 t CO_2 -e/MWh (NGERs 2021)

Electrical power estimates were derived from installed power and output capacity provided by PWC.

4 GHG ESTIMATE RESULTS

The MDRTS GHG estimate provides a coarse quantification of GHG emissions in order to understand the nature and scale of GHG emissions to inform the referral under the EP Act. Greenhouse gas emissions are measured as carbon dioxide equivalence (CO₂-e). This means that the amount of a greenhouse gas that are emitted is measured as an equivalent amount of carbon dioxide which has a global warming potential of one.

All numbers quoted below are estimates and are in the order of +/- 50% definition. The numbers below should be considered with this level of accuracy in mind. The accuracy of the estimate will increase as the project definition increases. It is recommended that the engineering contractor incorporates a GHG estimate in their subsequent engineering design phases.

The estimated Scope 1 and 2 emissions from the construction and operation of the MDRTS project are detailed in Table 4-1, Figure 4-1 and are discussed below¹. The full table of results is included in Appendix B.

Main findings are:

- Total project emissions including construction (5 years) and operation (50 years) is 2.1MT CO₂e. Scope 1 emissions account for 95% of emissions, 2.00MT CO₂e and Scope 2 emissions account for 5% of emissions, 0.10MT CO₂e.
- Construction contributes 22,000 T CO₂e over the 2-year construction period comprising of scope 1 emissions. Emissions during the 1st year are 10,000 T CO₂e/yr and 12,000 T CO₂e/yr during the 2nd year of construction.
- Operations contributes a total of ~2.0 MT CO₂e over the 50-year operating life or approximately 41,000T CO₂e per year during operations. Annual emissions are made up of 2,000 T CO₂e /yr from electricity use and 39,000 TCO₂e /yr from the other sources. The source of these emissions is outlined in Table 4-2.
- The largest source of emissions for MDRTS is methane emissions from the anoxic breakdown of organic material in the dam that account for ~93% of project emissions 38,000T CO₂e/yr. This is followed by Scope 2 electricity emissions that account for ~5% of project emissions 2,000TCO₂e/year, from the pumping of water into the dam as well as treatment and distribution of water from the dam (Table 4-1 and Figure 4-1). The project is estimated to consume ~3 GWhr of electricity a year, this represents a 0.2% increase in the current annual DKIS electricity usage.
- For context NT total GHG emissions for 2019-2020 was approximately 20.7 million tonnes (MT) of CO₂e. Approximately 1.4 MT CO₂e per year was emitted from public electricity generation in the Territory (DISER 2021, DISER 2021^a & Clean Energy Regulator 2022).
- Electricity usage account for 5% of emissions, or approximately 107,000T CO₂e.
- Vegetation and land use change account for 0.9% of emissions, approximately 19,000T CO₂e.
- Civil and construction emissions account for 0.8% of total project emissions or approximately 19,000T CO₂e.

¹ Emissions estimates are rounded to the nearest 1,000.

Table 4-1. Construction and Operation GHG Emissions by Scope

	SCOPE 1	SCOPE 2	TOTAL
Construction	21,517	-	21,517
Operation	1,974,070	106,852	2,080,922
Total	1,995,535	106,852	2,102,439

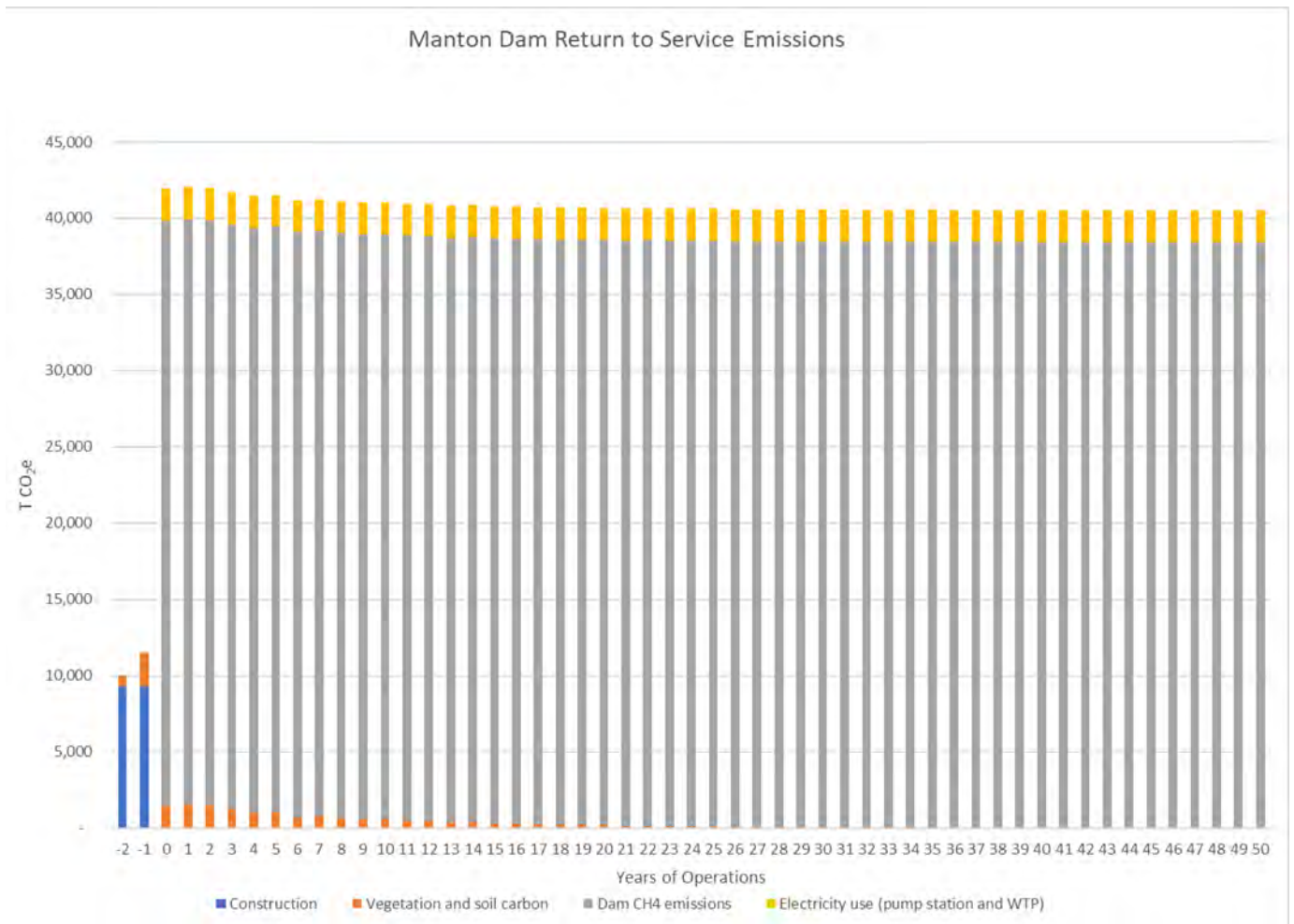


Figure 4-1. Total MDRTS Project GHG Emissions Including Construction and Operations. Note construction years are negative years prior to start up.

Table 4-2. Construction and Operation GHG Emissions by Source

SOURCE	TCO ₂ E	% OF TOTAL
Civil and Construction	18,552	1%
Vegetation and land use change	19,054	1%
Methane emissions	1,957,982	93 %
Electricity for operations	106,852	5 %

Emissions from construction are dominated by construction works associated with pipeline infrastructure, approximately 0.08 MTCO₂e, Strauss WTP, approximately 0.06 MTCO₂e and Manton Dam, approximately 0.03 MTCO₂e (Table 4-3 and Figure 4-3). These emissions total approximately 0.17 MTCO₂e during construction.

Table 4-3. Construction GHG Emissions by Source

SOURCE	TCO ₂ E	% OF CONSTRUCTION EMISSIONS
Construction diesel PWC LV	297	1%
Construction diesel Pipeline	9,041	42%
Construction diesel Strauss	5,945	28%
Construction diesel Manton	3,269	15%
Dam area (aerobic) vegetation and soil	210	1%
Clearing of pipeline vegetation and soil	2,516	12%
Clearing of infrastructure at dam vegetation and soil	120	>1%
Clearing of Strauss vegetation and soil	120	>1%

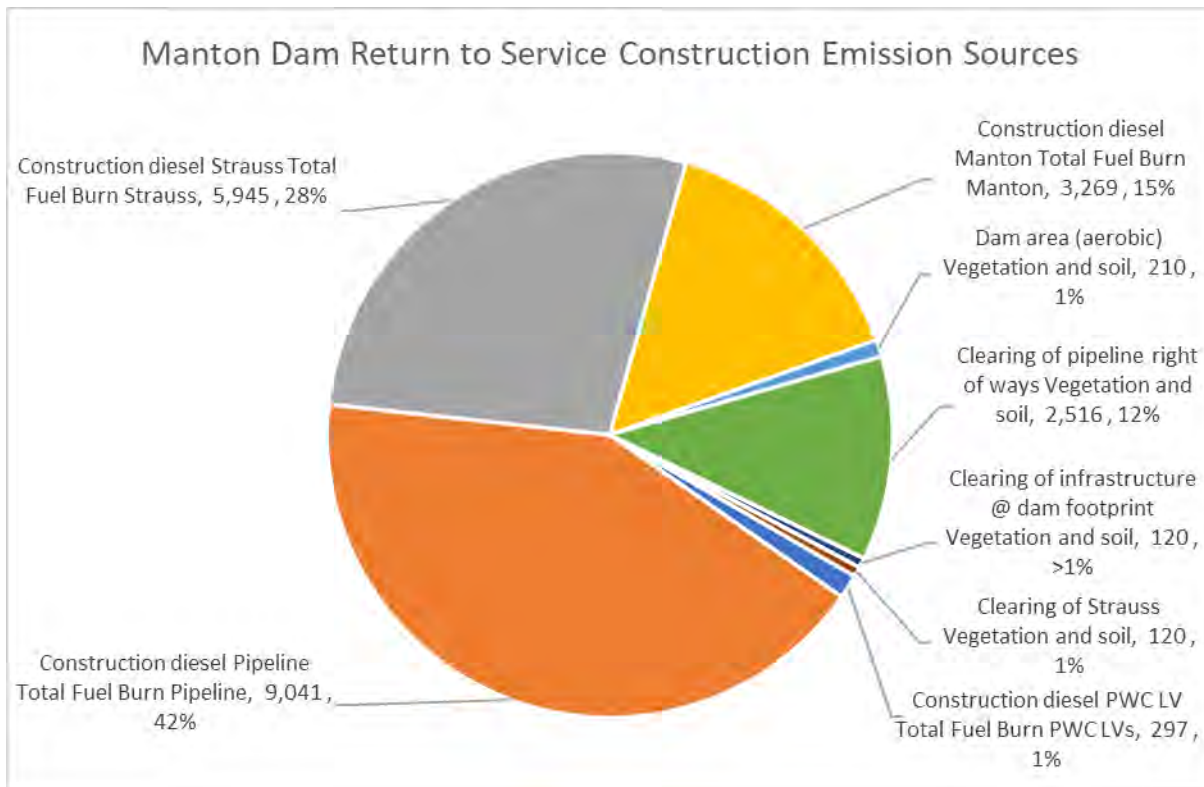


Figure 4-2. MDRTS Construction GHG Project Emissions by Source and Activity

Emissions from operations are dominated by scope 1 emissions (Table 4-4). Of the scope 1 emissions methane emissions accounts for the majority of emissions, resulting in 94.1% of scope 1 emissions. The remaining significant emissions are associated with electricity usage (Figure 4-3).

Table 4-4. Operations GHG Emissions by Source

SOURCE	TCO2E	% OF OPERATIONS EMISSIONS
Electrical (Scope 2)	106,852	5%
Dam Methane Emissions (Scope 1)	1,957,982	94%
Vegetation and land use change (Scope 1)	19,054	1%

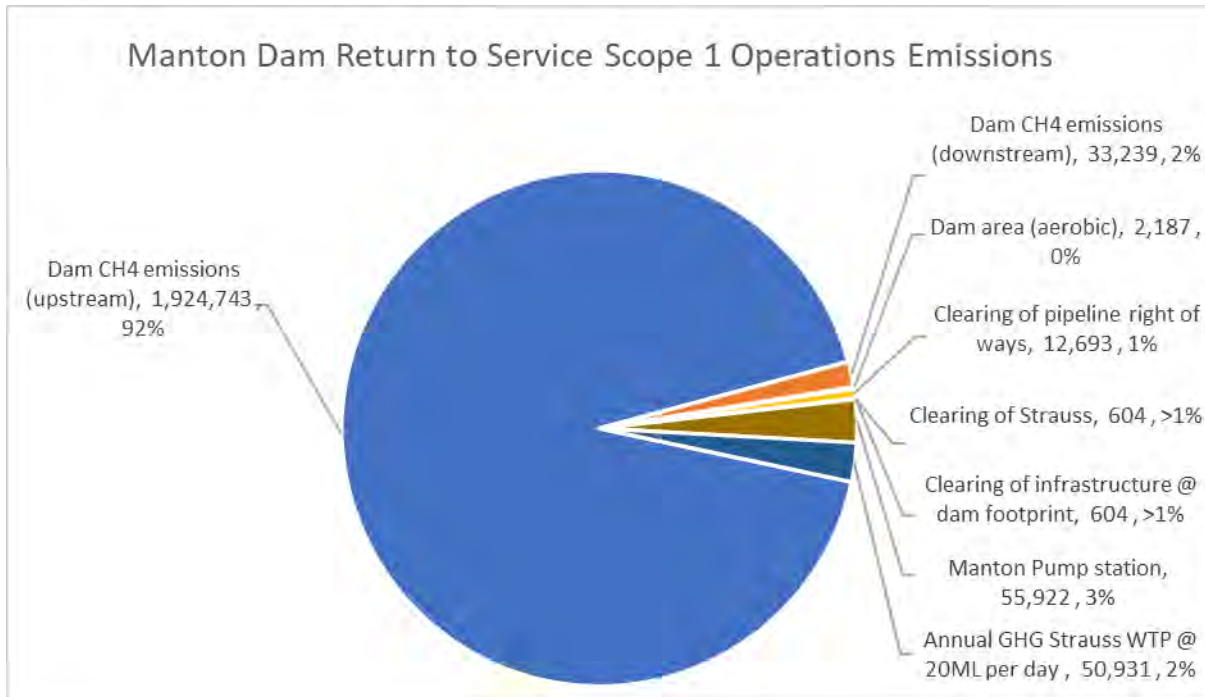


Figure 4-3. MDRTS Operation GHG Project Emissions by Source and Activity

5 REVIEW AGAINST NT POLICY

The scope of this report is to estimate GHG emissions of the MDRTS project and review these emissions against the NT GHG policy and legislation. The below section describes the relevant NT GHG policy and legislation. A review of NT EPA GHG policy and legislation is included in sections to give context to the emissions estimate. A summary of recommendations for the project against this policy and legislation are included in section 6.

5.1 NT Long Term Emissions Target

‘Northern Territory Climate Change Response: Towards 2050’ (NTG 2020)

The Northern Territory Government’s Climate Change Response: Towards 2050 (the Response) provides a policy framework that will enable the Northern Territory to strategically manage climate change risk and opportunities. It is a whole of Government response and partnership with all Territorians. Everyone has a role to play.

This *Response* defines the Territory’s target to achieve net zero emissions by 2050. This target recognises the role the NT plays in the world-wide movement towards low-carbon economies in an effort to avoid the worst effects of climate change and keep the increase in global average temperature to well below 2 degrees Celsius.

The *Response* identifies 4 key objectives to inform future actions and guide development of mitigation and adaptation strategies, these are each outlined below:

1. achieve net zero emissions

Our objective is to progressively reduce net greenhouse gas emissions in the Territory, with the goal of achieving net zero emissions by 2050. This long-term objective sets expectations about future emissions constraints to help our industries and businesses plan and adapt. Aiming to achieve net zero emissions aligns the Territory with all other States and Territories across Australia.

2. build a resilient Territory

Our objective is to build resilience to climate change in the most vulnerable aspects of the Territory’s communities, economy and environment. Building a resilient Territory means understanding the likely future effects of climate change, putting in place measures to minimise negative impacts, and identifying opportunities presented by adaptation measures that may bring an economic advantage for the Territory.

3. unlock opportunities from a low carbon future:

Our objective is to unlock opportunities for Territorians, industries and businesses in the transition to a low carbon future. The Territory has a natural advantage to be able to capitalise on low carbon opportunities with its abundance of natural assets and resources. By acting early, the Territory will position itself to make the most of the opportunities that are presented as the world transitions to a low carbon future.

4. inform and involve all Territorians

An effective response to climate change requires action from industry, business, community and individuals. Our objective is that all Territorians will understand the potential impacts from climate change, know what they can do to contribute to the response, and take advantage of any opportunity it provides.

The Territory government has drafted a three-year action plan to implement the *Response*. This action plan *Delivering the Climate Change Response: Towards 2050 A Three-Year Action Plan for the Northern Territory Government* (the *Action Plan*).

MDRTS Project presents an opportunity to unlock opportunities for a low carbon future by investing in solar energy for power generation.

It is recommended that the MDRTS Project review the opportunities to reduce emissions of the project and integrate an emissions reduction scope of work into the design process of the project. It is recommended the project develops a GHG management plan aligning with the NT long term emissions target.

5.2 Roadmap to Renewables Energy

Roadmap to Renewables, 50% by 2030. (NTG 2017)

The Northern Territory Government's 50 per cent renewable energy target is defined, in this report, to be 50 per cent of the electricity consumed in 2030 inclusive of behind-the-meter generation, future self-generating enterprises and new large industrial consumers. The roadmap sets out recommendations to achieve its goal.

The roadmap makes 11 recommendations. It recommends that the Northern Territory Government should align its policy objectives, departmental activity and government programs toward the development and purchase of renewable energy-generated electricity. It recommends in order to kick start the roll out of renewable energy generation, it is proposed that government uses its purchasing power to create initial demand through purchasing electricity from renewable energy suppliers.

There is an opportunity to reduce emission from the project and to align with this policy through the use of renewable electricity. Further this is an opportunity to align with the PWC environment sustainability policy to *support the adoption of renewable energy*. MDRTS should consider aligning with the recommendations made in the *Roadmap to Renewables Energy* and subsequent action plan. Specifically, MDRTS should align with the action plan item below:

Item 1.5.1. Undertake a review of emissions across all Territory Government's agencies to identify opportunities to reduce emissions and inform development of agency specific action plans to reduce emissions.

It is recommended that MDRTS consider the following:

- Review the opportunity to reduce emissions of the project. Integrate an emissions reduction scope of work into the design process of the project.
- Review the opportunity to increase the percentage of renewable energy consumed by the project through the supply of renewable energy to the project.

5.3 NT Large Emitters Policy

The NT Large Emitters Policy details the NT Government's minimum requirements for the management of greenhouse gas emissions from new or expanding industrial and land use development projects. It has been established in recognition of the Northern Territory's target of net zero greenhouse gas emissions by 2050.

Large greenhouse gas emitters are either industrial projects or land use projects that involve the clearing of native vegetation and exceed the below thresholds:

- Industrial project threshold: Estimated scope 1 emissions of 100 000 T CO₂e in any financial year over the life cycle of a project, not counting emissions generated from land clearing directly associated with the Project.

- Land use project threshold: Estimated scope 1 emissions of 500 000 T CO₂e generated from a single land clearing action OR cumulatively from multiple land clearing actions on a 'property' over time.

Projects that exceed one of the thresholds are required to develop a greenhouse gas Abatement Plan detailing the expected emissions from the project and develop a plan that demonstrates how the project will meaningfully contribute to the Territory's net zero emissions target.

The MDRTS Project emissions do not exceed the industrial thresholds or the land use thresholds over the life of the project.

5.4 NT GHG Offset Policy

To support the use of offsets under the *EP Act*, the Territory Government has established the Northern Territory Offsets Framework under section 125(2) of the *Environment Protection Act 2019*. This includes both the NT Biodiversity Offsets Policy as well as the NT Greenhouse Gas Emissions Offset Policy. This policy and technical guidelines are currently in Draft and undergoing stakeholder consultation.

The Territory Government has an objective to transition the Territory's economy to a low carbon economy.

This objective is reflected in the Territory's target of net zero emissions by 2050 established by the Climate Change response.

The Climate Change Response includes a range of actions designed to support the achievement of this target. One of these actions is the development of a Greenhouse Gas Emissions Offsets Policy under the Northern Territory Offsets Framework. This policy will guide the use of offsets as a tool to support the decarbonisation of industry in the Territory.

Under the NT Offsets Framework, offset requirements can be applied to environmental approvals under the EP Act or statutory approvals under a Prescribed Act. This enables offsets to be used as a tool to compensate for emissions produced by development, such as land clearing, resource exploration and extraction, or the establishment and ongoing operation of a facility.

The NT Government may consider the use of offsets to compensate for emissions in the assessment and approval stages of a development project. The NT Government will only consider the use of offsets as appropriate where proponents have applied the mitigation hierarchy to the project. This means all reasonable steps have been taken by proponents to first avoid or mitigate emissions, and significant residual emissions will remain.

The overarching target that applies to emissions in the Territory is the NT target of net zero greenhouse gas emissions by 2050. There may also be additional or interim targets set in the future by the NT Government to help achieve this target.

Emissions offsets must make a material and meaningful contribution towards achieving the Territory's target of net zero emissions by 2050, as well as any additional or interim targets set to achieve this 2050 target.

In general offsets should be applied to a project where significant residual emissions will be produced. Emissions may be produced and identified over periods of time over the life of a project (for example, annually or every five years) or through a more distinct or "one off" emitting event such as land clearing. Residual emissions include any emissions remaining once all reasonable steps have been taken to first avoid or mitigate the production of emissions.

Assessing agencies and decision makers are responsible for determining whether residual emissions are significant. The determination about whether residual emissions are significant and the amount of residual emissions that need to be offset should be made based on the following:

- the estimated emissions produced by the project, either annually or for a single event
- the projected emissions profile over the life of the project
- the target for emissions offsets identified in Section 6 of the policy
- the overall impact on the Territory's emissions profile and trajectory towards the Territory's target of net zero emissions by 2050, based on:
 - the emissions produced by the project
 - the cumulative emissions produced across a proponent's enterprises in the Territory
 - the emissions associated with the relevant industry.
- the capacity of the project, proponent and industry to avoid, mitigate or offset emissions
 - the advice of any assessing agencies for the project (for example, the NT EPA for projects assessed under the EP Act)
 - national and international emissions reduction targets, strategies and obligations.

If Power and Water Co. chose to utilise offsets as a method of aligning with NT policy described in in section 5.1, then the project should consider this policy.

5.5 NT EP Act

The NT EPA has incorporated the Northern Territory Government's net zero greenhouse gas emissions by 2050 target into the environmental objective for the NT EPA's Environmental Factor: Atmospheric Processes. The Policy sets out the Northern Territory Government's expectations for how GHG emissions are to be managed from new, or expanding, industrial and land use development projects as one means of achieving the net zero by 2050 target.

The NT EPA has released a draft Environmental factor guidance: Atmospheric processes, Greenhouse Gas Emissions. This policy and technical guidelines are currently in Draft, it has undergone stakeholder consultation and is in internal review.

The draft guideline states that under the Environmental Factor: Atmospheric Processes a proponent is to refer a proposed action to the NT EPA if its emissions exceed:

- Industrial project threshold: Estimated scope 1 emissions of 100 000 T CO₂e in any financial year over the life cycle of a project, not counting emissions generated from land clearing directly associated with the Project.
- Land use project threshold: Estimated scope 1 emissions of 500 000 T CO₂e generated from a single land clearing action OR cumulatively from multiple land clearing actions on a 'property' over time.

The NT EPA proposes to adopt the thresholds as a guide to when a proposed action requires referral to the NT EPA for consideration under the EP Act. This project does not exceed these triggers, therefore there is no requirement to refer this project under the Environmental Factor: Atmospheric Processes of the NT EP ACT.

6 SUMMARY AND RECOMMENDATIONS

The MDRTS Project does not trigger thresholds for scope 1 or scope 2 emissions noting the above policies, therefore no formal abatement plan is required as part of NT EPA referral submission.

A review of these emissions against each of the identified NT legislation and policies is completed above and a summary of recommendations is provided below.

- It is recommended that MDRTS project develop a GHG Management Plan addressing the following items (cover in a PWC corporate GHG Management plan):
 - Develop a project GHG management plan aligning with the NT long term target of Net Zero.
 - Review the opportunities to reduce emissions of the project and integrate an emissions reduction scope of work into the design process of the project.
- Review the opportunity to increase the percentage of renewable energy consumed by the project.
- Recommend implement a data improvement plan in line with section 2.2.7.

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APPENDIX A FULLCAM MODEL INPUTS

The following inputs were utilised for the MDRTS project GHG emissions calculations for areas cleared for the project.

FullCAM version 6.20.03.0827

Configuration

- Forest System including minerals
- tree yield formula

Timing

- Simulation timing: Step
- Start simulation 1/1020
- End simulation 12/2500
- Simulation steps: Monthly with recording of output every 12 simulation steps (i.e. annual)

Data Builder

- Lat Long: -12.863 79; 131.181 66, Apply downloaded data
- State = Northern Territory
- SA2 = Gulf (71057)
- NPI region = No Region
- Growth Region = 1
- Spatial data averaged over 100ha
- Native Species Regeneration>-500mm rainfall

Site

- Water, temperature and Productivity Cycle table data across all time
- t/ha output, max aboveground biomass 42.7441 tdm.ha Trees

Trees & Soil

- Native Species Regeneration>-500mm rainfall
- 18.9677% clay in soil by weight

Initial conditions

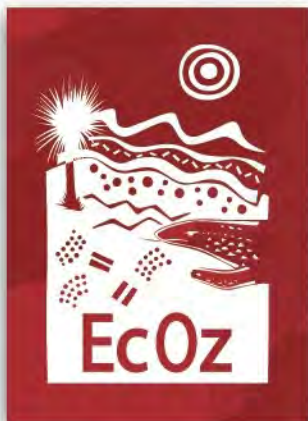
- Trees / Standing Dead / Debris and Soil– Standard values utilised

Events

- 1 Jan 2024 Initial clearing: no product recovery – dam clearing 100% site affected
 - o Standard values
 - o 100% of material converted to CO₂ via oxidation
 - o Sensitivity carried for 100% of material converted to CH₄ via anerobic breakdown.
- 1 Jan 2128 Plant trees: Native Species Regeneration>-500mm rainfall – site revegetation
 - o Standard value

APPENDIX B GHG ESTIMATE RESULTS

Annual Emissions										Construction		Operation																			
Year	Percentage of phase		Uplift included		T/CO ₂ e		-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Construction																															
Scope 1																															
Construction diesel PWC LY	Total Fuel Burn PWC LYs	1%	Yes	20%	297	T/CO ₂ e	297	149	149																						
Construction diesel Pipeline	Total Fuel Burn Pipeline	42%	Yes	20%	9,041	T/CO ₂ e	9,041	4,520	4,520																						
Construction diesel Strauss	Total Fuel Burn Strauss	28%	Yes	20%	5,945	T/CO ₂ e	5,945	2,972	2,972																						
Construction diesel Manton	Total Fuel Burn Manton	15%	Yes	20%	3,269	T/CO ₂ e	3,269	1,635	1,635																						
Dam area (aerobic)	Vegetation and soil	1%	No			T/CO ₂ e	210	103	107																						
Clearing of pipeline right of ways	Vegetation and soil	12%	No			T/CO ₂ e	2,516	562	1,955																						
Clearing of infrastructure @ dam footpri	Vegetation and soil	1%	No			T/CO ₂ e	120	27	93																						
Clearing of Strauss	Vegetation and soil	1%	No			T/CO ₂ e	120	27	93																						
Scope 2																															
Not identified																															
Scope 3																															
Not included in scope of work																															
Operations																															
Scope 1																															
Dam CH ₄ emissions (upstream)	Dam CH ₄	92%	No		37,740	T CO ₂ e/yr	1,824,743	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	37,740	
Dam CH ₄ emissions (downstream)	Dam CH ₄	2%	No		652	T CO ₂ e/yr	33,239	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	652	
Dam area (aerobic)	Vegetation and soil	0%	No			T/CO ₂ e	2,187	71	82	88	71	75	83	49	74	60	63	63	61	67	56	69	59	57	48	45	46				
Clearing of pipeline right of ways	Vegetation and soil	1%	No			T/CO ₂ e	12,693	1,239	1,343	1,297	1,020	831	893	596	635	531	446	442	362	350	258	273	215	200	173	146	139				
Clearing of infrastructure @ dam footpri	Vegetation and soil	0%	No			T/CO ₂ e	604	59	64	62	49	40	43	28	30	25	21	21	17	17	12	13	10	10	8	7	7				
Clearing of Strauss	Vegetation and soil	0%	No			T/CO ₂ e	604	59	64	62	49	40	43	28	30	25	21	21	17	17	12	13	10	10	8	7	7				
Scope 2																															
Manton Pump station	Electricity use (NGERs location based emissions)	3%	Yes		1,097	T CO ₂ e/yr	55,922	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	1,097	
Annual GHG Strauss WTP @ 20ML per	Electricity use (NGERs location based emissions)	2%	Yes		999	T CO ₂ e/yr	50,931	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999		



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APPENDIX E ARCHAEOLOGICAL ASSESSMENT REPORT

MANTON DAM RETURN TO SERVICE (MDRTS) – ARCHAEOLOGICAL SURVEY REPORT



A report EcOz Environmental Consultants, Darwin, NT

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Cover photo: A diagnostic Gartcraig brick at MDAS03.

March 2023

EXECUTIVE SUMMARY

The Power and Water Corporation (PowerWater) proposed to return to service Manton Dam, 64km south of Darwin. The dam was constructed during WWII to supply reticulated water to Darwin, ostensibly to bolster the town's water supply, building up its capacity to accommodate more troops to fight the Japanese. The dam became obsolete with the construction of the much larger Darwin River Dam in the 1970s.

The project incorporates three components or areas:

- Manton Dam and associated pump infrastructure and a pipeline easement to the Stuart Highway
- A pipeline extending north to a water treatment plant (WTP)
- The Strauss WTP

An archaeological assessment was required to determine the impact this proposed development will have, if any, on cultural heritage (archaeological) sites. EcOz Environmental Consultants engaged Ellengowan Enterprises to:

- Through literature and field survey ensure that the entire project area has had an archaeological survey
- Report on any finds highlighting any that require special management
- Provide recommendations on how to mitigate the impact the project may have on archaeological sites and objects

Seven archaeological sites were recorded across the project area ranging from features that relate to WWII to an aboriginal site. Sites 1 and 2 are both associated with the adjacent WWII Strauss Airfield. Site 3 is a stone artefact scatter. Site 4 is an isolated concrete slab. Site 5 is a WWII camp comprising of a concrete slab and metallic artefacts. Sites 6 and 7 are WWII heritage consisting of a 44-gallon drum dump and concrete slab with brickwork respectively.

Recommendations:

- Site 1 (SWTP1) – Features within the site are considered to have high significance, which should be avoided. If they cannot be avoided, the heritage regulator should be asked for their assessment on whether the site could be included within the existing declared area or not.
- Site 2 (SWPT2) – Features within the site are considered to have high significance, which should be avoided. If they cannot be avoided, the heritage regulator should be asked for their assessment on whether the site could be included within the existing declared area or not. The site also contains two isolated stone artefacts, which are assessed as having low significance and may be destroyed.
- Site 3 (MDCP1) – Assessed as having low significance. A permit to destroy should be sought from the heritage regulator, otherwise restrict damage to the existing Telecom/power line easement.
- Site 4 (MDCP2) – Avoid and if not, destroy following vegetation clearance and photogrammetry survey.
- Site 5 (MDAS1) – Avoid, otherwise destroy following vegetation clearance and photogrammetry survey.
- Site 6 (MDAS2) – Avoid, otherwise destroy following vegetation clearance and photogrammetry survey.
- Site 7 (MDAS3) – Avoid, otherwise destroy following vegetation clearance and photogrammetry survey.

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1.0 INTRODUCTION

1.1 Background and consultancy brief

An archaeological assessment was required for the Power and Water Corporation's (PowerWater) Manton Dam Return to Service (MDRTS) project. EcOz Environmental Consultants engaged Ellengowan Enterprises to compile all the previous reports and to incorporate recent surveys into this study.

The previous reports included two assessments of the proposed Strauss Water Treatment Plant (SWTP) (Jung 2017 and 2022), and a pre-disturbance assessment of the current rising main pipeline between Manton Dam and the Cox Peninsula Road (Crassweller 2009). Two additional archaeological surveys were undertaken on the proposed pipeline between Manton and the proposed SWTP during November 2022 and February 2023. The results of these last two surveys and the previous survey information are presented in this report.

The Manton Dam and the pipeline was constructed during World War II (WWII) to provide a reticulated water source for Darwin town, to increase the town's capacity in the war against Japan. Manton Dam was superseded by the construction of the Darwin River Dam in the 1970s and was used subsequently as a recreational dam for boating, fishing and water skiing.

The MDRTS project is divided into three areas:

- Manton Dam and pipeline easement to Stuart Highway
- A pipeline easement alongside the Start Highway to the water treatment plant (WTP)
- The WTP at Strauss.

The scope for this report was to:

- Identify any prescribed archaeological objects or places as defined under the Northern Territory *Heritage Act 2011*, and any archaeological sites located within the survey area.
- Assess the nature, distribution and significance of these objects or places and discuss possible constraints to the works posed by the presence of archaeological and historic sites and an indication of what sites are likely to be the most sensitive in this respect.
- Review previous surveys, collates that data, used to guide further surveys and then reports on it
- Present a final report including a summary of survey results, determination of significance of sites and the likely impact of the proposed development, and recommendations regarding management strategies or mitigation procedures as appropriate under the Northern Territory *Heritage Act 2011*.

1.2 Location of the study area and brief description

Manton Dam lies 64km from Darwin, with the pipeline to the proposed SWTP being approximately 20km long (Fig. 1). Figures 2 to 4 show three area details. The pipeline corridor width is 20m, which includes a 10m easement either side of the centreline. The terrain, from south to north, begins at Manton Creek, which is a steep sided gully draining eastward from Manton Dam. Manton Creek has cut through a ridgeline at Manton Gap, the site of Manton Dam with its mix of WWII and 1970s infrastructure. The pipeline corridor follows north from Manton Creek and immediately crosses the Stuart Highway, over flat terrain and a small riparian zone, which

drains into Manton Creek. The route then traverses low laterite hills parallel to the Stuart Highway, which transition to flat black soil plains, transected by several drainage lines, swamps and small acreage allotments. The route crosses the Stuart Highway again to connect into the proposed SWTP just to the north of the Cox Peninsular Road.

The pipeline route is largely only accessible during the dry season.

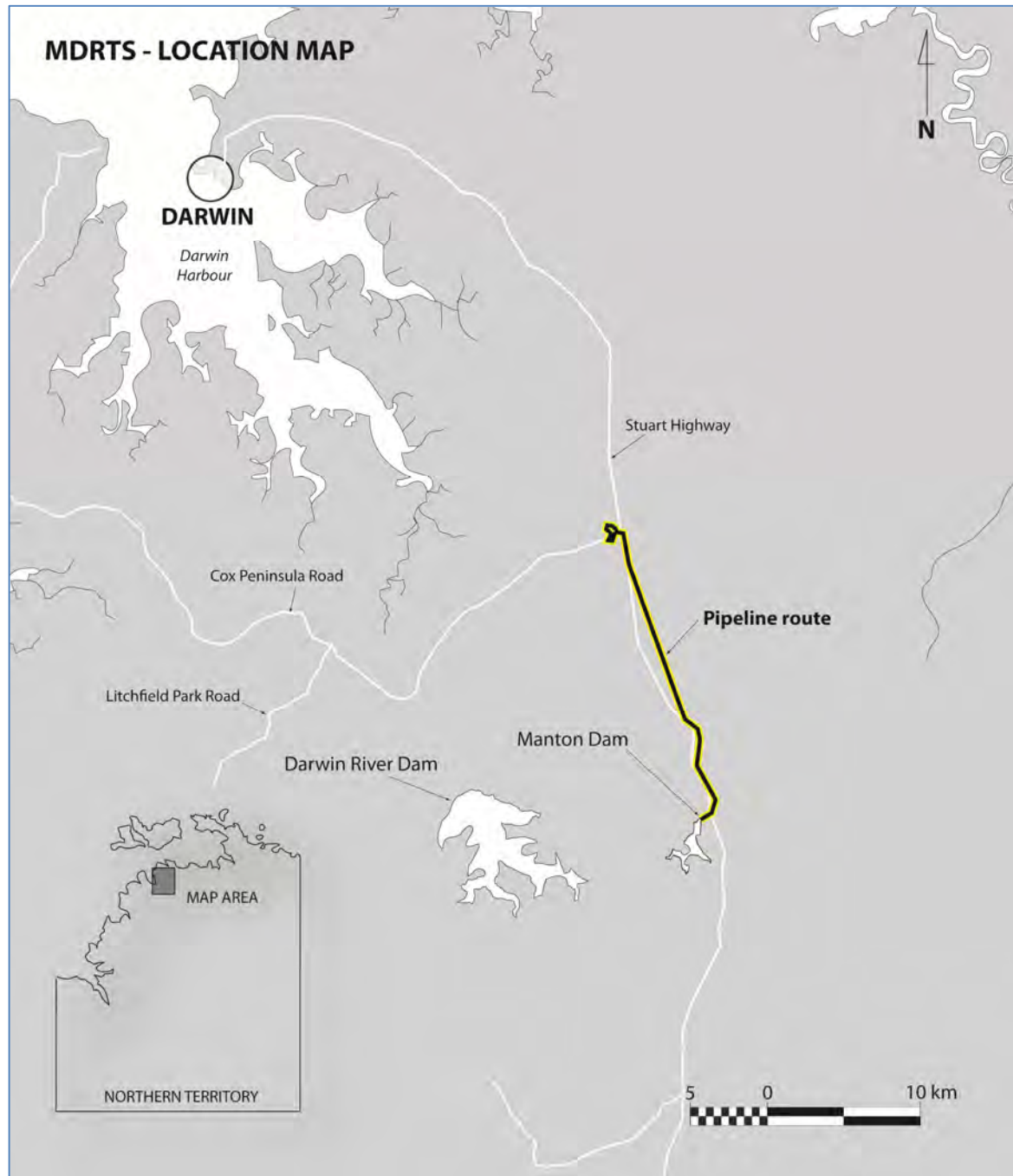


Figure 1. MDRTS location map showing the three survey sections.

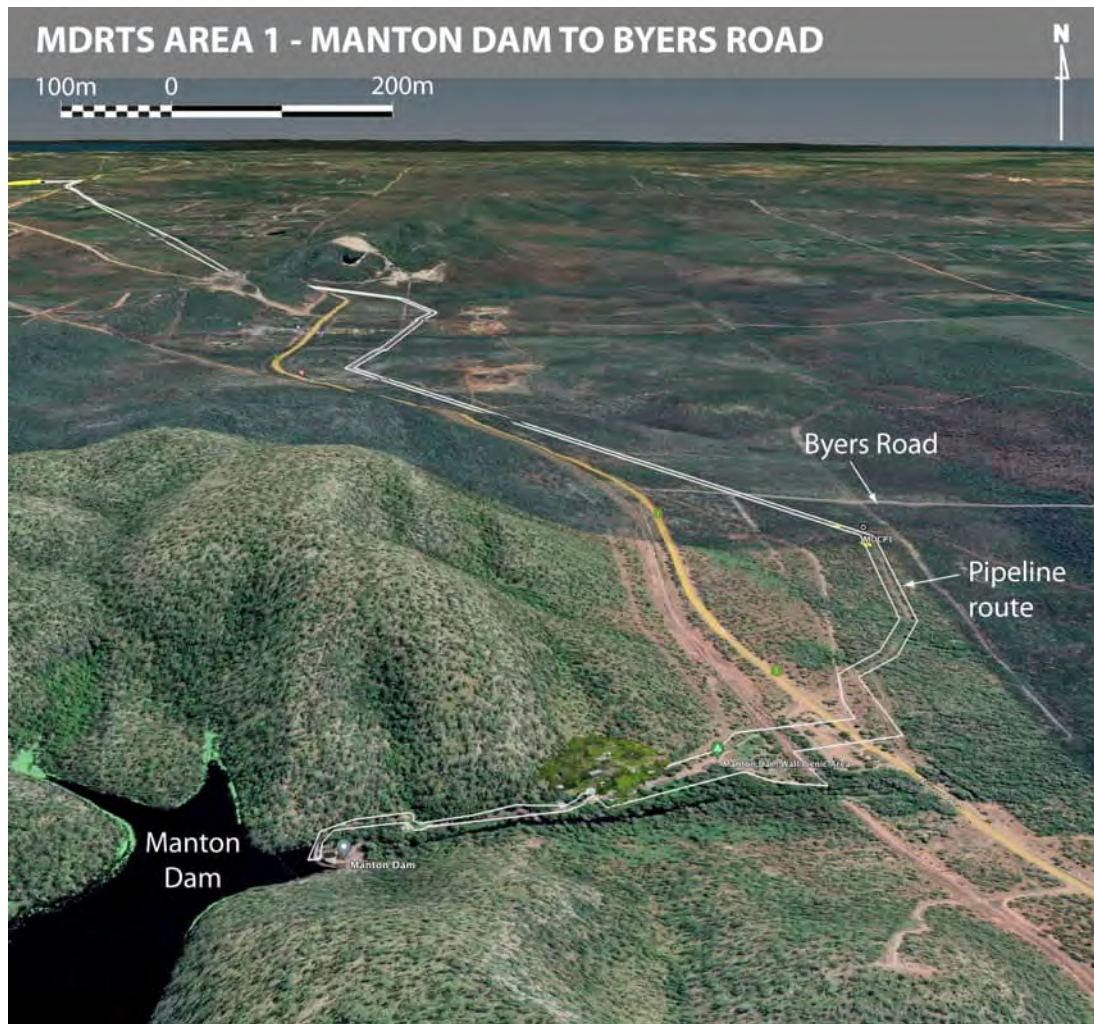


Figure 2. Map of MDRST Area 1 - Manton Dam to Byers Road (After Google Earth).



Figure 3. Map of MDRST Area 2 - Byers Road to Strauss Airfield (After Google Earth).



Figure 4. Map of MDRTS Area 3 - Strauss Water Treatment Plant (After Google Earth).

2.0 HERITAGE LEGISLATIVE FRAMEWORK

2.1. Northern Territory legislation

There are two kinds of heritage sites protected under the Northern Territory *Heritage Act 2011*, declared and prescribed places and objects. The current *Heritage Act* was instigated on 1 October 2012 and supersedes the *Heritage Conservation Act* of 1991. The *Act* places legal constraints on owners of private property, local government and the Crown:

- Places or objects listed on the Northern Territory Heritage Register are declared heritage places and objects that are protected under section 33 of the *Act*, and;
- Prescribed archaeological places and objects, which may or may not be declared, are protected under sections 29 and 39 of the *Act*.

It is an offence under the *Act* to damage, destroy, alter or carry out work of any sort on declared or prescribed sites without the written consent of the Minister or Minister's delegate. If considered appropriate, the Heritage Branch may on occasion utilise the discretion available in the *Act* to give permission for small-scale disturbance (such as the relocation of isolated stone artefacts) without the need for a formal application. The discretion is allowed under s148 of the *Act*, which in effect says that a heritage officer (such as an archaeologist) may undertake actions (or authorise actions), not construed as an offence.

2.1.1 Declared heritage places and objects

Categories, which describe the status of each site on the Northern Territory Heritage Register database, are listed in Table 1.

Table 1. Site status on the Northern Territory Heritage Register database

Status	Description
D	Declared heritage place.
NR	Not recommended. HC* determined that the place did not meet heritage assessment criteria and did not hold sufficient value to warrant declaration under the <i>Act</i> .
RF	Refused by the Minister. HC* recommended for declaration and Minister refused to do so.
P	Proposed. HC* has determined that the place warrants declaration under the <i>Act</i> but has not yet made its recommendations to the minister.
RV	Revoked. Declaration as a heritage place pursuant to Section 26(1) of the <i>Act</i> is revoked.
N	Nominated. HC* has yet to complete its assessment of the heritage value of the place.

*Heritage Council

The Northern Territory Heritage Register contains places that possess special significance for the Northern Territory and have been recognised for a wide range of natural and cultural values. As a result, it includes places that have been deemed significant because of their environmental and/or cultural characteristics. For the purposes of the current report, only places of historic or archaeological significance have been included. A search of the register indicates that no sites are listed on the Heritage Register, for the MDRTS programme area. The surrounding area, however, has declared places: The WWII Noonamah Cricket Pitch and Oval, as well as the WWII Noonamah Railway Siding and Store Depot and Strauss Airfield itself (Appendix 1).

2.1.2 Prescribed archaeological places and objects

The Heritage Branch, Community Participation and Inclusion Territory Families, Housing and Communities,¹ hold the Archaeological Sites Register. Included in this register are the protected prescribed sites that consist of all recorded and registered archaeological sites and objects pertaining to the past occupation by Aboriginal people. Any historic sites listed on this register do not indicate that these sites are protected or hold legal significance under the Northern Territory *Heritage Act*.

2.2. Constraints

2.2.1 Ground Integrity (GI)

Assessing ground surface integrity provides an indicator of whether or not the landscape under study has been modified, and if so the degree of disturbance encountered. It then becomes possible to gauge the degree to which modification has influenced the environmental context within which artefacts and/or places of cultural and/or scientific interest are located. Ground surface integrity must also be assessed from the perspective of the current legislation.

The *Aboriginal Cultural Heritage Act 2003* (in Queensland, but equally applicable to the Northern Territory) provides a definition for GI that includes the removal of native vegetation as inferring the ground has been subjected to ‘significant ground disturbance’. Under these criteria of modification, therefore, the *Act* assumes that archaeological integrity and significance is greatly reduced, is negligible, or even extinguished completely.

Contrary to this however, archaeologists are continually finding evidence that important cultural heritage material and/or places regularly survive not only land clearing activities but also invasive farming techniques such as ploughing.

Combined with this is the fact that, regardless of levels of GI, significant Aboriginal objects and/or significant Aboriginal areas can be defined on entirely cultural grounds, by Traditional Owners, not requiring any assessment of ground surface integrity.

Levels of GI are determined using a percentage range between 0-100% where 0% indicates all GI is gone, and 100% represents excellent preservation of the original context. Zero – 0%; Poor – 1-25%; Moderate- 26-50 %; Fair – 51-75 %; Good – 76-85%; Excellent 86-100%.

2.2.2 Ground Surface Visibility (GSV)

Assessments of ground surface visibility provide an indication of how much of the ground surface can actually be seen.

Ground surface visibility (GSV) is most commonly inhibited by vegetation but other inhibitors may include concrete, gravel and bitumen. Levels are determined using a percentage scale similar to that used for the calculation of Ground Integrity (GI), in that 0% represents zero visibility and 100% represents maximum visibility (bare ground). Zero – 0%; Poor – 1-25%; Moderate – 26-50 %; Fair – 51-75 %; Good – 76-85%; Excellent – 86-100%. The better the visibility, the more potential there is for locating cultural/archaeological material.

¹Formerly The Department of Tourism and Culture (DTC), formerly The Department of Lands, Planning and Environment (DLPE), formerly The Department of Natural Resources, Environment and the Arts (NRETAS).

3.0 METHODS

3.1 Survey extent and methods

Previous survey work had already been undertaken at WPT on the eastern side of the historic North Australian Railway (NAR) for the proposed WTP and on the western side of the NAR (Jung, 2017; Jung, 2022a). The results of those surveys left gaps, as there were no surveys at:

- Pipeline easement
- Manton Dam to the highway

The MDRTS archaeological survey schedule was as follows:

1. The first survey was on 7 January 2017 for the eastern area of the WTP (Jung 2017).
2. The second survey was conducted on 27 October 2022 from Area 1 (including a women's Dreaming site) with Donna Jackson (Larrakia) and Kerry Moran (PowerWater).
3. The third survey was conducted on 2 November 2022 for the western area of the WTP, again with Donna Jackson (Jung, 2022a).
4. The fourth survey for the MDRTS was conducted on 10 February 2023 with Graham Kenyon (Limilngan-Wulna) and Wilson Lee (PowerWater). Surveys two and four are a focus of this report and cover the gaps in our understanding of the distribution, extent and condition of the archaeology for the project.

The archaeological survey method utilised in this survey was based on sampling strategies. These strategies can be 'purposive', where specific areas are targeted, or 'probabilistic', where decisions are made to survey without any prior knowledge or predictive model of what heritage resources might exist in the landscape to be surveyed. Cultural heritage survey strategies generally involve transects across the project area chosen at random (probabilistic) to avoid possible bias in the results, or transects within particular areas (purposive) known to potentially contain Aboriginal cultural heritage or contain sites that were identified in previous research or surveys.

The availability of water is a key determinate as to where people were in the environment in prehistory. This survey will focus on any waterways, rivers, creeks and soaks, including any areas suitable for the preservation of rock art in the survey area.

All finds were recorded by GPS and photographed. Site boundaries were delineated, based on decreasing frequency of finds from the site centroid.

3.1.1 Identification of archaeological material

Stone artefacts, including tools and debitage, the by-product of manufacture, are identified on the following criteria after McCarthy (1976), Holdaway and Stern (2004):

- Bulb of percussion
- Ercure scar (on the ventral surface)
- Point of force application (PFA) and associated ring crack
- Termination types (e.g. feathered, stepped, hinged, plunge)
- Flake scars (dorsal scars and ridges)
- Cores (identified by the presence of negative flake scars)
- Hammer stones (identified by the presence of end-crushing on pebble stones)
- Retouch (reworking of flake margins)
- Raw material type

- Grinding stones (very smooth wear on upper surface)

List of artefact type abbreviations:

- Ax – Axe
- Ad – Adze
- An – Anvil
- Bl – Blade
- C – Core
- Cf – Core fragment
- Cp – Core piece
- Ct – Core tool
- F – Flake
- Fp – Flake piece
- Gs – Grindstone/Grinding plate
- Hs – Hammer stone
- M – Manuport
- Rtf – Retouched flake
- S – Scraper
- Sc – Single platform core
- Ts – Top stone
- X – Axe/wasted cobble
- Z – Other e.g., ceremonial

3.1.2 *Definition of archaeological sites*

3.1.2.1 *Historical Sites*

Historical sites in north Australia are those that have physical evidence of European and non-European activities. These range from Macassan sites to military sites of WWII. The Macassan sites are afforded automatic protection under the *Act*. WWII sites, however, are only protected under the *Act* once they have undergone a nomination process. Both Macassan, WWII and other historic sites, such as Chinese mining areas, the Overland Telegraph Line (OTL), the North Australian Railway etc., may overlap with Aboriginal heritage sites.

3.1.2.2 *Aboriginal Heritage Sites*

Aboriginal archaeological sites can be classified by seven main types: 1) stone knapping sites, including quarries, 2) background scatters, including isolates, 3) stone arrangements, such as mounds, walls, fish traps or stone motifs, 4) shell middens, 5) burials, 6) scarred trees and 7) rock art sites.

Burke and Smith (2004:63) define an archaeological site as ‘any place that contains the physical evidence of past human activity.’ Australia, however, has what has been referred to as a background scatter of stone artefacts, which refers to low-density artefact scatters that either represent singular knapping events (‘dinner-time’ camps or ‘hunting camps’), or larger sites that have been buried or disturbed. To differentiate this site type from larger sites that may contain thousands of artefacts, the term Archaeological Site (AS) is used to describe home-camps or quarries i.e., places where people have been returning to for millennia, as opposed to sites that have very low artefact densities that represent sporadic visits i.e., background scatters (BS).

3.2 Assessment of archaeological significance

From personal observations, Aboriginal people regard all material cultural heritages as significant. They are, after all, the tangible reminders of their culture and represent a finite resource. It is a western construct to assess sites and objects as a hierarchy. Significance assessment in archaeology, therefore, is complex, dependent on a range of factors. These can be classified as low, moderate or high significance, following the International Council on Sites and Monuments (ICOMOS) Charter for the Conservation of Places of Cultural Significance, or the Burra Charter (Maquis-Kyle and Walker, 1992).

Archaeological significance, however, very much depends on the research questions being posed (see Sullivan and Bowdler, 1984; Moratto and Kelly, 1981). Generally low significance finds have poor diversity of artefact types and in very low densities. Sites that are likely to be particularly valuable in answering archaeological research questions are given moderate archaeological significance. High archaeological significance sites have very high artefact densities per metre squared, with rare and unique finds that is well preserved and has high ground integrity (see below). The concept of significance in cultural heritage assessments is often irrelevant, whereby the client merely seeks to determine absence or presence of cultural material on their proposed works area and how best to mitigate their impact on those finds to comply with the *Act*.

4.0 RESULTS

4.1 Results of the survey undertaken for this report

The survey in October 2022 traversed the entire length of the pipeline route. There was only a narrow and shallow drainage line encountered, with an archaeological potential. It was flowing at the time of the survey. Its banks were covered in dense vegetation reducing GSV to <5%. The drainage line is subject to yearly flooding and sediment deposition. This was the only water source seen throughout the whole route, apart from Manton Creek. The survey in February 2023 could only access the stoney ridge near Manton Creek and limited areas off main roads. Most of the line was impassable due to flooding.

4.2 Archaeology of the project area

Seven archaeological sites were determined across the project area. Table 2 combines the historical data (Sites 1, 2, 3 and 4) and new data from this report (Sites 5, 6 and 7). All sites are mapped in Figure 5. There were no Aboriginal archaeological sites found from Manton Dam to the highway. A previous Cultural Heritage Management Plan, however, was developed for the WWII heritage sites at the Manton Dam Heritage Precinct (Jung, 2022b). The impacts on the proposed works at the Heritage Precinct involve replacement of the inlet valves on the intake tower in the dam, a WWII feature and the replacement of four outlet valves, also WWII features. A 1970s electric pump house is also to be demolished (Jung, 2022b: 37 and 38). There will be no other impacts on the Heritage Precinct. Of note, however, is that none of the WWII heritage structures in the Heritage Precinct are Heritage listed. They are yet to be formerly nominated as heritage places to the Northern Territory Heritage Council.

Site 1 (SWTP1) comprises of WWII heritage features on the eastern side of the NAR. These range from a large 44-gallon drum dump to bomb craters and Anti-Aircraft (AA) gun pits, all of which are associated with Strauss Airfield. Within the site are significant features: two AA sites. Site 2 (SWTP2) is on the western side of the NAR. The site was also used as a practice firing range for Strauss Airfield and contains features such as AA pits and practice firing range backstops. These are earthen structures to stop bullets. Numerous UXOs and extended ordinance was found at the site. Two isolated stone artefacts were also found at Site 2.

Site 3 (MDCP1), recorded in 2009, was inspected (Figs 6 to 8). It was the only stone artefact site found along the MDRTS route, although two isolated stone artefacts were recorded during the survey in November 2022 at the WTP. A legacy Telecom Australia cable and power line easement goes through Site 3 and has heavily impacted the site.

Site 4 (MDCP2) was relocated. It consists of a concrete slab measuring 1.9m x 3.2m. It was covered in heavy vegetation and lies near the pipeline route's western boarder.

Site 5 (MDAS1) was found adjacent to Site 1. It comprises of a concrete slab, 44-gallon drums, a latrine and metallic artefacts (Figs 9 and 10). Site 6 (MDAS2) solely comprised of 44-gallon drums is shown in Figure 11.

Another new site (Site 7) was found 320m to the south of Byers Road, referred to as Manton Dam Archaeological Site 3 (MDAS3). Figures 12 and 13 show the site. The site is of a concrete slab and disarticulated tin sheeting. The site measures 10m x 7.5m and it was possibly a brick building. Several bricks with the mark: 'Gartcraig' were found, some still lining the outer wall of the slab and mortared in place (Fig. 14). The Gartcraig Fire Clay Co is a Scottish company that fired

bricks from the 1870s to ca. 1921 (<https://www.scottishbrickhistory.co.uk/gartcraig-fire-clay-co-millerston-glasgow-history/>. Accessed 11 February 2023).

Together with the other concrete slabs, the construction method is similar and with the same aggregate. They're all most likely to be WWII heritage sites. No new Aboriginal archaeological sites were found in February 2023.

Table 2. All recorded archaeological sites – MDRTS programme (see Jung, 2017 and 2022)

Site #	Site Name	Feature Id	Site Type	Easting	Northing	Description
1	SWTP1	AA01	WWII heritage	725234	8598203	44-gallon gabion light Anti-Aircraft gun pit
		AA02	WWII heritage	725203	8598201	44-gallon gabion light Anti-Aircraft gun pit
		Bomb crater	WWII heritage	725173	8598036	Circular depression with 16m diameter
		Impact crater	WWII heritage	725250	8598790	Circular depression with 2.5m diameter
		Drum line	WWII heritage	725294	8598261	Seven 44-gallon drum joined end to end (possible latrine?)
		44-gallon drum dumpsite	WWII heritage	725366	8598616	44-gallon drum dumpsite. >200 drums
		Bottles/Asbestos	WWII heritage	725262	8598893	Numerous beer bottle fragments with diagnostic elements/asbestos tiles
		Other material	WWII heritage/modern dump			Various finds
2	SWTP2	SJ22-0306	WWII heritage	725093	8598478	AA GUN PIT 1
		SJ22-0307	WWII heritage	725076	8598505	AA GUN PIT 2 LARGE
		SJ22-0308	WWII heritage	725113	8598527	AA GUN PIT 3
		SJ22-0309	WWII heritage	725142	8598537	DRUMS X 3
		SJ22-0310	WWII heritage	725144	8598549	SINGLE DRUM AND PIPE
		SJ22-0311	WWII heritage	725144	8598556	SINGLE DRUM
		SJ22-0312	WWII heritage	725142	8598574	5 DRUMS NO ARRANGEMENT. DISTURBED FORMER AA SITE?
		SJ22-0313	WWII heritage	725057	8598586	ASBESTOS DUMP
		SJ22-0314	WWII heritage	725027	8598576	2X METAL SLEEPERS
		SJ22-0315	WWII heritage	725021	8598559	INSULATOR
SJ22-0316	Aboriginal	725020	8598557	F(S) - isolith		

		SJ22-0317	WWII heritage	724995	8598570	DISTURBED SOIL RIDGE FIRING RANGE
		SJ22-0318	WWII heritage	724962	8598653	MORTAR ROUND AND BULLET
		SJ22-0319	Aboriginal	725005	8598665	F(Q) - isolith
		SJ22-0320	WWII heritage	724873	8598823	MORTAR AND BULLET
		SJ22-0321	WWII heritage	724888	8598828	FIRING RANGE
		SJ22-0322	WWII heritage	724888	8598889	SHELL FRAG MORTAR
		SJ22-0323	WWII heritage	724874	8598897	MORTAR
		SJ22-0324	WWII heritage	724868	8598919	MORTAR CASING LIVE?
		SJ22-0325	WWII heritage	724812	8598967	FIRE RANGE RIDGE
		SJ22-0326	WWII heritage	724865	8599002	CORRUGATED IRON SHEETS
		SJ22-0327	WWII heritage	725115	8598762	IRON TUB
		SJ22-0328	WWII heritage	725135	8598364	DRUMS. OLD AA?
		SJ22-0329	WWII heritage	725206	8598389	RAIL BRIDGE
3	MDCP1	Stone artefact scatter	Aboriginal	731882	8580950	On low ridge near Manton River. Quartz flakes and debitage (knapping floor)
4	MDCP2	MDCP2	WWII heritage	730860	8584648	Concrete slab on flat ground
5	MDAS1	WWII heritage	WWII heritage	731865	8580870	On low ridge near Manton River. Concrete slabs and 44 gallon drums, tin
6	MDAS2	WWII heritage	WWII heritage	726648	8595294	Flat ground north of Townend Road. Dump of 44 gallon drums
7	MDAS3	WWII heritage	WWII heritage	731839	8581011	Large concrete slab, with brick outer wall, tin, upright metal frame.

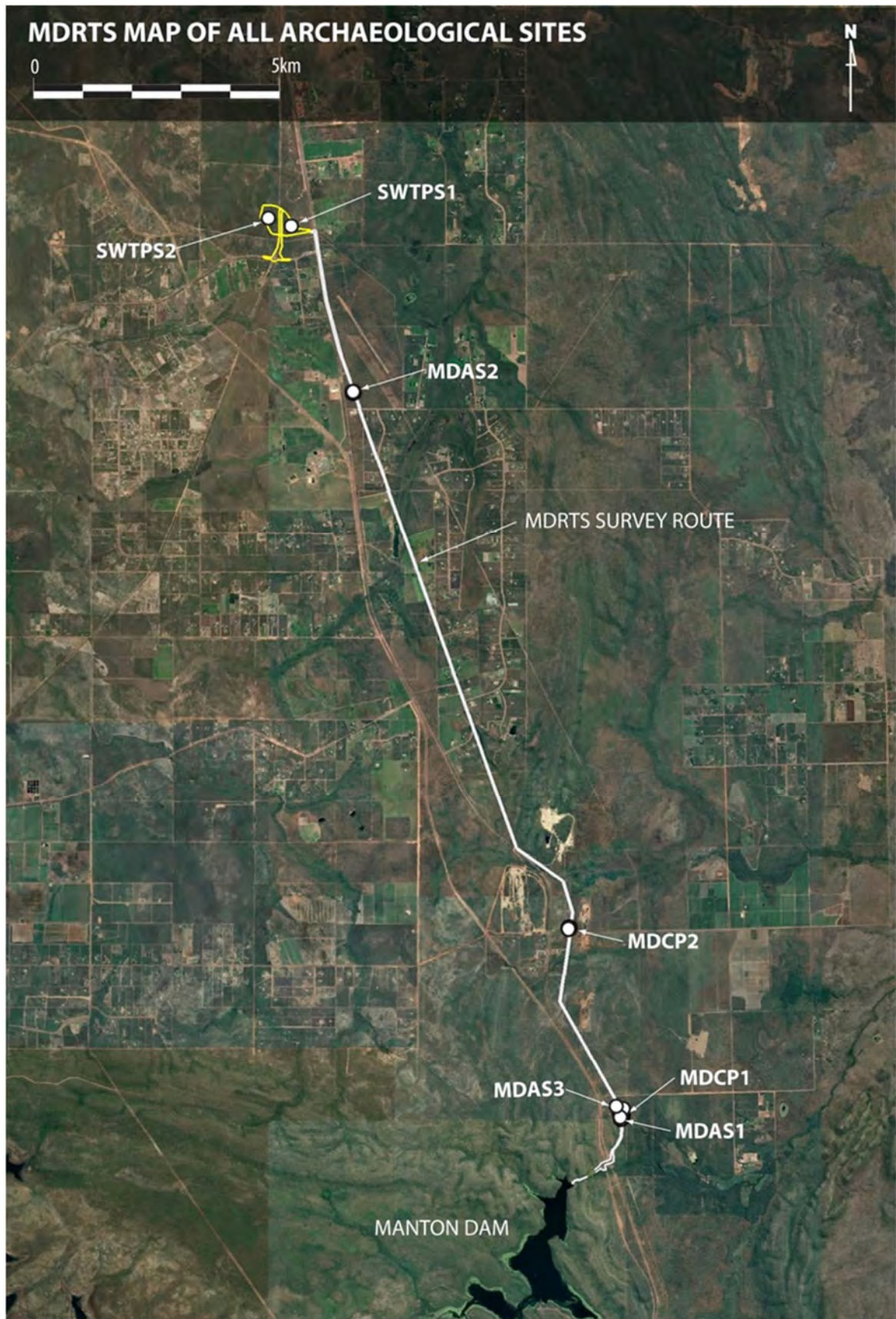


Figure 5. MDRTS map of all recorded archaeological sites (After Google Earth).



Figure 6. MDCP1 quartz flakes and debitage (Scale in 1cm).



Figure 7. MDCP1 site context view with Wilson Lee (L) and Graham Kenyon (R).



Figure 8. Typical flake on quartz, MDCPI.



Figure 9. Context view of MDASI showing 44-gallon drums and concrete slabs in background. Scale in 1cm.



Figure 10. Weight scale? MDASI.



Figure 11. MDAS2 - 44-gallon drum dump.



Figure 12. MDAS3 – historic slab. Scale in 1cm.



Figure 13. MDAS3 historic slab looking north.



Figure 14. MDAS3 with 'Gartcraig' bricks. Scale in 1cm.

4.3 Significance assessment of finds

The following assessment criteria are used in this report to determine the level of significance of finds. Table 3 lists the sites and their corresponding level of significance as assessed in this report.

Significance Indicate if you can which of the heritage assessment criteria you believe this place or object meets:

(a) it is important to the course, or pattern, of the Territory's cultural or natural history;

(b) it possesses uncommon, rare or endangered aspects of the Territory's cultural or natural history;

(c) it has potential to yield information that will contribute to an understanding of the Territory's cultural or natural history;

(d) it is important in demonstrating the principal characteristics of a class of cultural or natural places or environments;

(e) it is important in exhibiting particular aesthetic characteristics;

(f) it is important in demonstrating a high degree of creative or technical achievement during a particular period;

(g) it has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons, including the significance of a place to Aboriginal people as part of their continuing and developing cultural traditions;

(h) it has a special association with the life or works of a person, or group of persons, of importance in the Territory's history

(https://nt.gov.au/__data/assets/pdf_file/0004/520906/heritage-register-nomination-form.pdf). Accessed 15 March 2023).

Table 3. Significance criteria for all recorded archaeological sites – MDRTS project

Location	Site #	Significance	Criteria met
Strauss	1	High	A, B, C, D, H
Strauss	2	High	A, B, C, D, H
Pipeline	3	Low	A
Pipeline	4	Low	G
Pipeline	5	Low	A
Pipeline	6	Low	A
Pipeline	7	Moderate	A, C

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This report combines the results of previous archaeological surveys from 2017 and November 2022, together with new survey outcomes from October 2022 and February 2023, which had not been reported on for PowerWater's proposed MDRTS project. Seven archaeological sites were recorded, six of which relate to WWII Heritage sites and one is an Aboriginal Heritage site.

PowerWater's MDRTS project will have little impact on significant Aboriginal cultural heritage sites, as the only site found had already been impacted by existing infrastructure. Most of the pipeline route traverses through country that is not conducive to site preservation. The proposed project will, however, impact significant WWII heritage sites (Sites 1 and 2) at the WPT and one site (Site 7) of moderate significance along the pipeline route. The following specific recommendations are suggested to minimalise the impacts.

5.2 Recommendations

5.2.1 *Recommendations: Site 1 (SWTP1)*

- Option 1. Avoid. The site relates to the WWII history and archaeology of the Darwin region. The site contains features that should be avoided. Two of these have been assessed as having high significance, namely the two AA pits. Site 1, furthermore, should be included in the Declared Heritage Area as it is clearly a part of the WWII Strauss Airfield.
- Option 2. Site destruction. The site is not part of the Declared Heritage Area, nor has it been nominated for heritage listing. Further clarification should be sought from the regulator as to the level of disturbance at the site.

5.2.2 *Recommendations: Site 2 (SWTP2)*

- Option 1. Avoid. The site relates to the WWII history and archaeology of the Darwin region. The site contains features that should be avoided. Two of these have been assessed as having high significance, namely the two AA features and two firing ranges/back stops. Site 2, furthermore, should be included in the Declared Heritage Area as it is clearly a part of the WWII Strauss Airfield.
- Option 2. Site destruction. The site is not part of the Declared Heritage Area, nor has it been nominated for heritage listing. Further clarification should be sought from the regulator as to the level of disturbance at the site.

5.2.3 *Recommendations: Site 3 (MDCP1)*

- Option 1. Avoid. The site is a stone artefact scatter. Although impacted already by existing infrastructure, further damage to the site should be restricted to the already disturbed area within the Telecom and power line easement.
- Option 2. Destroy. The site has been assessed as having low significance. Permit to destroy should be sought from the heritage regulator.

5.2.4 *Recommendations: Site 4 (MDCP2)*

- Option 1. Avoid. The site is concrete slab relating to the WWII occupation of the area. The site lies 5m from the pipeline's western boundary, outside of the already disturbed easement.
- Option 2. Destroy. The site is of low significance and may be destroyed post vegetation clearance and photogrammetry survey.

5.2.5 *Recommendations: Site 5 (MDAS1)*

- Option 1. Avoid. The site is a WWII camp consisting of concrete slab, 44-gallon drum and metallic artefacts. The site is on the proposed works western boundary. An exclusion zone is suggested (Appendix 2).
- Option 2. Destroy. The site is of low significance and may be destroyed post vegetation clearance and photogrammetry survey.

5.2.6 *Recommendations: Site 6 (MDAS2)*

- Option 1. Avoid. The site is a WWII dump of 44-gallon drums. It is between the eastern boundary and existing pipeline.
- Option 2. Destroy. The site is of low significance and may be destroyed.

5.2.7 *Recommendations: Site 7 (MDAS2)*

- Option 1: Avoid. The site is of a large concrete slab with fired brickwork. An exclusion zone is suggested for the site (Appendix 2).
- Option 2: Destroy, following vegetation clearance and photogrammetry survey.

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APPENDIX 1: Maps of declared Heritage Areas



Figure 15. – WWII Strauss Airstrip
(http://www.ntlis.nt.gov.au/heritageregister/?p=103:303:::NO:P303_PLACE_ID:310#.
Accessed 27 March 2023)



Figure 16. WWII Cricket Pitch & Oval Noonamah
(http://www.ntlis.nt.gov.au/heritageregister/?p=103:303:::NO:P303_PLACE_ID:592#.
Accessed 27 March 2023).



Figure 17. WWII Noonamah Railway Siding and Store Depot
(http://www.ntlis.nt.gov.au/heritageregister/f?p=103:303::::NO:P303_PLACE_ID:591#.
Accessed 27 March 2023).

APPENDIX 2: Polygon boundary co-ordinates for Archaeological sites (AS) – exclusion areas, MDAS1 and MDAS3 – MDRTS project

MDAS1 exclusion area		
Datum GDA94, Zone 52L		
Point	Easting	Northing
1	731867	8580884
2	731859	8580882
3	731856	8580876
4	731856	8580864
5	731871	8580859
6	731875	8580867
7	731872	8580879
MDAS3 exclusion area		
Datum GDA94, Zone 52L		
Point	Easting	Northing
1	731830	8581017
2	731836	8581004
3	731846	8581007
4	731841	8581021

**APPENDIX F REGULATORY REQUIREMENTS AND APPROVALS
REGISTER**

Regulatory Requirements and Approvals Register

Project name: Manton Dam Return to Service

Date: June 2023

Author: EcOz

Jurisdiction	Aspect	Legislation/Policy	Approval/Permit	Relevance to Project	Regulatory Authority	Responsibility
Commonwealth	Environment (whole)	<i>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)</i>	Class of Actions Approval	Approval under the EPBC Act is required for impacts to MNES.	DCCEEW	Proponent
Commonwealth	Tenure/access	<i>Aboriginal Land Rights Act</i>	N/A			N/A
Northern Territory	Environment (whole)	<i>Environmental Protection Act (EP Act)</i>	Environmental Approval	An Environmental Approval is required for proposals that are likely to have a significant impact on the environment.	NT EPA	Proponent
Northern Territory	Erosion	<i>Soil Conservation and Land Utilisation Act 1969</i>		An Act to make provision for the prevention of soil erosion and for the conservation and reclamation of soil. The Minister may declare erosion hazard areas and issue soil conservation orders. This Act is not typically applied.	DEPWS	Proponent
Northern Territory	Flora and fauna	<i>Territory Parks and Wildlife Conservation Act 1976</i>	Permit to take or interfere with wildlife	Pursuant to Section 56, the taking or interfering with wildlife that is listed as threatened, requires approval at the Ministerial level.	DEPWS	Proponent
Northern Territory	Flora and fauna	<i>Weed Management Act</i>		Under the Act it is an offence to introduce and/or spread listed weed species.	DEPWS	Proponent
Northern Territory	Health and safety	<i>Public and Environmental Health Act</i>	Wastewater works design approval	Demonstrate compliance with Code of Practice for Onsite Wastewater. Applicable to sewage	DOH	Proponent
Northern Territory	Health and safety	<i>Work Health and Safety (National Uniform Legislation) Act & regulations</i>	Hazardous chemicals notification	A notification to NT Worksafe is required when operators of any facility where hazardous chemicals are present or likely to be present in a quantity that exceeds 10% the threshold quantity detailed in Schedule 15 of the WHS Regulations.	NT Worksafe	Proponent
Northern Territory	Heritage	<i>Aboriginal Sacred Sites Act</i>	Authority Certificate	An Authority Certificate is required to provide for protection of Aboriginal sacred sites and indemnify a proponent against prosecution under the Act. A Certificate is issued under Sect 22 when the Authority is satisfied that, the work or use of the land could proceed or be made without there being a substantive risk of damage to or interference with a sacred site on or in the vicinity of the land; or an agreement has been reached between the custodians and the applicant.	AAPA	Proponent
Northern Territory	Heritage	<i>NT Heritage Act</i>	Work approval	A Work Approval is required under Section 72 prior to undertake work (including disturbing or relocating) on a heritage place or object.	TFHC Heritage Council	Proponent
Northern Territory	Planning	<i>NT Building Act</i>	Building permit	This is required for infrastructure located within a building control area.	DIPL	Proponent
Northern Territory	Planning	<i>NT Building Act</i>	Occupancy permit	This is required to ensure buildings have been constructed in accordance with a building permit.	DIPL	Proponent

Regulatory Requirements and Approvals Register

Project name: Manton Dam Return to Service

Date: June 2023

Author: EcOz

Jurisdiction	Aspect	Legislation/Policy	Approval/Permit	Relevance to Project	Regulatory Authority	Responsibility
Northern Territory	Planning	<i>NT Planning Act</i>	Development permit	Under Sect 44 a Development Permit is required: a) if a provision of a planning scheme allows development only with the consent (b) if the proposed development is the subdivision or consolidation of land (c) if an interim development control order allows development only with the consent A Development Permit is also required for: - clearing greater than 1 ha of vegetation in certain zones (NTPS Section 3.3). - placement of fill material below the level of the highest astronomical tide (NTPS Section 3.4). - development on land subject to primary or secondary storm surge (NTPS Section 3.7) - dredging within Darwin Harbour (NTPS Section 3.9).	DIPL	Proponent
Northern Territory	Planning	<i>NT Planning Act</i>	Planning scheme amendment	Planning scheme amendment may be required to rezone land from its existing zone and use to zoning aligned with the proposed future use	DIPL	Proponent
Northern Territory	Roads and transport	<i>Control of Roads Act 1953</i>	Permit to work in a road reserve	Work within NT Government road reserves requires a permit under the Act.	DIPL	Proponent
Northern Territory	Roads and transport	<i>Control of Roads Act 1954</i>	Road agency approval	Required to undertake work involving creation of a new access onto a NT Government road, modification of an existing access, discharging stormwater or installation of new infrastructure within the NTG road network.	DIPL	Proponent
Northern Territory	Roads and transport	<i>Local Government Act</i>	Road agency approval & stormwater infrastructure	Where roads and stormwater infrastructure are the responsibility of a local government authority, approval is required to undertake works involving establishing a new access, modification of an existing access, discharging stormwater or installation of new infrastructure within the NTG road network.	DIPL	Proponent
Northern Territory	Roads and transport	<i>Motor Vehicles Act</i>	Permit for oversize or overmass vehicle	Permits may be required to allow for safe transport of large components from any land based area to project area.	DIPL	Proponent
Northern Territory	Roads and transport	<i>Traffic Act</i>	Permit to work within NT Government Road Reserve	A Permit is required where construction activities will occur within the NT Government road reserve. All works will require a Development Approval and Traffic Management Plan	DIPL	Proponent
Northern Territory	Waste	<i>Waste Management and Pollution Control Act</i>	Environmental Protection Approval	Under Schedule 2 of the WMPC Act an EPA is required for construction, installing or carrying out works in relation to premises for: - Disposing of waste by burial (unlikely to be applicable to MASDP) - Storing, recycling, treating, or disposing of Schedule 2 listed wastes on a commercial basis (likely to be required for certain industries, including common user water treatment and disposal) - A liquefied natural gas (LNG) and/or methanol plant which will produce more than 500,000 tonnes per annum (may be required for LNG proponents)	NT EPA	Proponent
Northern Territory	Waste	<i>Waste Management and Pollution Control Act</i>	Environment Protection License	Under Schedule 2 of the WMPC Act an EPL is required for operating premises that require an Environment Protection Approval (see above). This is likely to apply to some or all of the industries nominated for the MASDP.	NT EPA	Proponent

Regulatory Requirements and Approvals Register

Project name: Manton Dam Return to Service

Date: June 2023

Author: EcOz

Jurisdiction	Aspect	Legislation/Policy	Approval/Permit	Relevance to Project	Regulatory Authority	Responsibility
Northern Territory	Waste	<i>Water Supply and Sewerage services act 2000</i>	Water supply or sewerage services licence	Under Section 14 of the Act a permit must not carry on a water supply service or sewerage service without a licence. Application of Act to common user wastewater disposal pipeline and outfall to be further considered. The Act provides for licencing of sewerage services and the acceptance of trade waste. A licensee must publish a Trade Waste Code setting out conditions on which the licensee will approve trade waste being discharged.	Utilities Commission	Proponent
Northern Territory	Water	<i>Water Act</i>	Waste discharge licence	A waste discharge licence is required where waste comes into contact with water.	DEPWS	Proponent
Northern Territory	Water	<i>Water Act</i>	Bore work permit	Permit required to construct or do work on a bore in a Water Control District (WCD).	DEPWS	Proponent
Northern Territory	Water	<i>Water Act</i>	Water Extraction Licence	Licence required to extract water in a Water Control District (WCD).	DEPWS	Proponent

APPENDIX G PRE-REFERRAL SCREENING OUTCOMES

Pre-Referral Screening Report

Project: Manton Dam Return to Service



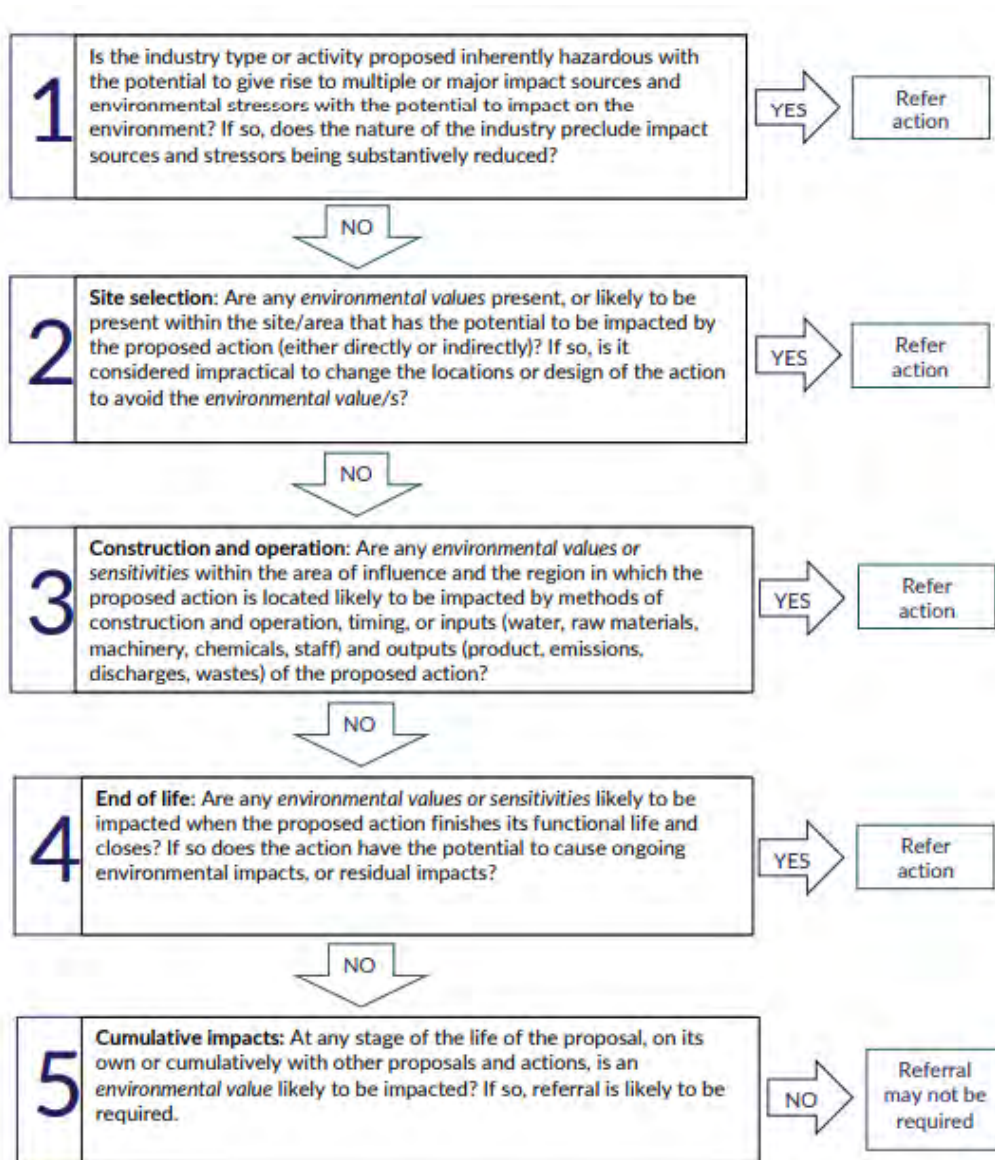
The NT EPA have developed a pre-referral screening tool to assist proponents determine whether their Proposal has potential to have a significant impact on the environment and therefore requires referral under the *Environment Protection Act 2019*. The tool is also used to identify the key environmental factors that are relevant to a Proposal that may require more detailed consideration during site selection and project planning. The tool has two parts:

- Part 1 – Screening Questions
- Part 2 – Answer Checklist

The tool is provided in the *Guideline – Referring a Proposal to the NT EPA* <https://ntepa.nt.gov.au/publications-and-advice/environmental-management>.

EcOz Environmental Consultants were engaged by Power and Water Corporation (NT) to undertake pre-referral screening of the Manton Dam Return to Service. The screening was undertaken with reference to the screening questions shown in Figure 1 and the results are documented in Table 1 below.

Figure 1. Pre-screening tool screening questions (Source: NT EPA 2021)



Pre-Referral Screening Report

Project: Manton Dam Return to Service



Table 1. Pre-referral screening tool checklist

Theme	Factor and Objective	Background information (about the project)	Environmental values, sensitivities (based on desktop and/or surveys)	Pre-referral screening questions					Assessment of potential for significant impact	
				Q1	Q2	Q3	Q4	Q5		
			<ul style="list-style-type: none"> No distinct natural landforms. 	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>						The proposal will not have a significant impact on landforms because there are no distinctive landforms within the footprint. The Landform environmental factor does not require further assessment.
Land	Landforms <u>Objective:</u> Conserve the variety and integrity of distinctive physical landforms.	<ul style="list-style-type: none"> No distinct natural landforms. 	<ul style="list-style-type: none"> No distinct natural landforms. 	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Uncertain <input type="checkbox"/> N/A <input type="checkbox"/>						The project will disturb land and soils but is unlikely to have a significant impact for the following reasons: <ul style="list-style-type: none"> Erosion risk will be managed through an ESCP in accordance with the IECA BPESC Guidelines. The contamination investigation footprint is estimated to be 350m² at Manton Dam. The diesel tank is empty and has an estimated holding capacity of 90,000L. The Manton Dam infrastructure has not been operational since 1972. A contamination investigation and remediation work for potential hydrocarbon contamination will be undertaken as part of the infrastructure removal works, in the event that contamination is identified. An unexpected finds procedure will be included in the demolition CEMP. If required a Remediation Plan will include remediation requirements for soil applicable for future use. Ground disturbance of removed infrastructure will be limited to landscaping (scaping and topsoiled if required) to allow the areas to be free draining. No soil material being moved around the site. Assessment for asbestos will be undertaken prior to demolition works, if asbestos is identified a licenced Asbestos Removalist for the removal and disposal of asbestos will be engaged. Contamination risk from minor storages of fuels and other hazardous chemicals used during construction will be managed through a Construction EMP. Chemicals required for operation of the Strauss WTP will be stored and handled as per accepted standards and legislative requirements. Waste from the water treatment process will be managed by a licenced waste contractor. The Terrestrial environmental quality factor does not require further assessment.
	Terrestrial Environmental Quality <u>Objective:</u> Protect the quality and integrity of land and soils so that environmental values are supported and maintained.	<ul style="list-style-type: none"> Project activities are in previously disturbed areas, and not in areas of high erosion risk and the potential for contamination from this project is low. 	<ul style="list-style-type: none"> Majority of the footprint near Manton Dam, Strauss WTP, and the pipeline and fibre optic cable corridor easements have been previously disturbed, however some land clearing is required during construction. The historic operations of Manton Dam have potential contamination sources of hydrocarbons and asbestos remnants from decommissioned infrastructure. Potential hydrocarbon sources is a small footprint ~350m² which includes: <ul style="list-style-type: none"> Redundant empty diesel tank (~90,000L capacity and empty) Redundant transformer yard Generator fill points Electric pump house Engine servicing areas All structures are located on a permeable concrete foundation. Potential asbestos footprint is small (~260m²) and include the: <ul style="list-style-type: none"> Garage Electric pumphouse No other known soil contaminating activities have occurred across the area. 	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Uncertain <input type="checkbox"/> N/A <input type="checkbox"/>						

Pre-Referral Screening Report

Project: Manton Dam Return to Service



Theme	Factor and Objective	Background information (about the project)	Environmental values, sensitivities (based on desktop and/or surveys)	Pre-referral screening questions					Assessment of potential for significant impact	
				Q1	Q2	Q3	Q4	Q5		
	<p>Terrestrial Ecosystems</p> <p>Objective: Protect terrestrial habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.</p>	<ul style="list-style-type: none"> Majority of the Manton Dam site and pipeline and fibre optic cable easements have been cleared of vegetation. Ecology surveys were undertaken for the Project in targeted areas. 	<ul style="list-style-type: none"> There are two known records within the centre of the Strauss WTP that will be impacted by development. The survey area for <i>Typhonium</i> identified a significant population is present north-west of the Strauss WTP footprint. The project will not directly impact this population The Strauss WTP contains habitat for the Northern Brushtail Possum – identified within and around the site boundary, however due to their mobile nature and progressive clearing, should not be impacted. 	<p>Yes <input type="checkbox"/></p> <p>No <input checked="" type="checkbox"/></p>						<p>Terrestrial ecosystems may be impacted by:</p> <ul style="list-style-type: none"> vegetation clearing and habitat removal introduction and spread of weeds loss of <i>Typhonium</i> plants in footprint loss of Northern Brushtail Possum habitat alteration of surface water flows downstream of the dam wall. <p>The Terrestrial ecosystems factor requires further assessment to determine whether impacts are likely to be significant.</p>
Water	<p>Hydrological Processes</p> <p>Objective: Protect the hydrological regimes of groundwater and surface water so that environmental values including ecological health, land uses and the welfare and amenity of people are maintained.</p>	<ul style="list-style-type: none"> No groundwater will be extracted. Manton Dam was constructed for the purposes of water supply source – a surface water extraction license exists. Surface water released to Manton River will be reduced from 30 L/s to 2-5 L/s. Dam to be completely empty 5% of the years of operations. 	<ul style="list-style-type: none"> Manton River downstream of the dam wall is a non-perennial stream order 4 watercourse, that since the construction of the dam wall in the 1940s has had a regular release of approximately 30 L/s running downstream. This has likely influenced the nature of the watercourse to have more water flow over the dry than it may have before the dam was constructed. 	<p>Yes <input type="checkbox"/></p> <p>No <input checked="" type="checkbox"/></p> <p>Uncertain <input type="checkbox"/></p> <p>N/A <input type="checkbox"/></p>					<p>Hydrological processes may be impacted by:</p> <ul style="list-style-type: none"> lowering of water levels in Manton Dam reduced flows in the Manton River downstream of the dam wall. <p>The Hydrological processes factor requires further assessment to determine whether impacts are likely to be significant.</p>	
	<p>Inland Water Environmental Quality</p> <p>Objective: Protect the quality of groundwater and surface water so that environmental values including ecological health, land uses and the welfare and amenity of people are maintained.</p>	<ul style="list-style-type: none"> Risks to water quality will be limited to during construction when there is potential for runoff from cleared areas to watercourses and minor spills/leaks from construction equipment. Operation of the Strauss WTP will require storage and handling of hazardous chemicals and wastes. Storage and handling will comply with Australian Standards and legislative requirements. Power Water operates numerous treatment facilities in the Darwin Region. 	<ul style="list-style-type: none"> Within Darwin Rural Water Control District, but no water allocation plan applies. 	<p>Yes <input type="checkbox"/></p> <p>No <input checked="" type="checkbox"/></p> <p>Uncertain <input type="checkbox"/></p> <p>N/A <input type="checkbox"/></p>					<p>The project is unlikely to have a significant impact on water quality for the following reasons:</p> <ul style="list-style-type: none"> Erosion risk will be managed through an ESCP in accordance with the IECA BPESC Guidelines. Contamination risk from minor storages of fuels and other hazardous chemicals used during construction will be managed through a Construction EMP. Chemicals required for operation of the WWTP will be stored and handled as per accepted standards and legislative requirements. Waste from the water treatment process will be managed by a licenced waste contractor. Recreational use of Manton Dam is set to continue through project operation – water will be treated and monitored at the Strauss WTP to ensure adequate standards for human consumption are met. Water will not be used for consumption without being treated. <p>The Inland water environmental quality factor does not require further assessment.</p>	
	<p>Aquatic Ecosystems</p> <p>Objective: Protect aquatic habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.</p>	<ul style="list-style-type: none"> Manton Dam current full supply level is 38.71m AHD. Surface water level in Manton Dam will reduce to below 34.77m AHD. Manton River receives uncontrolled (during wet season) and controlled surface water flows from Manton Dam. 	<ul style="list-style-type: none"> Manton Dam supports aquatic plants and fish. Manton River discharges to Adelaide River 13 km from Manton Dam wall. Two waterbodies retain water during the Dry season, one small waterbody ~ 2km downstream and one large waterbody ~ 11km downstream and then ~ 2km upstream from Adelaide River Riparian vegetation associated with Manton River 	<p>Yes <input type="checkbox"/></p> <p>No <input checked="" type="checkbox"/></p> <p>Uncertain <input type="checkbox"/></p> <p>N/A <input type="checkbox"/></p>					<p>Aquatic ecosystems may be impacted by changes to hydrological processes described above. The Aquatic ecosystems factor requires further assessment to determine whether impacts are likely to be significant.</p>	
Sea	<p>Coastal Processes</p> <p>Objective: Protect the geophysical and hydrological processes that shape coastal morphology so that the</p>			<p>Yes <input type="checkbox"/></p> <p>No <input type="checkbox"/></p> <p>Uncertain <input type="checkbox"/></p> <p>N/A <input checked="" type="checkbox"/></p>					<p>The project will not interact with or impact any of the sea factors due to its location.</p>	

Pre-Referral Screening Report

Project: Manton Dam Return to Service



Theme	Factor and Objective	Background information (about the project)	Environmental values, sensitivities (based on desktop and/or surveys)	Pre-referral screening questions					Assessment of potential for significant impact
				Q1	Q2	Q3	Q4	Q5	
	environmental values of the coast are maintained.	The Project will not interact with or impact and of the Sea themed factors due to its geographical location.		<input type="checkbox"/>					
	Marine Environmental Quality <u>Objective:</u> Protect the quality and productivity of water, sediment and biota so that environmental values are maintained		Yes No Uncertain N/A	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	
	Marine Ecosystems <u>Objective:</u> Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.		Yes No Uncertain N/A	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	
Air	Air Quality <u>Objective:</u> Protect air quality and minimise emissions and their impact so that environmental values are maintained.	Minor levels of dust will be generated during construction, particularly during stages of vegetation clearance. Besides the Strauss WTP the majority of the components are highly modified and/or cleared.	The nearest receptors are rural properties and dwellings approximately 0.8 km to the north and 0.3 km to the south.	Yes No Uncertain N/A	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p>The project will produce air emissions in the form of dust and exhaust emissions from diesel exhaust during construction but is unlikely to have a significant impact on air quality for the following reasons:</p> <ul style="list-style-type: none"> Dust emissions will be short-term in any given area during construction. There are no sensitive receptors proximate to the works that would be affected by dust. Standard dust control measures will be implemented through an ESCP and CEMP. Exhaust emissions from construction equipment are not of a magnitude that would alter local air quality. <p>The Air quality factor does not require further assessment.</p>
	Atmospheric Processes <u>Objective:</u> Minimise greenhouse gas emissions so as to contribute to the NT Government's goal of achieving net zero greenhouse gas emissions by 2050.	<ul style="list-style-type: none"> A GHG emissions estimate has been prepared. Scope 1 emissions sources include land clearing and operation of diesel-powered vehicles and equipment. Scope 2 emissions will be produced from the Strauss WTP which will be connected to the Darwin Katherine Interconnected grid System. The bulk of project emissions come from the anoxic breakdown of material within Manton Dam, which would occur regardless of the project progressing and are not required to be accounted for. 	NTG net zero by 2050 target	Yes No Uncertain N/A	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p>The project will produce GHG emissions from land clearing, construction and operation of the Strauss WTP but will not have a significant impact for the following reasons:</p> <ul style="list-style-type: none"> GHG emissions assessment indicates emissions will be well below the thresholds in the Large Emitters Policy. <p>The Atmospheric processes factor does not require further assessment.</p>

Pre-Referral Screening Report

Project: Manton Dam Return to Service



Theme	Factor and Objective	Background information (about the project)	Environmental values, sensitivities (based on desktop and/or surveys)	Pre-referral screening questions					Assessment of potential for significant impact		
				Q1	Q2	Q3	Q4	Q5			
People	Communities and Economy <u>Objective:</u> Enhance communities and the economy for the welfare, amenity and benefit of current and future generations of Territorians.	<ul style="list-style-type: none"> Project will increase water availability for Darwin region. Recreational access to the Dam will be ongoing – however use will be restricted when water levels are low and potential hazards are present. Various levels of community consultation have occurred, including community focus groups and information sessions. A Stakeholder Engagement and Communication Plan has been prepared to collaborate, consult and inform stakeholders. Noise from Strauss WTP operations will be very low and consistent with other pump stations located in urban areas throughout the Darwin Region. 	<ul style="list-style-type: none"> There are no current surface water extraction licences downstream of the Dam. Manton Dam currently regularly used for recreational purposes, including tourism as a site of interest for Darwin history. Water will be provided to Greater Darwin Region Pipeline easement traverses multiple land use types – including nearby rural residential properties. Residential properties approx. 500 m from Strauss WTP. 	Yes No Uncertain N/A	<input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p>The project has potential to provide benefits to the Greater Darwin region through increased water availability.</p> <p>The community and economy may be impacted by:</p> <ul style="list-style-type: none"> traffic, noise and dust during construction restrictions on recreational use of Manton Dam loss of access to the heritage sites at the Manton Dam wall reduced water availability in Manton River downstream of the dam. <p>The Community and economy factor requires further assessment to determine whether impacts are likely to be significant.</p>
	Culture and Heritage <u>Objective:</u> Protect culture and heritage.	<ul style="list-style-type: none"> AAPA Authority Certificate acquired. Previous archaeological surveys have not identified anything within the Project footprint, however western side of Strauss WTP has not yet been surveyed. Consultations are ongoing with downstream property owners and the Northern Land Council (NLC) regarding possible reduction in Dry season discharges and impact on potential downstream sacred site. 	<ul style="list-style-type: none"> No sacred sites. Easement at the northern end is close to Hughes WWII Airstrip (Declared Heritage site under <i>Heritage Act</i>). Heritage survey's found heritage items. No declared heritage sites under the Heritage Act. Connection of WWII heritage values in project area (Strauss WTP and pipeline easement) with surrounding declared heritage value areas. Sacred site along Manton River (downstream of Manton Dam wall) 	Yes No Uncertain N/A	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p>Heritage may be impacted by:</p> <ul style="list-style-type: none"> works around the Manton Dam wall where there is an existing heritage site damage to previously unrecorded archaeological objects (unexpected finds) reduced surface water flows downstream where there is a sacred site. <p>The Culture and heritage factor requires further assessment to determine whether impacts are likely to be significant.</p>	
	Human Health <u>Objective:</u> Protect the health of Northern Territory population.	<ul style="list-style-type: none"> Recreational access to the Dam will be ongoing – however use may be restricted when water levels are low and potential hazards are present. Manton Dam is an existing waterbody with potential biting insect habitat. Storage and handling of hazardous chemicals will be managed in accordance with Work Health and Safety Regulations. 		Yes No Uncertain N/A	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p>The Project is unlikely to impact Human health for the following reasons:</p> <ul style="list-style-type: none"> Recreational access will be restricted using signage in certain areas when water levels drop below a safe level. Biting insect habitats are not expected to be increased. Water from the dam will be treated so that it will be suitable for human consumption. <p>The Human health factor does not require further assessment.</p>	

This pre-referral screening checklist was prepared by a suitably qualified professional who is appropriately accredited and experience in impact assessment

Name: Kylie Welch
Qualifications: Master of Social Science (Environment and Planning); Bachelor of Science (Hons)
Certification: Certified Environment Practitioner 975



Signature: *K. R. Welch*

Date: 30/06/2023

APPENDIX H AAPA CERTIFICATE (C2010/151) (REDACTED)

APPENDIX I HYDROLOGICAL MODELLING REPORT (POWER AND WATER 2023B)

Darwin Region Water Supply Modelling

Manton Dam catchment and water balance
modelling summary

Headworks Planning, Water Services, August 2023

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1.0 Background

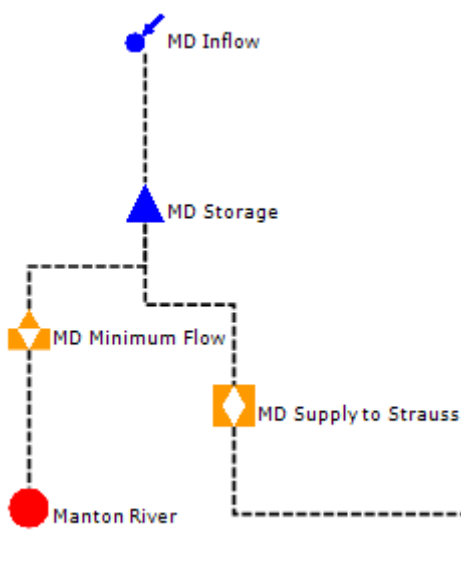
The Darwin Water Supply Model was developed using the eWater Source modelling platform in 2015 as part of the *Darwin Water Supply Medium Term Options Assessment* (Entura et al, 2016: D2015/335705). There have been many updates to the Darwin Water Supply Model since it was developed, and since the return to service of Manton Dam and the development of the Adelaide River Offstream Water Storage (AROWS) were identified as the preferred water supply augmentation options for Darwin.

The model is a water balance model that simulates supply from groundwater (Howard East and McMinns Borefields) as well as three existing and proposed surface water storages; Darwin River Dam, Manton Dam and AROWS. This model is currently used to estimate water supply system yield, the impact of demand growth on supply reliability, and determine when demand restrictions may be required during drought periods. It was also used to provide input into the Environmental Referral for the Manton Dam return to service project.

The purpose of this report is to describe how the Manton Dam component of the Darwin Water Supply System Model was developed and provide a summary of the results used to inform the environmental referral.

2.0 Model Development

This section focusses on the development of the Manton Dam component of the water supply model, summarising the key assumptions and data inputs for the original model development (as described in more detail in the *Darwin Water Supply Medium Term Options Assessment* report (Entura et al, 2016: D2015/335705)). Section 3.0 discusses the major updates since that time.



The Manton Dam component of the water balance model includes:

- Manton Dam inflow node – estimated surface water flow into Manton Dam. This is a direct output of the Manton Dam catchment model that was developed using the eWater Rainfall Runoff Library.
- Manton Dam storage node – includes the storage dimensions (elevation-volume-surface area relationship), direct rainfall onto the storage, losses from evaporation and losses from infiltration.

- Flow to Manton River – made up of wet season spills from the storage as well as a “MD Minimum Flow” node that controls the dry season release to the river.
- Supply to Strauss Treatment Plant – controlled by the “MD Supply to Strauss” constraint node which defines the transfer capacity of the Manton Dam pump station.

2.1 Data Input

Historic Climate Data

SILO Patch Point climate data was used to provide extended rainfall and evaporation datasets with data available from 1889 to the present (Queensland Government, accessed 2015). This data set is derived using Bureau of Meteorology (Bureau) data where possible and relies on interpolation for periods with no recorded data.

Rainfall data was sourced from Patch Point data at Manton Dam (coordinates below). Evaporation data was sourced from Darwin Airport as this is the most reliable source of evaporation data with a continuous period of record (from 1957) in the Darwin region. This data was compared against observed pan evaporation data at the Darwin River Dam site (available from 1988 to 2014 though not officially published) and a relationship was derived for Manton Dam and Darwin River Dam (Entura et al, 2016). Based on this relationship, a factor of 0.83 was applied to convert Darwin Airport evaporation data to Manton Dam.

Table 1 – Climate data sources (Entura et al., 2016: D2015/335705)

Climate Data	Site Name	Source	Coordinates
Rainfall	Manton Dam	SILO Patch Point	-12.84, 131.10
Evaporation	Darwin Airport	SILO Patch Point – SPan (synthetic pan evaporation) with applied factor of 0.83	

Streamflow Calibration Data

Streamflow data was obtained from the DLRM (now Department of Environment, Parks and Water Security) Water Portal. There is one gauging station located within the Manton Dam catchment (G8170075) and a gauging station that was located on the Manton River in Acacia Gap (just upstream of the confluence with Adelaide River) that is no longer active (G8170033). This flow data was used to calibrate the catchment model for Manton Dam.

Table 2 – Streamflow data (Entura et al., 2016: D2015/335705)

Gauging Station	Station Number	Period of Operation	Catchment Area (km ²)	% missing
Manton River upstream Manton Dam	G8170075	16/6/1965 – present	28	15%
Manton River Acacia Gap	G8170033	4/12/1959 – 28/10/1986	222	30%

General Assumptions

Where there was no data available, some general assumptions were made:

- Seepage was assumed to be fixed at 0.167 mm/day – assumed from a previous study. This has not been verified but continues to be used in the Source model. Seepage is not expected to be a major loss when compared to extraction and evaporation.
- A constant release of 30 L/s from Manton Dam to Manton River.

2.2 Rainfall Runoff Model

Rainfall runoff modelling was undertaken to allow a long dataset to be developed for input to the Darwin Water Supply Source model.

Calibration of the Manton Dam catchment model prioritised the following streamflow characteristics (in order of highest to lowest priority):

1. Low annual streamflow
2. Base flow recessions – this was flagged as particularly important during consecutive low flow years
3. Average monthly flow
4. Skewness
5. Standard deviation
6. Total streamflow

The Sacramento conceptual numeric model was selected as it was better at mimicking the baseflow and interflow conditions (as prioritised in the calibration process) compared to other models such as SIMHYD (which have fewer parameters). A comparison of the recorded and simulated flows is shown in Figure 1 and Figure 2.

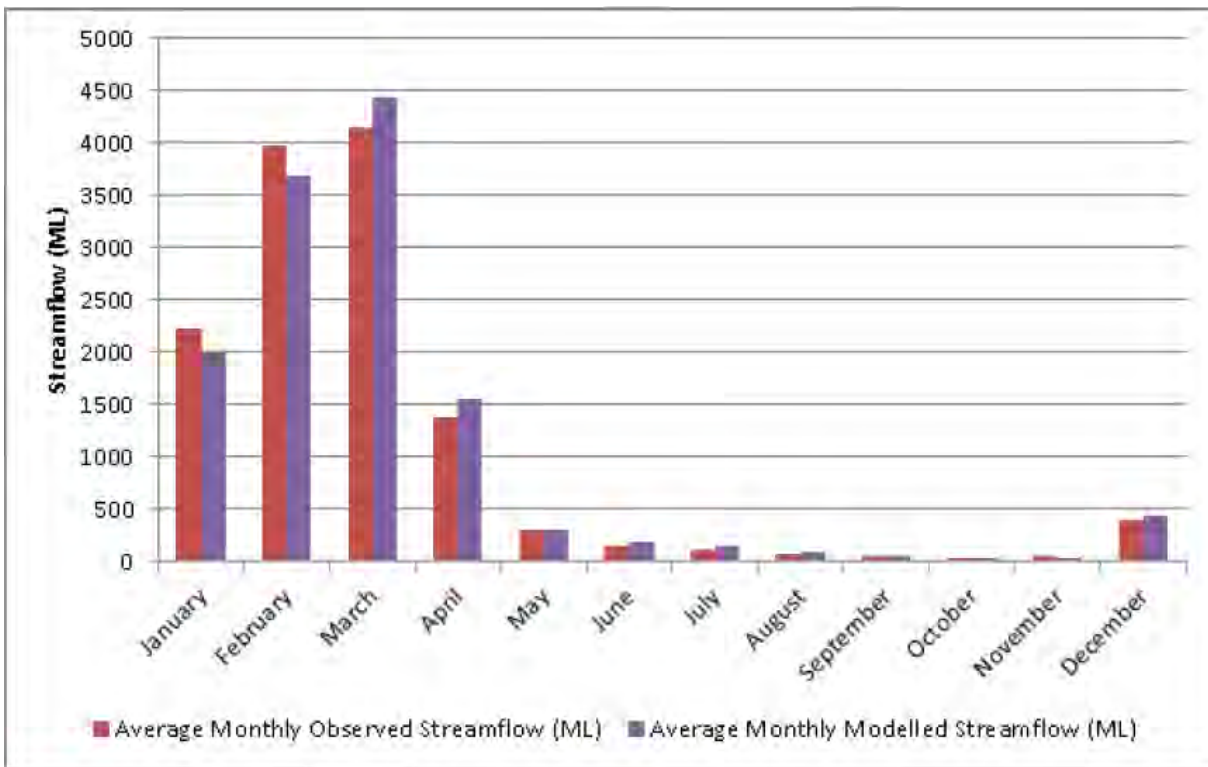


Figure 1 – Manton Dam rainfall runoff model calibration monthly results (Entura et al., 2016: D2015/335705)

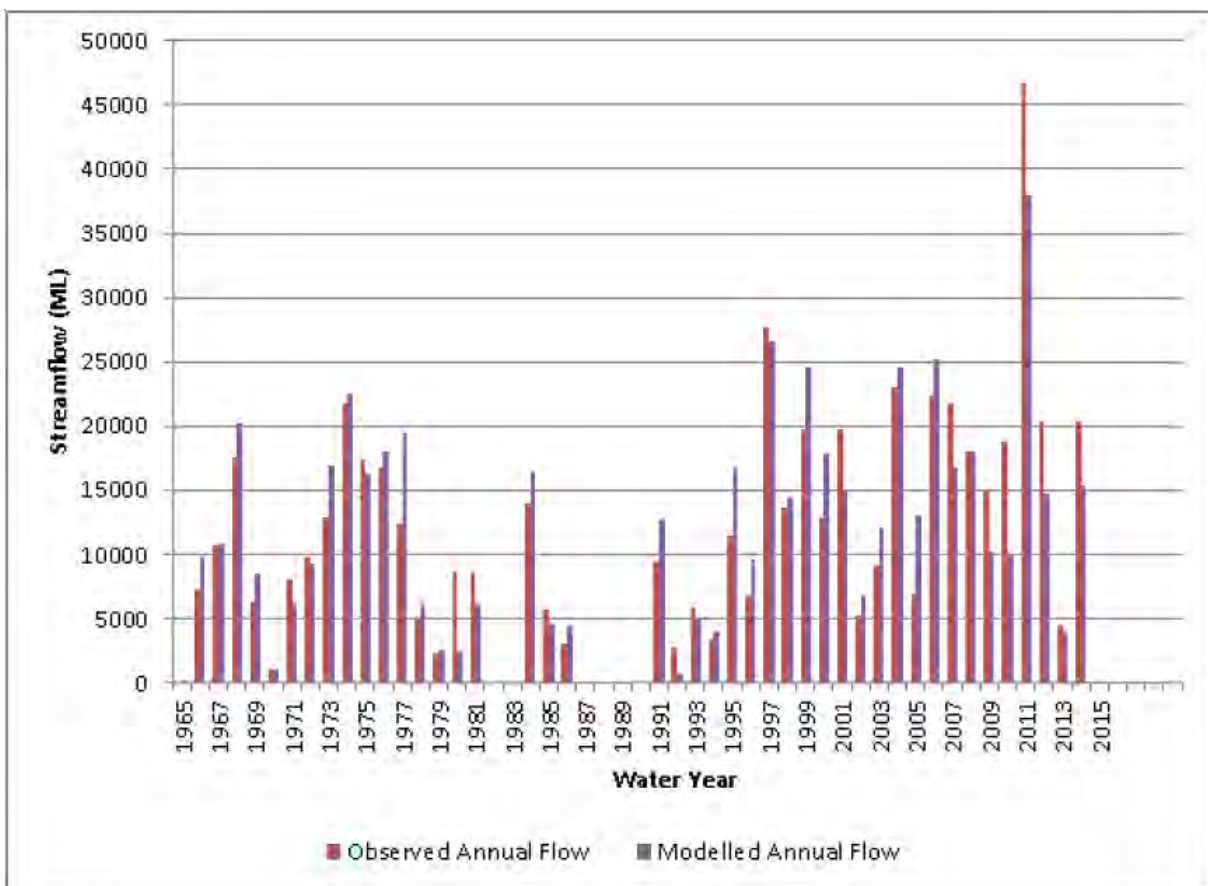


Figure 2 – Manton Dam rainfall runoff model calibration annual results (Entura et al., 2016: D2015/335705)

2.3 Stochastic Data Generation

Stochastic datasets were generated in order to provide a long dataset that has the same characteristics of the historic climate record. A long dataset is required in water supply system modelling to assess system reliability and to design robust systems that can maintain water supply during an extended drought period that may not have occurred in recorded history but may occur in the future.

Concurrent 1,000 year rainfall and evaporation datasets were generated for each storage catchment (ie. Darwin River Dam, Manton Dam and AROWS) using the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) Stochastic Data Generation Methodology. This methodology was selected as it allowed climatically correlated data across multiple sites and multiple parameters (rainfall and evaporation) to be generated.

The stochastic rainfall and evaporation datasets for the Manton Dam catchment were then run through the calibrated rainfall runoff model to develop a corresponding inflow dataset for Manton Dam.

A comparison of the historic and stochastic datasets is shown in Table 3.

Table 3 – Daily statistics of historic and stochastic data (all units in mm) (Entura et al., 2016: D2015/335705)

Data Series	Mean	Median	Standard Deviation	Skewness	Max	Min
Manton Historic Streamflow	0.98	0.15	3.74	10.96	147	0
Manton Stochastic Streamflow	0.98	0.14	3.83	11.53	154	0
Manton Historic Evaporation	5.41	5.48	0.96	-0.19	10.0	1.7
Manton Stochastic Evaporation	5.39	5.42	0.94	-0.21	10.1	1.7
Manton Historic Rainfall	4.05	0.00	11.04	5.53	245.0	0
Manton Stochastic Rainfall	4.04	0.00	10.92	5.66	260.8	0

3.0 Model Updates

3.1 Climate Change

The original (2015) model incorporated different climate scenarios, however, Power and Water engaged OD Hydrology in 2019 to review the methodology for incorporating climate change and recommend an updated methodology if required. This update was completed in 2020 with historical and stochastic datasets developed for the following climate change scenarios:

- **Baseline – RCP4.5 with median (50th percentile) GCM;**
- Lower evaporation – RCP4.5 with 10th percentile GCM;
- Higher evaporation – RCP4.5 with 90th percentile GCM; and

- Higher emission scenario – RCP8.5 with median (50th percentile) GCM.

For each climate scenario, data was generated for three projection years; 2030, 2050 and 2070. Note that this section discusses the development of data for all emission scenarios, however, the modelling completed for the Manton Dam RTS Environmental Referral used only the Baseline climate scenarios. The other scenarios were developed in order to complete a climate change sensitivity assessment.

The following process was used to generate the climate data for each scenario (OD Hydrology, 2020: D2020/166987):

1. Determine the Global Climate Models (GCMs) which should be considered. GCMs were excluded if they were not recommended for the Monsoonal North region, and if they did not have factors for both rainfall and evapotranspiration.
2. Then for each scenario:
 - a. From the considered GCMs select the GCM relevant to the scenario based on the ranking of GCMs on annual evaporation change (10th, 50th and 90th percentile projected change);
 - b. Apply the monthly rainfall and evapotranspiration change factors from the chosen GCM to:
 - i. The model climate data (rainfall and evaporation); and
 - ii. The climate data required for the Sacramento flow generation.
 - c. Generate climate change Sacramento flow by running climate change adjusted rainfall and evapotranspiration through the Sacramento rainfall runoff model;
 - d. Compile climate and hydrological time-series into model datasets for import into the Source model.

Monthly GCM projections were obtained from the Climate Change in Australia (CCIA) Climate Futures Exploration Tool (developed by CSIRO and BoM). Of the 49 available GCMs, 17 were considered for the RCP4.5 emissions scenario. These were ranked based on the annual change in evapotranspiration, and the GCMs selected that correspond to 10th, 50th (Baseline) and 90th percentile change (Table 4).

Table 4 - Percentile annual evapotranspiration change (RCP4.5; Monsoonal North) (OD Hydrology, 2020: D2020/166987)

Percentile	2030	2050	2070
10 th	1.88%	3.02%	4.06%
50 th (median)	2.90%	4.10%	5.50%
90 th	4.22%	6.60%	7.86%

A comparison of all RCP4.5 GCMs is presented in Figure 3, which shows the variation between climate models. This variation is more significant when comparing simulated rainfall changes (Figure 4), with some models predicting an increase in rainfall, and others predicting a decrease in rainfall. Note that due to the significant variation in rainfall predictions, existing rainfall data has been applied for all Baseline projection years (2030, 2050 and 2070), with climate change factors only applied to the evapotranspiration datasets. This was considered to be a reasonably conservative approach for a Baseline scenario as some of the selected GCMs resulted in an increase in rainfall.

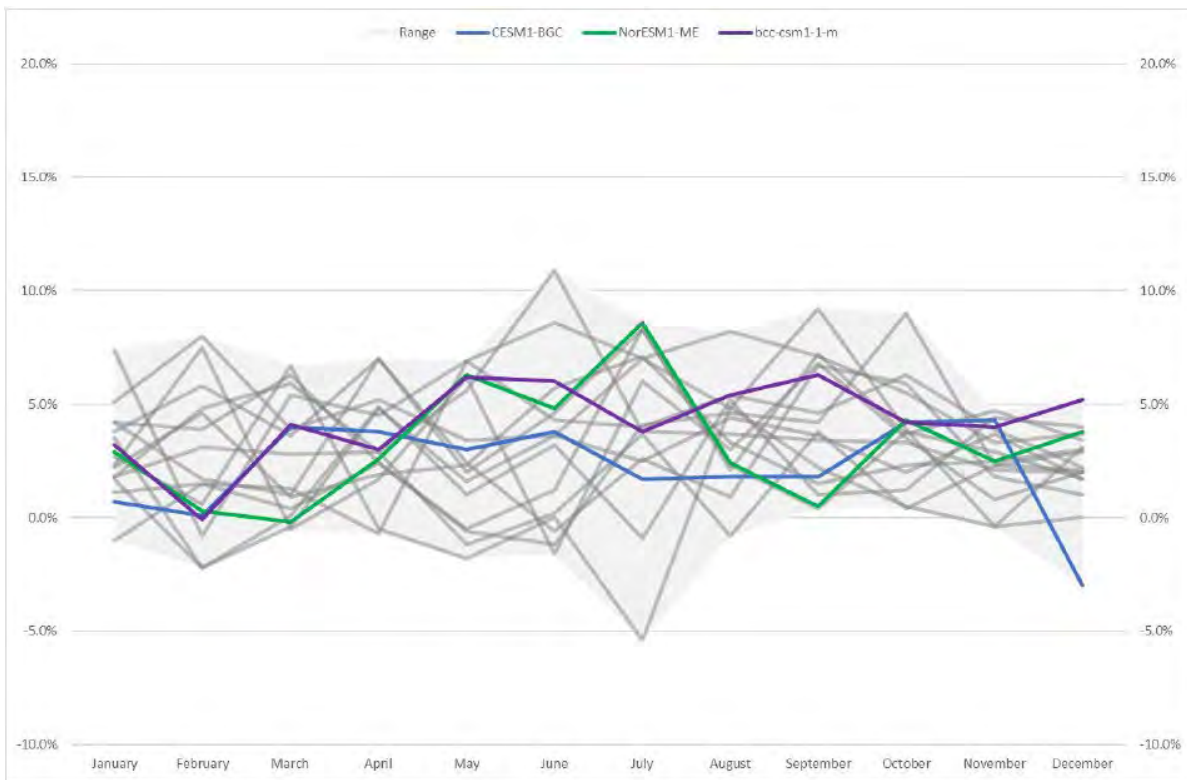


Figure 3 - Monthly evaporation change factors for the considered RCP4.5 Monsoonal North GCMs with selected 10th (blue), 50th (green) and 90th (purple) percentile GCMs highlighted (OD Hydrology, 2020: D2020/166987)

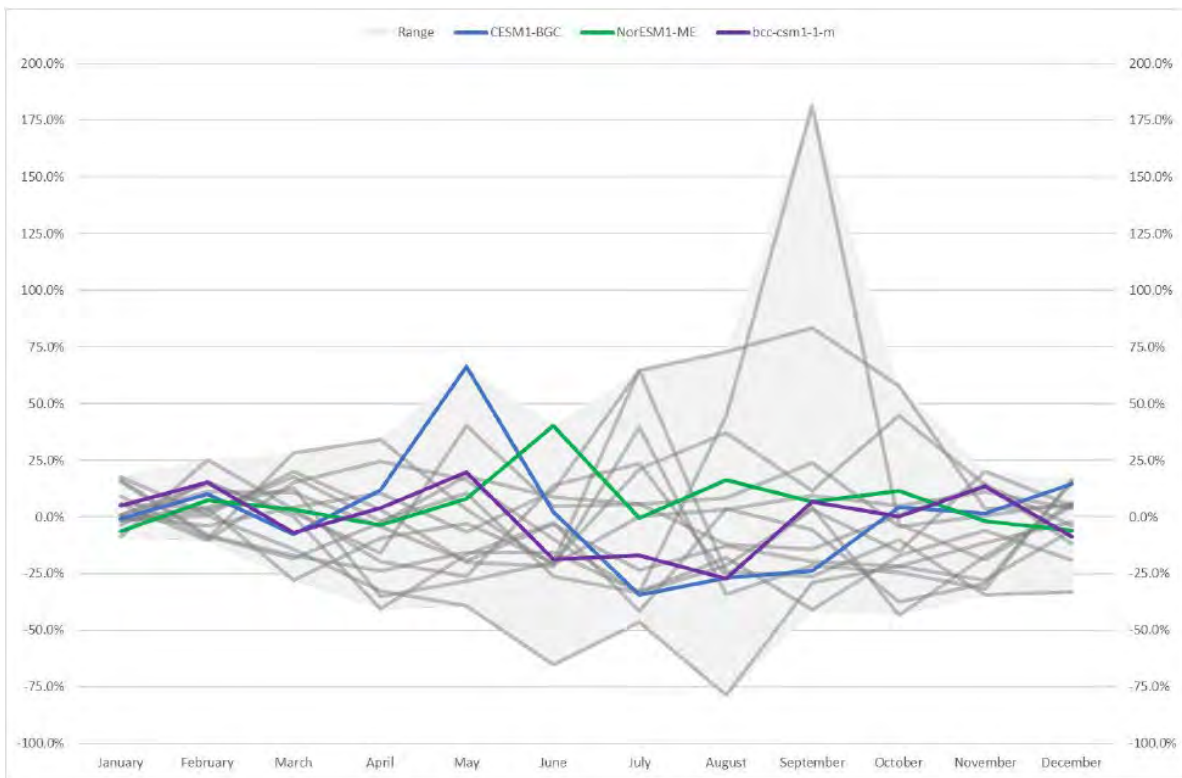


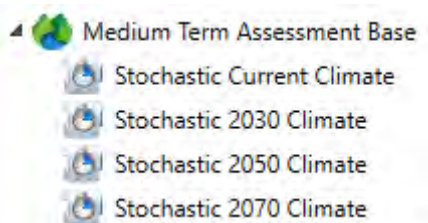
Figure 4 – Monthly rainfall change factors for the considered RCP4.5 Monsoonal North GCMs corresponding to the 10th (blue), 50th (green) and 90th (purple) percentile GCMs (OD Hydrology, 2020: D2020/166987)

The final set of climate change factors are presented in Table 5. These factors were applied to the “existing climate” evaporation stochastic dataset (developed based on historic climate data as discussed in the section above) to produce three new climate change datasets; 2030, 2050 and 2070. The evaporation datasets, along with the existing rainfall dataset, were then run through the rainfall runoff models to produce the climate change streamflow datasets for each storage catchment (including Manton Dam as well as Darwin River Dam and AROWS).

Table 5 – Baseline monthly evapotranspiration change factors (Monsoonal North; RCP45;50th percentile GCM)

Month	2030	2050	2070
	NorESM1-ME	GISS-E2-R-CC	MIROC5
January	2.9%	2.9%	5.5%
February	0.3%	3.7%	6.6%
March	-0.2%	3.9%	2.0%
April	2.6%	6.4%	5.6%
May	6.3%	4.5%	9.3%
June	4.8%	8.6%	8.1%
July	8.6%	3.9%	7.6%
August	2.4%	4.5%	6.0%
September	0.5%	5.2%	4.6%
October	4.3%	4.3%	5.3%
November	2.5%	2.8%	5.0%
December	3.8%	2.6%	4.9%

“Scenario Input Sets” (shown below) have been developed in the Source model that enable users to simulate different climate change scenarios as required. Each of the different scenarios below apply the relevant evaporation, rainfall and runoff datasets for each water storage.



3.2 General Updates

There have also been many other general updates that do not directly relate to the Manton Dam component of the water balance model, including:

- Update of the model to only include Darwin River Dam, Manton Dam, AROWS and the groundwater supply. All other water supply augmentation options that were assessed in the 2016 options assessment were removed.

- Development of 10,000 year stochastic datasets to be used in modelling of the levels of service for a multi-source system. These datasets were not applied for the Manton Dam modelling.
- Minor changes to functions in the model and updates as the software develops and improves.
- Updates to the demand calculations as part of a project to develop a new Demand Forecast Model for the Darwin Region.

4.0 Results – Manton Dam RTS Environmental Referral

General assumptions:

- A continuous downstream flow release of 30 L/s is assumed for all scenarios.
- The 1,000 year stochastic datasets are used for all scenarios unless stated otherwise.
- The Manton Dam extraction scenarios assume a fixed transfer of 20 ML/day.
- Dead storage (or operational storage) is assumed to be at a level of 28 mAHD (ie. the model assumes that the Manton Dam pump station can extract water from the storage down to this level). The base of the storage is at an elevation of 24 mAHD.

4.1 Storage Reliability

Table 6 summarises the Manton Dam reliability results for different model scenarios. Assuming the 2030 climate scenario, the results show that there is a 1 in 20 year chance that supply from Manton Dam will fail (equivalent to a 95% storage reliability). The risk of supply failure is slightly less under the existing climate scenario (with a 96% storage reliability). With no extraction, the level in the Manton Dam does not reach dead storage during the Existing or 2030 scenarios.

Table 6 – Manton Dam supply reliability

Scenario	Storage Reliability (Years)
Stochastic - Existing - 0 ML	100%
Stochastic - Existing - 20 ML	96%
Stochastic - 2030 - 0 ML	100%
Stochastic - 2030 - 20 ML	95%

4.2 Impact on Downstream Flows

With an extraction of 20 ML/day (7,300 ML/yr), there will be a reduction in wet season spills from Manton Dam to the downstream Manton River. During an average year, it is estimated that this could be a 30% reduction in flows. This would vary depending on wet season rainfall and inflows, with no spill occurring during some wet seasons and a 16% reduction in wetter than average years (90th percentile). The potential variation is shown in Table 7.

Table 7 – Simulated average annual spill from Manton Dam (ML/yr) (Stochastic - Existing)

	0 ML/day extraction	20 ML/day extraction	% Reduction
Average Annual Spill	22,939	15,952	30%
10th Percentile	4,507	-	100%
50th Percentile	18,474	10,863	41%
90th Percentile	44,961	37,732	16%

The average monthly variation in spill volume is presented in Figure 5. The largest difference in spill volume is evident in the early months of the wet season (December to February) as extraction means that the storage takes longer to fill.

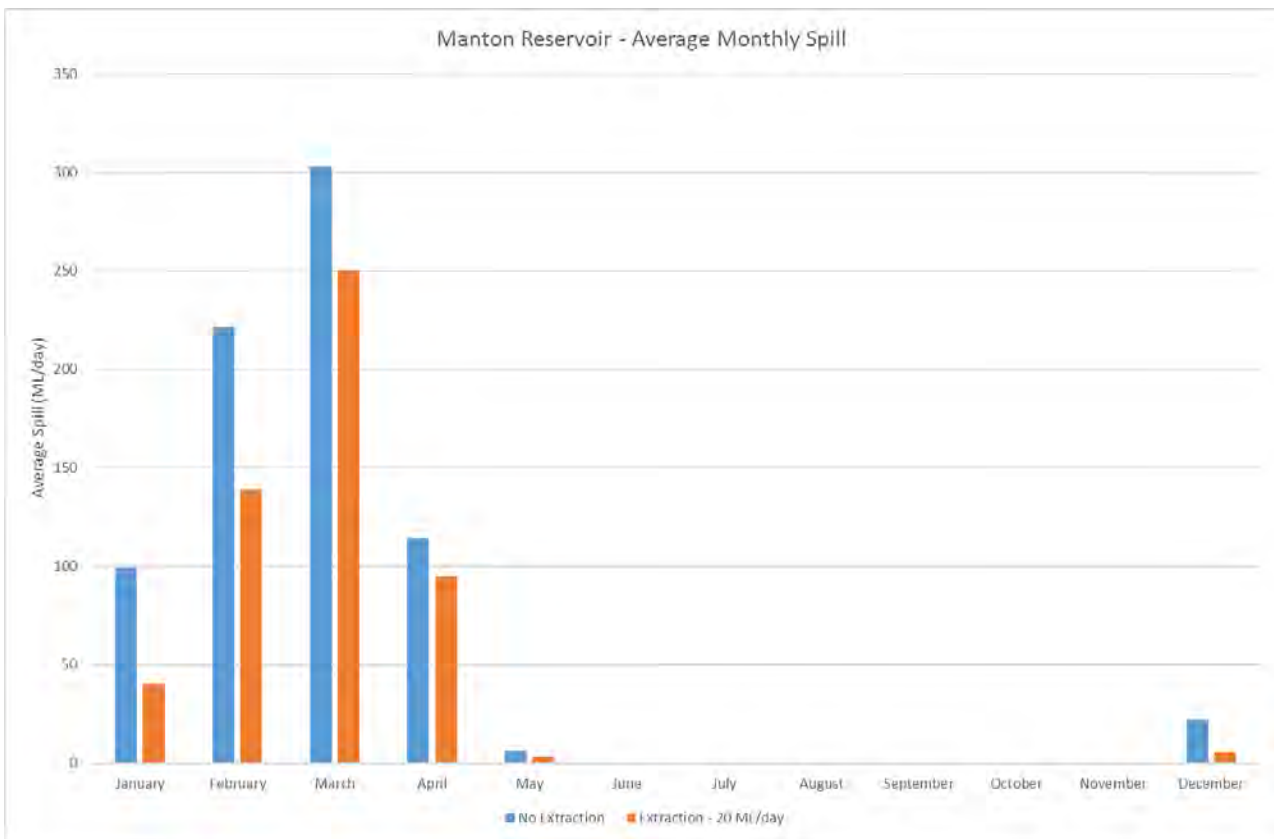


Figure 5 – Estimated average monthly spill volumes from Manton Dam

4.3 Impact on Recreation

The minimum level for recreation on Manton Dam is assumed to be equivalent to the minimum access level for the boat ramp. This minimum level is estimated to be 34.77 mAHD (refer figure below) which provides 1.5 m water depth at a point 2.5m from the end of the boat ramp. Note that “Recreation Failure” in the following discussion refers to when the simulated level in the storage falls below the minimum accessible level at the boat ramp (34.77 mAHD).

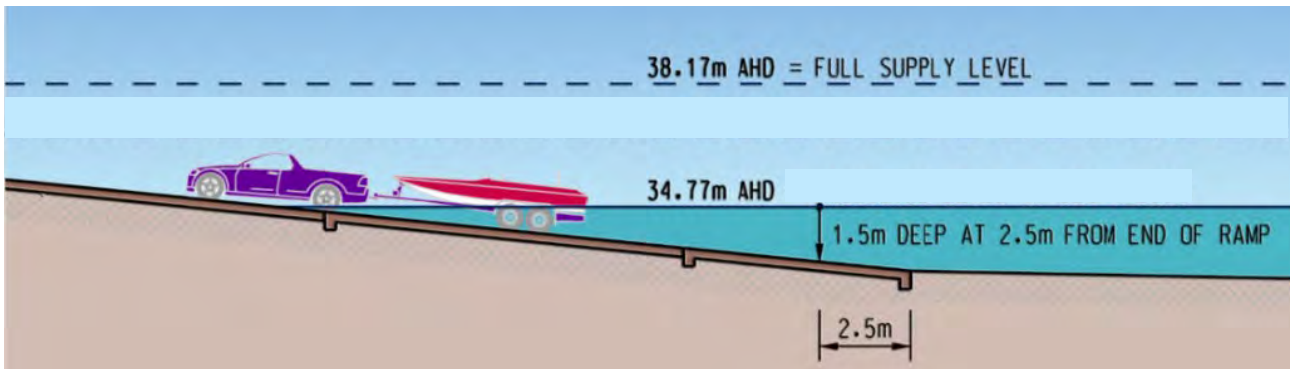


Figure 6 – Manton Dam boat ramp access levels

The objectives for modelling the impact on recreation were to determine:

- Likelihood that recreation would be impacted
- Estimated time to recreation failure depending on storage level (to inform the Recreation Management Plan) – this is to provide the community with advanced warning if the storage may be closed to recreation.

Recreation Reliability

Based on the modelling, it is estimated that Manton Dam may not be accessible for recreation during 1 in 5 years once the storage is operational and 20 ML/day is extracted. This is equivalent to an estimated “Recreation Reliability” of 80%. Without extraction, the storage would be accessible during 100% of years.

This annual reliability calculation does not take into consideration the length of failure event, so recreation may not be possible for only 1 day in the year, but would still counted as a “failure”. As a comparison, the recreation reliability has also been calculated based on failure days (Table 8). So, it is estimated that recreation will be possible during 94% of days based on current climate (93% of days when applying the 2030 climate scenario) once Manton Dam has returned to service.

Table 8 – Recreation reliability

Scenario	Recreation Reliability (Year)	Recreation Reliability (Days)
Stochastic - Existing - 0 ML	100%	100%
Stochastic - Existing - 20 ML	80%	94%
Stochastic - 2030 - 0 ML	100%	100%
Stochastic - 2030 - 20 ML	79%	93%

To illustrate the impact of extraction on storage levels in Manton Dam, Figure 7 compares level results with and without the extraction of 20 ML/day using historic climate data. The yellow line represents the minimum level for accessing the boat ramp.

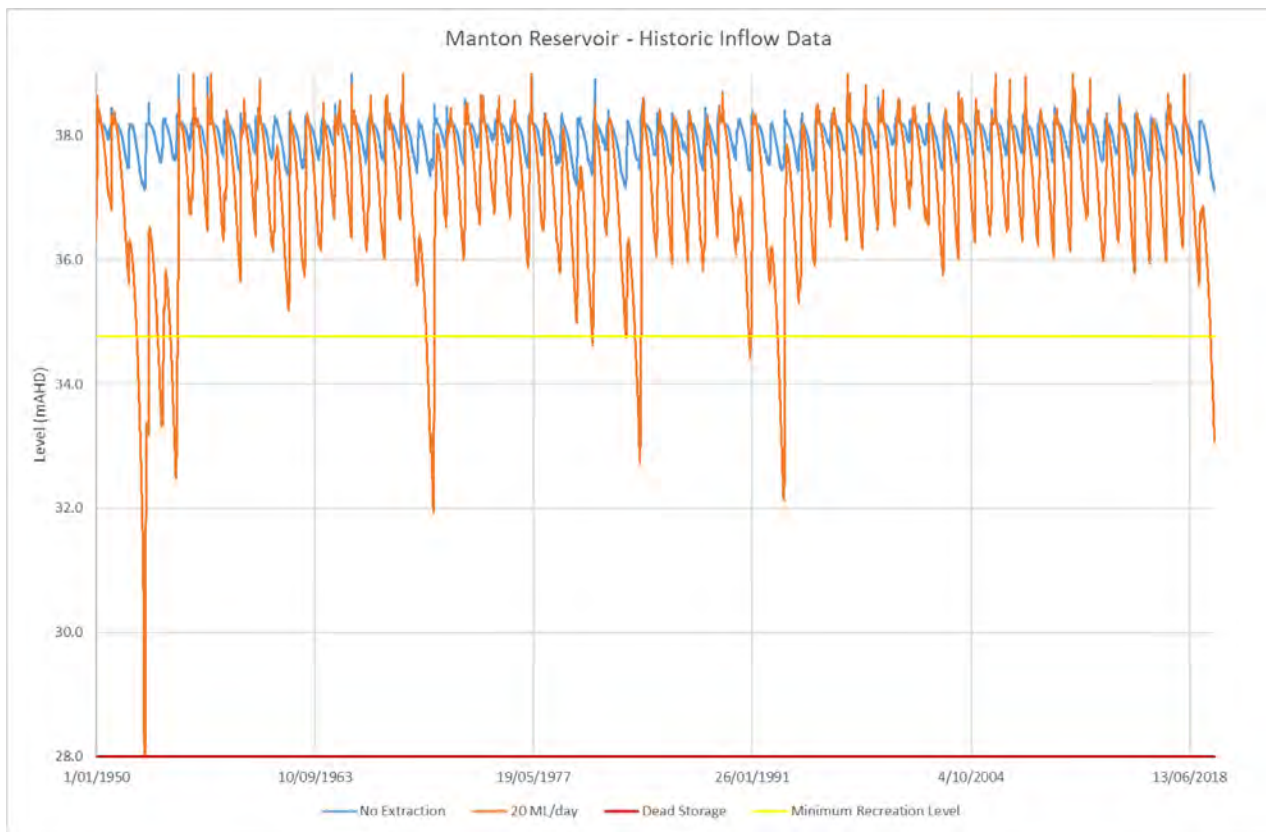


Figure 7 – Simulated Manton Dam storage levels with and without 20 ML/day extraction

Time to Failure

As part of the development of a Recreation Management Plan, a set of trigger levels was required in order to provide the community with advanced warning should closure of the reservoir for recreation be necessary. The 1st May was suggested as a trigger point as this represents the start of the dry season when no further rain is likely and the maximum storage level is known. For the purpose of water supply modelling in the Darwin Region, we assume a water year (rather than calendar or financial year) starting from 1st May.

A one year simulation from the 1st May was run 1,000 times to assess the likelihood of recreation failure, as well as how long before failure would occur. This is called a “batch run” when the same simulation is run multiple times with different climate inputs. Four batch runs were used in the assessment, each starting at different storage levels; 38 mAHd (or full just below full supply), 37 mAHd, 36 mAHd and 35 mAHd (Table 9). The results are summarised in Table 9.

Recreation only failed during 1% of simulations when starting at the full supply level, when there is minimal wet season inflows during that year. The likelihood of recreation failure increases significantly when the level in Manton Dam is below the full supply level at the start of the dry season (ie. following a poor wet season with below average inflows to the storage). Starting at 37 mAHd, the likelihood of failure increases to 77%. If the level at the 1st May is 36 mAHd, then there is a 99% chance that recreation will not be possible at some point during the year.

The estimated time to restrictions is also summarised in Table 9. The average days to failure from the 1st May depending on storage level is highlighted in green. The 10th and 90th percentile results have also been included in the table to illustrate the variation in the results. The time to recreation failure depends on

wet season inflows, so failure will occur earlier if there is late start to the wet season or if wet season inflows are below average. Due to this uncertainty, the level at 30 days prior to failure was also assessed.

Table 9 – Simulated time to recreation closure from 1st May

Level at 1st May (mAHD)	Volume (ML)	Chance of Recreation Closure (%)	Time to Recreation Closure (Days From 01 May)		
			Average	10th Percentile	90th Percentile
38	13146	1%	303	-	-
37	9991	77%	204	180	230
36	7176	99%	128	107	147
35	4912	100%	43	23	60

Though accurate predictions will be difficult at 1st May, the results are very consistent when looking at the level 30 days before the minimum boat level is reached. As the results in Table 10 show, it would be reasonably accurate to say that recreation on Manton Dam would not be possible in 30 days once a level of 35 mAHD is reached in the storage (assuming no significant rainfall occurs).

Table 10 – Simulated minimum storage levels 30 days before recreation closure

Level (mAHD) – 30 days before closure	
Average	35.23
Minimum	35.03
10th Percentile	35.16
90th Percentile	35.29
Maximum	35.32

References

Entura, Marsden Jacob Associates, Power and Water Corporation, OD Hydrology (2016), *Darwin Water Supply Medium Term Options Assessment*, D2015/335705.

OD Hydrology (2020), *Development of climate change datasets for Darwin Water Supply Source model*, D2020/166987.

Queensland Government (2015), SILO: Australian climate data from 1889 to yesterday, accessed in 2015 from <https://www.longpaddock.qld.gov.au/silo/>.

APPENDIX J SOCIAL IMPACT SCREENING TOOL

Project phase	Project activity	Category of social impact	Potential impacts on people	Elements of impacts - based on preliminary investigation	Initial assessment of potential significance	Mitigation/enhancement measures				
Which phase of the project is this impact relevant to?	Describe the social impact. Which project activity/activities could produce social impacts?	What social impact categories could be affected by the project activities	What impacts are likely, and what concerns/aspirations have people expressed about the impact? Summarise how each relevant stakeholder group might experience the impact. NB. Where there are multiple stakeholder groups affected differently by an impact, or more than one impact from the activity, please add an additional row.	Is this impact expected to be positive or negative?	The NT EPA Act defines a significant impact to be 'an impact of major consequence having regard to the context and intensity of the impact, and the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact'. With this in mind, categorise each impact (without mitigation or enhancement) using the 'levels of classification' in the 'dimensions of impact' tab. Include a brief justification for your response.	Based on your answers in columns E, F, G and H, is this impact likely to be potentially significant, as defined by the NT EPA Act 2019?	What mitigation/enhancement measures are being considered?			
				Extent (is the impact localised/impacts few people or broad)	Duration (will it be over particular project phases or permanent)	Magnitude or intensity (what is the likely scale of change)	Sensitivity of people potentially affected			
Negative impacts										
Construction	Construction of project infrastructure (at Manton Dam, along the easements, and Strauss WTP)	Way of life	Disruption to access of Manton Dam for recreational users during construction	Negative	Local - potential impacts to recreational users of Manton Dam	Short-term - construction associated with upgrades at Manton Dam would be short term	Negligible - there are currently periods of disrupted access when scheduled maintenance of the Dam is occurring	Moderate - consultation to date has identified the restriction of use of Manton Dam specifically for recreational use as a major concern	No	Construction Stakeholder Engagment and Communication Plan -Consultation with recreational users to inform them of disruptions - Schedule construction to minimise periods of closure/disruption Implementation of a Recreational Management Plan
Construction		Way of life	Restricted to access of Manton Dam wall heritage sites, carpark and picnic area	Negative	Local - potential impacts to local visitors and tourists	Permanent/irreversible- Security fencing will be erected for construction works and will remain through operation to restrict public access due to the Dam returning to service	Major - restrict access and use of carpark, picnic area and heritage sites	Moderate - consultation to date has identified the restriction of use of Manton Dam specifically for recreational use as a major concern. Heritage branch identified the Manton Dam heritage sites as supporting community and educational use.	No	Consultation with recreational users to inform the restricted public access to the area during construction and continued during operations will be undertaken through Stakeholder Engagement and Communication Plan and identified in the Recreational Management Plan as a restricted public access area. Future discussions with Heritage Branch on sites to remain and sites that can be removed, as part of the Heritage Management Plan for Manton Dam being developed by Power and Water. Planning is in place to secure and preserve the heritage assets and in the future make then available to the public through potential initiatives including periodic public open days and guided tours.
Construction		Surroundings	Amenity impacts (noise and dust) to nearby residents and users during construction/installation of pipeline and fibre optic cable	Negative	Local - only a few properties along the water pipeline easement are close enough to experience some amenity (dust/noise) impacts, users of the local road network may also observe increased traffic	Short-term - construction along the easement will be staged, impacts at a certain location will be short term	Moderate - currently rural amenity, however amenity impacts (noise and dust) are not expected to be significant	Low - currently rural amenity, however the broader area is used for agriculture etc so heavy machinery is not novel in the general area	No	Dust suppression methods to be included in Construction Environmental Management Plan Construction noise level monitoring, construction activities occurring in accordance with NT EPA Noise Management Framework Guideline 2018.
Construction		Surroundings	Amenity impacts (noise and dust) to nearby residents during construction/installation of Strauss WTP	Negative	Limited - closest properties are approximately 500m away	Short-term - Construction Stage 1 proposed over 20 months	Moderate - Noise modelling identified daytime construction residential criteria was exceeded due to high levels of intermittent noise, such as vehicle traffic. No noise modelling was undertaken for night time construction works.	Low - currently rural amenity, however the broader area is used for agriculture etc so heavy machinery is not novel in the general area	No	Dust suppression methods to be included in Construction Environmental Management Plan Construction noise level monitoring, construction activities occurring in accordance with NT EPA Noise Management Framework Guideline 2018. Traffic management plan will be prepared due to construction works are proposed on or near public roads.
Construction		Access	Altered access to some properties along the pipeline easement during construction along certain sections	Negative	Limited - only a few properties along the easement that are likely to have altered access	Short-term - construction would occur in stages along the easement, focusing on site establishment, construction and decommissioning section by section so as to minimise disruptions	Negligible - access would be altered but maintained	Low - there has been little concern from residents,	No	Access to properties will be maintained at all times using detours where necessary. Consultation with property owners impacted will be undertaken by the construction contractors in accordance with the approved Power Water Stakeholder Engagement and Communication Plan.
Construction		Culture	Interaction with sacred sites and Aboriginal archaeological sites	Negative	Local - consultation with AAPA has not identified any sites in footprint; an Authority Certificate has been obtained (C2010/151) prior to commencement of works. Archaeological assessment undertaken.	Medium-term - unexpected finds could include archaeological materials or burials - duration of impacts would be limited by implementation of unexpected finds procedures to relocate materials	Negligible - no sites identified during heritage surveys or consultation - unexpected finds will be managed in accordance with procedures agreed with site custodians	Moderate - due to many factors, Aboriginal Australians are more vulnerable to impacts than the majority of the Australian population	No	Unexpected finds 'stop work' procedure Continue consultation Indigenous stakeholders AAPA Authority Certificate obtained (C2010/151) Archaeological assessment has been undertaken by archaeologist – recommendations provided – refer to Section 7.6 Along pipeline values identified (with recommendations): Site 3 - Permit to destroy to be sought (low significance) Site 4, 5, 6 and 7 - Avoid, or Destroy following vegetation clearance and photogrammetry survey.
Construction		Culture	Disturbance of WWII archaeology and heritage	Negative	Local - consultation with NT Heritage Branch Archaeology assessment undertaken. Northern Australian Rail (NAR) infrastructure and bottles identified in project area, associated with other WWII heritage infrastructure in the region.	Medium-term - unexpected finds could include archaeological materials or burials - duration of impacts would be limited by implementation of unexpected finds procedures to relocate materials	Negligible - archaeology identified during heritage assessment has been determined to not be of significant value - unexpected finds will be managed in accordance with procedures agreed with NT Heritage Branch	Low - heritage objects are valued by people with an interest in local history	No	Works Permit under the Heritage Act to move NAR infrastructure and bottles at Strauss WTP. Consultation and preliminary advice has been sought with NT Heritage Branch Future discussions with Heritage Branch on sites to remain and sites that can be removed, as part of the Heritage Management Plan for Manton Dam being developed by Power and Water. CEMP include unexpected finds 'stop work' procedure Heritage/archaeological field assessment has been undertaken with archaeologist
Construction		Health and wellbeing	Biting insects on construction works during Manton Dam works	Negative	Limited - restricted to construction worker directly upgrading and installing infrastructure at Manton Dam	Short-term - for the duration of construction works	Negligible - construction activities occur during the day when biting insect activity is low, and workers typically wear long sleeve shorts and pants that protect against mosquito bites	Low - construction workers are not highly sensitive to nuisance impacts	No	CEMP include Biting Insect Management Plan, including both site-wide management and personal protective equipment
Operation	Operation of the Project as a water source to Darwin	Way of life	Lowering of Dam levels from extraction making the boat ramp in accessible for short periods in the late dry season in some years	Negative	Local - restricted to the community that directly uses Manton Dam for recreational activities	Short Term - modelling indicates based on previous 70years of rainfall data, the boat ramp would be accessible sporadically over nine periods of time (varying timeframes during the dry season) if a 20ML/day extraction regime was in place.	Moderate - restricted access would be temporary. Currently restricted public access to the Dam has occurred due to release water from the Dam for maintenance requirements.	High - Consultation to date has identified the use of Manton Dam specifically for recreational use as a major concern.	Yes	NTG have committed to sustaining use of Manton Dam as a recreational area for the community. Implementation of a Recreational Management Plan, including notification of boat ramp inaccessibility procedure
Operation		Way of life	Exposure of objects in Manton Dam increasing risk of collision with objects	Negative	Local - recreational users of Manton Dam	Medium Term - exposed object will be intermittent and only occur on reduction of water levels.	Negligible - exposed object will be temporary. Currently exposed objects in the Dam has occurred due to release water from the Dam for maintenance requirements	Low	No	Recreational Management Plan will outline the requirement to notify recreational users when water levels have dropped below safe and accessible levels in parts of the dam. The potential exposed objects have been surveyed and will be detailed in the management plan. Signage has been historically used to alert recreational users and will continue to be used.
Operation		Community	Restricted to access of Manton Dam heritage sites, carpark and picnic area for recreational and tourism users	Negative	Local - recreational users of Manton Dam	Permanent/irreversible- Security fencing will be erected for construction works and will remain through operation to restrict public access due to the Dam returning to service	Major - restrict access and use of carpark, picnic area and heritage sites and potentially impact	Moderate - consultation to date has identified the use of Manton Dam specifically for recreational use as a major concern. Heritage branch identified the Manton Dam heritage sites as supporting community and educational use.	No	Consultation with recreational users to inform the restricted public access to the area during operations will be undertaken through Stakeholder Engagement and Communication Plan and identified in the Recreational Management Plan. Planning is in place to secure and preserve the heritage assets and in the future make then available to the public through potential initiatives including periodic public open days and guided tours.

Project phase	Project activity	Category of social impact	Potential impacts on people	Elements of impacts - based on preliminary investigation	Initial assessment of potential significance	Mitigation/enhancement measures				
Which phase of the project is this impact relevant to?	Describe the social impact. Which project activity/activities could produce social impacts?	What social impact categories could be affected by the project activities	What impacts are likely, and what concerns/aspirations have people expressed about the impact? Summarise how each relevant stakeholder group might experience the impact. NB. Where there are multiple stakeholder groups affected differently by an impact, or more than one impact from the activity, please add an additional row.	Is this impact expected to be positive or negative?	The NT EPA Act defines a significant impact to be 'an impact of major consequence having regard to the context and intensity of the impact, and the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact'. With this in mind, categorise each impact (without mitigation or enhancement) using the 'levels of classification' in the 'dimensions of impact' tab. Include a brief justification for your response.	Based on your answers in columns E, F, G and H, is this impact likely to be potentially significant, as defined by the NT EPA Act 2019?	What mitigation/enhancement measures are being considered?			
					Extent (is the impact localised/impacts few people or broad)	Duration (will it be over particular project phases or permanent)	Magnitude or intensity (what is the likely scale of change)	Sensitivity of people potentially affected		
Operation		Health and wellbeing	Quality of water for drinking with recreational use continuing	Negative	Regional - impacts to drinking water supply to greater Darwin region	Long-term - for the operation of the project	Negligible - The planning process has included additional water treatment process (UV disinfection) is included in the proposed Dissolved Air Flotation and Filtration (DAFF) system to remove water quality risks associated with Manton Dam used as a recreational area.	High - consultation to date has identified this a main concern of stakeholders if recreational use to continue at Manton Dam	No	The Strauss WTP will be operated in accordance with all relevant regulatory guidelines, and abide by the Australian Drinking Water Guidelines.
Operation	Operation of the WTP at Strauss	Surroundings	Amenity impacts to nearby residents due to noise of Strauss WTP	Negative	Limited - closest properties are approximately 500m away	Long-term - noise emissions expected to be constant over the operational life of the project	Minor - Pumps at the WTP will be fully encapsulated in their own building to minimise noise. The pumps will be similar to existing pump stations throughout the Darwin region.	Medium - due to existing rural amenity	No	Noise management an Operational Noise Management Plan will be implemented as part of the Operations Environmental Management Plan for the Strauss WTP. Power and Water have an online general enquires, complaints and feedback platform for processing of complaints from the community.
Positive impacts										
Operation	Operation of the Project as a water source to Darwin	Way of life	Provision of drinking water as part of Power and Water's Darwin Region Water Supply Strategy and increased certainty of long-term water supply	Positive	Regional - people across the Darwin region would benefit from provision of drinking quality water	Long-term - expected to provide critical infrastructure for future water security for the Darwin Region	Major - Provides critical infrastructure for short term and long term drinking water security	High - allows for growth of Darwin region population with water security	No	Project aligns with the Territory Water Plan and Darwin Region Water Supply Strategy 2013 as the first stage in long-term water supply for urban users
Operation		Livelihoods	Promotes economic development and diversification in the region	Positive	Regional - affect people across the Darwin region with economic development growth	Long-term - for the duration of the project operation	Minor	Low	No	None considered
Construction	Construction of project infrastructure (at Manton Dam, along the easements, and Strauss WTP)	Livelihoods	Increased employment opportunities	Positive	Regional - people across the Darwin region would benefit from increased employment opportunities Proposed peak construction employment is 250 people	Short-term - Stage 1 construction will be over a 2 year, with the commencement and schedule of Stage 2 and 3 works TBC.	Moderate	Low - existing construction and development work opportunities across the Darwin and Palmerston regions	No	Preparation of a local procurement strategy to maximise local benefits.
Operation	Operation of the Project as a water source to Darwin	Livelihoods	Increased employment opportunities	Positive	Limited - 3 full time employees (Strauss WTP) 0.5 full time employees (Manton Dam pump station)	Long-term - for the duration of operations (50+ years)	Minor - limited employment opportunities to specialised trained employees	Low - employment to employees with existing skills of operating the Strauss WTP or Manton Dam	No	Preparation of a local procurement strategy to maximise local benefits.
Operation		Livelihoods	Continuation of tourism and recreation opportunities	Positive	Regional - affect people across the Darwin region	Long-term - for the duration of the project operation and continued use of Manton Dam as recreational area	Negligible - existing tourism and recreation opportunities will continue with use of Manton Dam	Low - affects existing recreational users, potential increase of tourism if site specific tours are scheduled for heritage sites (TBC)	No	Planning is in place to secure and preserve the heritage assets and in the future make then available to the public through potential initiatives including periodic public open days and guided tours.
Operation		Surroundings	Improved environmental, regional social and economic resilience	Positive	Regional - people across the Darwin region	Long-term - for the duration of the project operation	Minor	Low	No	None considered
Operation		Livelihoods	Increased water accessibility for use in improving/increasing agricultural output	Positive	Widespread - people across utilising water for agriculture and the people benefiting from the agriculture.	Long-term - for the duration of the project operation	Moderate - provides potential for future agricultural development in the Darwin Region	High - allows for growth of agricultural business through water security	No	The Northern Territory Agribusiness Strategy 2030 considers the growth of agriculture in the NT, which are highly dependent on water.

Determining significance

To be considered potentially significant, an impact must have at least:

- One 'highest' rating (column D)
- One 'second highest' rating (column C)
- One 'third highest' rating (column B)



Extent - which location(s) is/are affected?			
Limited Impact affects a small area in the immediate proximity of activities	Local Impact affects limited areas, near neighbours or local residences/land users	Regional Impact affects most of or an entire region (i.e. Tiwi Islands, Darwin Region)	Widespread Impact affects multiple regions

Duration - will the impact be time-limited (e.g. over particular project phases) or permanent?

Short-term Impacts occur sporadically and/or lasts a few days or weeks, after which values recover	Medium-term Impact occurs intermittently and/or only during the construction phase	Long-term Impact occurs over an extended period covering the construction and operational phases	Permanent/irreversible Impact is enduring, values are unlikely to recover
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Magnitude or intensity - what is the likely scale or level of change from the existing conditions?

Negligible No discernible impact on existing environment	Minor Impact is measurable but relevant thresholds or criteria for environmental protection are not met	Moderate Measurable impact (relevant thresholds met) and would impact effect group to a moderate extent (e.g. would impact time taken to travel to work but would not prohibit access)	Major Measurable impact (relevant thresholds met) and would impact effect group to a moderate extent (e.g. would prohibit access/travel route to work, or add significant time to journey which impacts other aspects of life and activities)
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Sensitivity or importance - how sensitive/vulnerable (or how adaptable/resilient) are people to the impact, or (for benefits) how important is it to people?

Very low Very low sensitivity to change, highly adaptable and impact is common in the environment	Low Low sensitivity to change, adaptable and impact is common in the environment	Medium Medium sensitivity to change, somewhat adaptable and impact is irregular in the environment	High High sensitivity to change, low capacity to adapt and impact is uncommon/rare in environment
-------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------

Examples					
Impact description	Extent (is the impact localised/impacts few people or broad)	Duration (will it be over particular project phases or permanent)	Magnitude or intensity (what is the likely scale of change)	Sensitivity of people potentially affected	Based on your answers, is this impact likely to be potentially significant, as defined by the NT EPA Act 2019?
High numbers of biting insects in the project area/inadvertent creation of new biting insect habitat could impact health of residents	Local - impacts to residents of the development (approx. 700 dwellings)	Long-term - for the operation of the project	Moderate - known biting insect issue in the area and impacts have occurred on other residential development projects	High - residents will include children and other people vulnerable to biting insect nuisance and disease	Yes

Examples					
<p>Inequitable distribution of benefits from the project - lease payments, royalties, employment opportunities</p>	<p>Regional - impacts could affect people across the Tiwi Islands</p>	<p>Long-term - the distribution of benefits from the project are anticipated to remain consistent throughout the project lifecycle</p>	<p>Moderate - lease payments and royalties will benefit certain groups - employment opportunities avoidable for broader community; however, there may be barriers to uptake of opportunities from communities across the Tiwis</p>	<p>High - Tiwi is home to the Tiwi Aboriginal people - due to many factors, Aboriginal Australians are more vulnerable to impacts than the majority of the Australian population</p>	<p>Yes</p>
<p>Increased local population due to construction workforce will have impacts on the local community, even though the workers will be accommodated at the existing port facilities</p>	<p>Regional - impacts could affect people across the Tiwi Islands</p>	<p>Medium-term - construction is scheduled to occur over twelve years, with a fairly maintained requirement of workers over that time</p>	<p>Major - 500 additional people would effectively double the local population of Pirlangimpi given workers would be accommodated approximately 1 km from community - this could introduce impacts to community cohesion, sense of place, way of life, and also could put pressure on existing capacity to support a population (e.g. rubbish generation, septic system, water supply, power, access to food and services)</p>	<p>High - Tiwi is home to the Tiwi Aboriginal people - due to many factors, Aboriginal Australians are more vulnerable to impacts than the majority of the Australian population</p>	<p>Yes</p>

Extent - how many people will experience the impacts?

Limited Impact affects a small number of people.	Local Impact affects near neighbours or local residences/land users.	Regional Impact affects people across most of or an entire region (i.e. Tiwi Islands, Darwin Region)	Widespread Impact affects multiple regions.
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Duration - how long will the impacts last?

Short-term Impacts occur sporadically and/or lasts a few days or weeks, after which values recover	Medium-term Impact occurs intermittently and/or only during the construction phase	Long-term Impact occurs over an extended period covering the construction and operationa phases	Permanent/irreversible Impact is enduring, values are unlikely to recover
--------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------

Magnitude or intensity - what is the likely scale or level of change from the existing conditions?

Negligible No discernible change from current conditions	Minor Change is measurable but tolerable	Moderate Change is measurable and may exceed tolerable limits for some people, but may be acceptable if managed in accordance with community expectations	Major Significant change that is unlikely to be amenable to management
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Sensitivity or importance - how sensitive/vulnerable (or how adaptable/resilient) are people to the impact, or (for benefits) how important is it to people?

Very low Very low sensitivity to change, highly adaptable and impact is common in the environment	Low Low sensitivity to change, adaptable and impact is common in the environment	Medium Medium sensitivity to change, somewhat adaptable and impact is irregular in the environment	High High sensitivity to change, low capacity to adapt and impact is uncommon/rare in environment
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Definitions from NSW Government Technical Supplement Social Impact Assessment 2021

		CATEGORIES	MEANING FOR WORKSHEET PURPOSE	FURTHER EXPLANATION AND EXAMPLES
SOCIAL IMPACTS		way of life	how people live, how they get around, how they work, how they play, and how they interact on a daily basis	Impacts on people's daily routines caused by construction activities and/or operational arrangements. Impacts on people's commuting/travelling times, their experience of travel, and their ability to move around freely. Impacts on people's experience of privacy, peace, and quiet enjoyment, especially if affected by increased noise. Impacts on people's general experience of life in their community, especially if the project might cause a 'tipping point' of cumulative impacts on their lives, e.g. through property acquisitions, severance of communities, or major disruption during construction.
		community	composition, character, cohesion, function, and sense of place	Composition - impacts on demographic characteristics and community structure. Can be changed by in-migration and out-migration over time, including the presence of newcomers and loss of longer term residents or sections of the community. Also inflow/outflow of temporary residents, e.g. during construction. Character - impacts on a community's shared identity and attributes, and natural and built features that people value. Can be affected by changes to buildings, vegetation, landscapes, land uses/industries, or land ownership and management. Cohesion and function - impacts on social connections, interrelationships, networks and interactions, trust and cooperation, participation in community activities and institutions, and the potential for harmony or conflict. Lack of cohesion can result in social dislocation, alienation, division, dispossession, tensions, impoverishment, and crime. Sense of place - impacts on feelings of belonging in a place, or identity with a place, which may derive from cultural or historical connections.
		access	how people access and use infrastructure, services and facilities, whether provided by local, state, or federal governments, or by for-profit or not-for-profit organisations or groups	Impacts on how people use roads and other access routes; severance, restrictions, and/or improvements in access. Impacts of project (including project-related transport) on pedestrian routes and people's access to schools, medical services, community services, and businesses. Impacts on capacity of services to respond to in-migrating residents.
		culture	both Aboriginal and non-Aboriginal culture, including shared beliefs, customs, values, and stories, and connections to country, land, waterways, places, and buildings	Impacts on people's values, customs, and beliefs associated with (or embedded in) the site or locality, e.g. as secondary effects of changes to scenic quality, landforms, or water flows. Strengthening of community values and culture through project design elements. For Aboriginal cultural heritage, also consider potential for intangible harm through 'cultural or spiritual loss' (i.e., loss or diminution of traditional attachment to the land or connection to country, or loss of rights to gain spiritual sustenance from the land).
		health and wellbeing	physical and mental health ^[1] , especially for those who are highly vulnerable to social exclusion or substantial change, plus wellbeing of individuals and communities	Health impacts, and well-founded concerns/fears about health impacts, associated with noise, dust, odour, vibration, lighting, and toxic materials. Stress, anxiety, and uncertainty - or hopes - about a proposal, about changes to adjacent uses, and about cumulative change to a neighbourhood. Psychological stress and fears/hopes for the future. Potential impact of the project on social behaviours such as alcohol/drug use, domestic or other violence. Impacts of project elements on ability to sleep, people's general health and wellbeing, and overall community health.
		surroundings	access to, and use of, services that ecosystems provide ^[2] , public safety and security, access to and use of the natural and built environment, and its aesthetic value and amenity ^[3]	Impacts on anything provided by the environment and that is useful for people, e.g. food and clean water supply, flood or fire defences. Impacts on safety of pedestrians, children, drivers, and cyclists. Impacts on levels of crime and violence, perceptions of crime, safety, and security, especially for women. Loss or enhancement of public spaces. Impacts on the perceived quality and uses of a natural or built area. Impacts on the valued features, the soundscape, and aesthetics of a place and how people use or appreciate it.
		livelihoods	people's capacity to sustain themselves, whether they experience personal breach or disadvantage, and the distributive equity of impacts and benefits	Impacts on people's livelihoods, e.g. from new employment and business opportunities (positive), or from disruption during construction (negative). For Aboriginal people, rights to land and to gain spiritual and cultural sustenance from the land.
		decision-making systems	whether people experience procedural fairness; can make informed decisions; have power to influence decisions; and can access complaint, remedy and grievance mechanisms	Capacity of affected people to influence project decisions, including elements of project design. Extent to which they can navigate large amounts of technical material and make informed decisions. Effectiveness of engagement mechanisms at enabling all groups (especially vulnerable or marginalised groups) to participate in the assessment process. Levels of trust in the rigour and impartiality of the assessment process. Extent to which people feel empowered to determine their futures, including after a project closes. Opportunities for people to have a say in the project's community investment decisions. Accessibility and effectiveness of complaint and remedy procedures.

[1] The World Health Organization defines health as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity. For this guideline, wellbeing is a state in which people have their basic needs met, can realise their

[2] "Ecosystem services" include: provisioning services, such as food and water; regulating services, such as flood and disease control; supporting services, such as nutrient cycling, that maintain the conditions for life on Earth; and cultural services, such as spiritual,

[3] When considering perceptions of adverse impacts on amenity, an evaluation must be made of the reasonableness of those perceptions. This evaluation involves 'the identification of evidence that can be objectively assessed to ascertain whether it supports a

Definitions from NSW Government Technical Supplement Social Impact Assessment 2021

CATEGORIES	EXAMPLES
A social impact may be physically observable or it may manifest as rational or justified fears (of negative impacts in the future) or aspirations (of positive impacts in the future).	<p>Physically observable impacts <i>More paths and cycleways</i> <i>Acquisition of residential properties</i></p> <p>Rational or justified fears <i>Psychological stress regarding the future personal and community impacts of compulsory property acquisition</i></p>
A social impact may be experienced positively by some people, and negatively by others.	<p>Positive <i>Improved livelihoods owing to more work opportunities</i></p> <p>Negative <i>Increased prevalence of adverse health conditions</i></p>
A social impact may be tangible or intangible.	<p>Tangible <i>Availability of affordable housing</i></p> <p>Intangible <i>Community cohesion</i></p>
Social impacts may be direct or indirect. They may also combine with other impacts from a single project or be cumulative with impacts from other projects.	<p>Direct <i>Sleep disturbance caused by construction noise</i></p> <p>Indirect <i>Strain on family relations and health from sleep disturbance caused by construction noise</i></p> <p>Combined <i>Sleep disturbance due to increased noise and restricted access because of significantly reduced street parking caused by a single project</i></p> <p>Cumulative <i>Sleep disturbance due to increased noise and restricted access because of significantly reduced street parking from one project. In addition, poor air quality creating health conditions and strained family relations from another project</i></p>
A social impact may be best assessed using quantitative methods or qualitative methods.	<p>Directly quantitative <i>Changes in population demographics</i></p> <p>Partially/indirectly quantitative <i>Incidence of voluntary work among a community as a proxy indicator of community cohesion</i></p> <p>Qualitative (measurable through perception surveys or oral story telling, for example) <i>Cultural values</i> <i>Sense of place</i></p>

CATEGORIES	EXAMPLES
	<i>Connection to Country</i>
A social impact may be experienced differently within a community, by different communities, and at different times/stages of the project.	Different experiences within a community <i>An increase in the value/cost of housing may be positive for homeowners wanting to rent out or sell their properties, but negative for individuals and families wanting to buy or rent.</i>
	Different experiences for different communities <i>People living near a project may experience most of the noise and dust impacts, while people in the region's nearest town may benefit from most of the job opportunities.</i>
	Different experiences over time <i>People's experiences of impacts during project construction may be quite negative, whereas experiences during operation may be more positive.</i>

APPENDIX K BASELINE NOISE ASSESSMENT

11 December 2020

680.30046-L01-v1.0 20201215

Power and Water Corporation
GPO Box 4150
DARWIN NT 0800

Attention: Adrian White

Dear Adrian

Baseline noise assessment Proposed Strauss Water Treatment Plant

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was engaged by Power and Water Corporation (PWC) to carry out statistical, background noise monitoring to determine noise management levels during the construction of the proposed water treatment facility at Berry Springs. The facility is to be located approximately 100 metres north of the existing Amadeus Basin gas pipeline to the south of Strauss WWII airstrip (the Project Site).

At the completion of construction all plant associated with the facility is to be housed inside enclosures and is not expected to detract from the noise amenity of the area.

2 Background Noise Monitoring

2.1 Existing Acoustic Environment

Construction noise management levels were derived using data collected during daytime hours to align with the proposed construction hours, in accordance with Section 3.3 of the NTEPA "Noise Management Framework Guideline" (the Guideline).

Continuous, statistical noise monitoring was conducted at two locations in the path between the nearest, potentially affected, noise-sensitive receptors and the Project Site; as per discussions between SLR and the Client. The purpose of the monitoring was to characterise and quantify the existing acoustical environment in the area surrounding the Project Site. Table 1 presents the details of the nominated monitoring locations.

Table 1 Noise Monitoring Locations

Location ID	Nearby Noise sensitive receptor(s)	Noise monitoring location approximate co-ordinates	Location Description
North	<ul style="list-style-type: none"> Residential 	Northing: -12°40'29", Easting: 131°4'29"	North side of Cox Peninsula Rd, Approx. 145 m from the nearest receiver (to the south of Cox Peninsula Rd)

Location ID	Nearby Noise sensitive receptor(s)	Noise monitoring location approximate co-ordinates	Location Description
South	<ul style="list-style-type: none"> Residential 	Northing: -12°40'14"; Easting: 131°4'42"	North of gas easement, approx. 140m west of Stuart Highway, 430m west of nearest receiver

Figure 1 shows a schematic diagram of the monitoring locations and the nearest identified sensitive receptors. **Figure 1 Site Layout and Monitoring Locations**



2.2 Noise Criteria

The Guideline sets out noise management levels for residential and other noise-sensitive receivers and how they are to be applied.

The Project Site is situated within the surrounding "Rural Living" zone on the outskirts of Darwin. As such, the recommended assigned noise levels taken from the Guideline and reproduced in Table 2 may be applied to residences surrounding the Project Site.

Table 2 Standard construction hours and assigned noise levels

Recommended standard hours	Recommended assigned noise affected level ¹	Explanation
Monday to Saturday 7am to 7pm	RBL + 10 dB	The recommended assigned noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the recommended assigned noise affected level, proponents should apply all feasible and reasonable work practices to meet the recommended assigned noise affected level. Proponents should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
Sundays and public holidays 9am to 6pm		
Outside recommended standard hours	RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. Proponents should apply all feasible and reasonable work practices to meet the noise affected level.

¹ RBL = Rating Background Level

2.3 Background Noise Monitoring Results and Noise Management Levels

Table 3 presents the results of daytime background monitoring, as well as the noise management levels for each location.

Table 3 Background Noise Monitoring Results

Monitoring Location	Land-use of nearby receptors for assessment purposes	Measured Ambient Noise Levels ¹ dBA				Noise Management Level (dBA)
		LA1	LA10	LA90 (RBL ²)	LAeq	
North	Residential	63	56	41	55	51
South	Residential	79	71	39	77	49

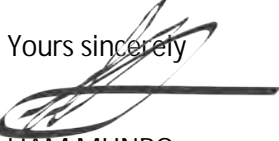
¹ NT EPA recommended standard construction period Daytime - 7.00 am to 7.00 pm Monday to Saturday, 9.00 am to 6.00 pm Sunday

² RBL = Rating Background Level

Table 3 shows daytime construction residential criteria are exceeded at both monitoring locations, prior to any construction activity taking place. This is a common occurrence where there are high levels of intermittent noise, such as vehicle traffic (ie: along Stuart Highway and Cox Peninsula Road, which is highlighted by the LA1 (the loudest one percent of the monitoring period) being measured at >20 dB above the RBL (the quietest 90% of the monitoring period)).

Sound pressure levels at the monitoring locations are expected to increase during the loudest construction operations on the Project Site, however these activities are expected to be of a short duration and mitigation measures, such as those set out in AS 2436-2010, shall be applied as necessary. It is considered unlikely that noise generated from construction activities will be perceivable over existing daytime ambient noise levels (at the closest receivers) due to current levels of vehicle traffic noise surrounding the Project Site.

Should there be any noise complaints related to construction activities, noise monitoring should be carried out at the boundary of the complainant's property, as well as at the closest background monitoring location, to determine if construction noise has made a significant contribution to overall noise levels.

Yours sincerely


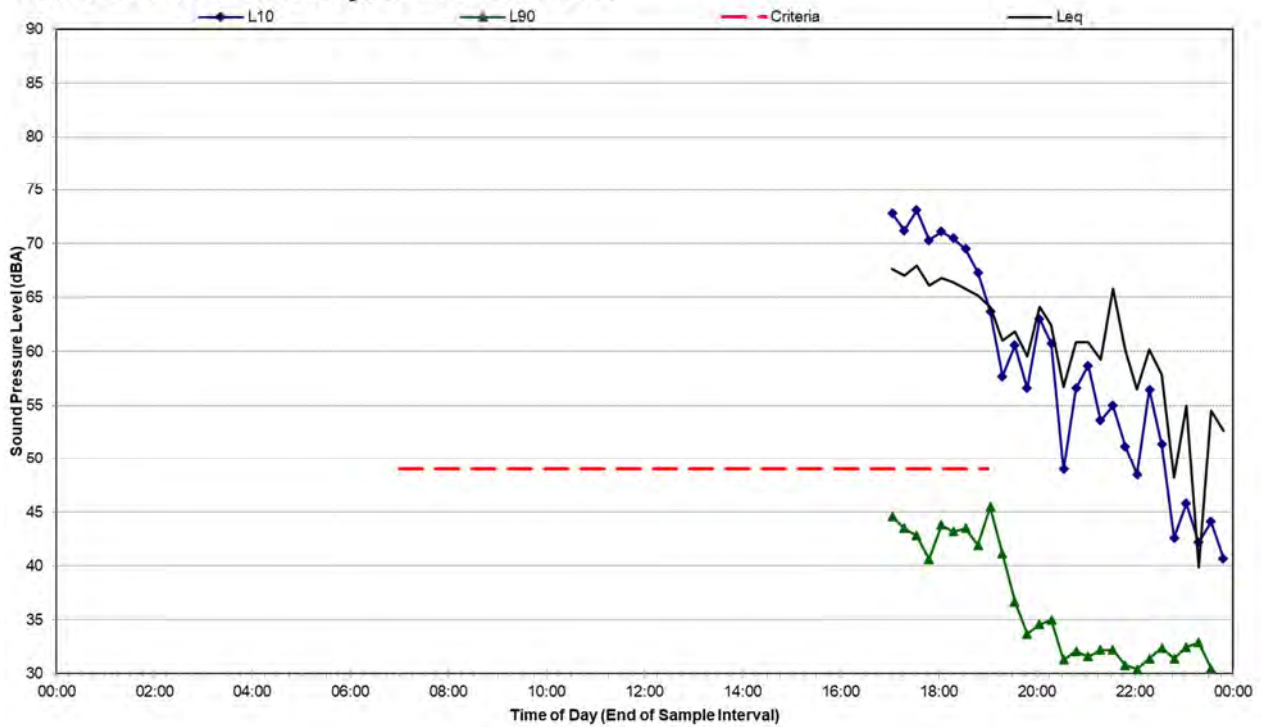
LIAM MUNRO
Associate Consultant

Checked/
Authorised by:
PT

STATISTICAL NOISE MONITORING GRAPHS

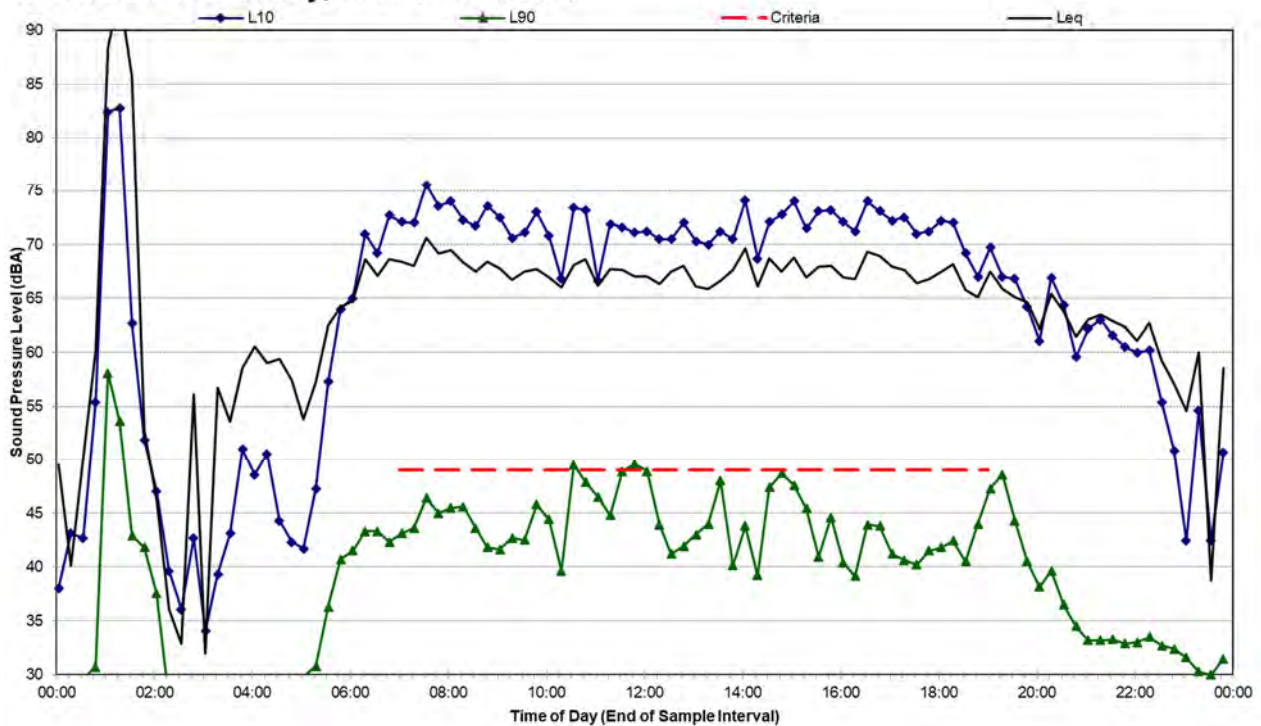
Statistical Ambient Noise Levels

South Location - Thursday, 26 November 2020



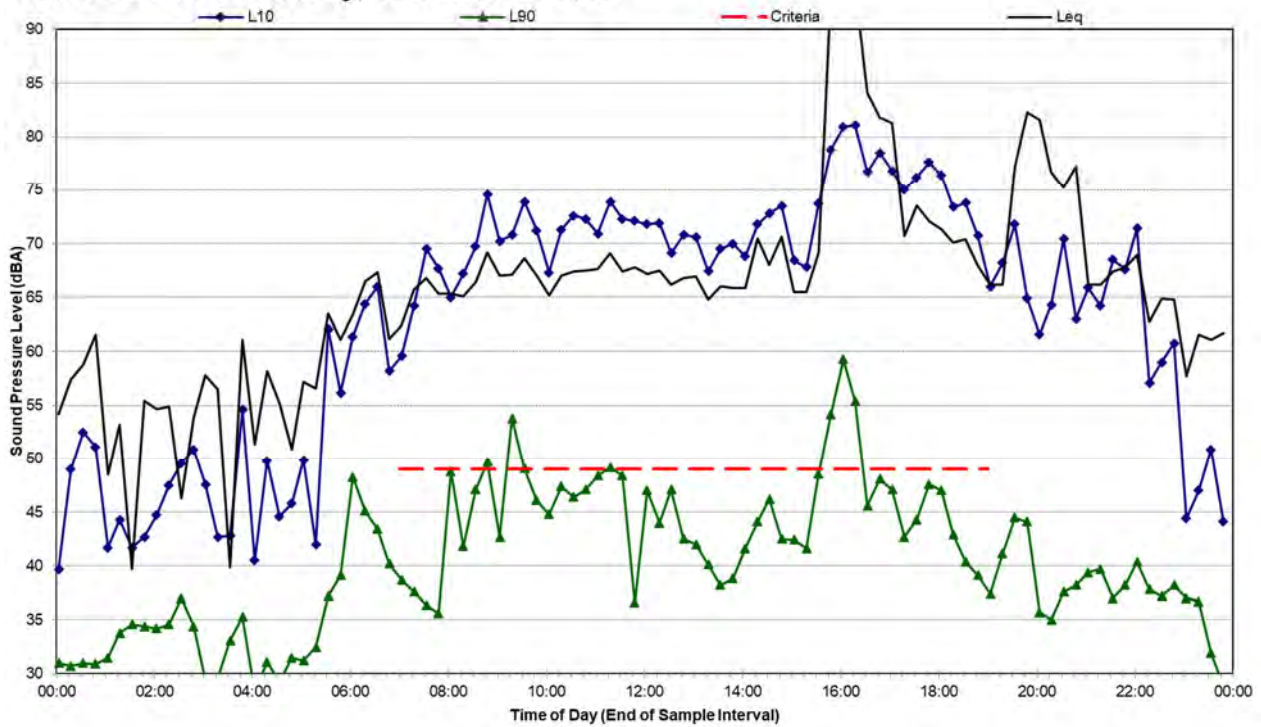
Statistical Ambient Noise Levels

South Location - Friday, 27 November 2020



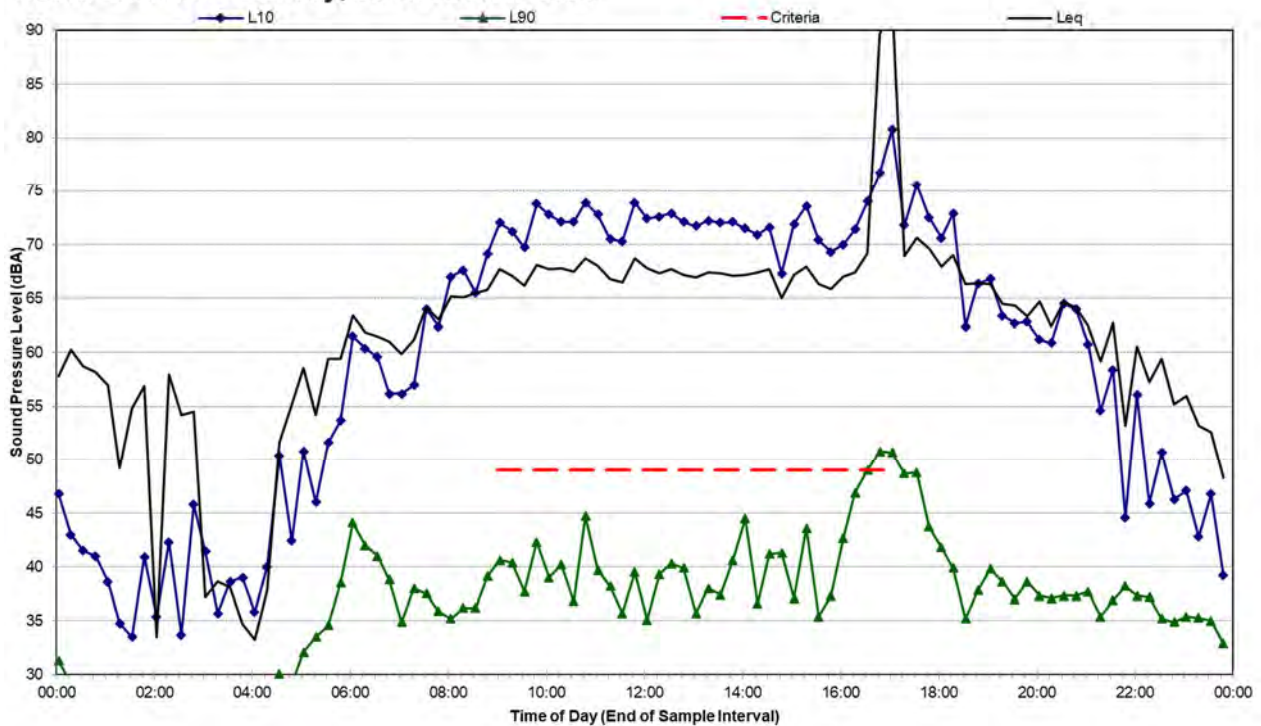
Statistical Ambient Noise Levels

South Location - Saturday, 28 November 2020



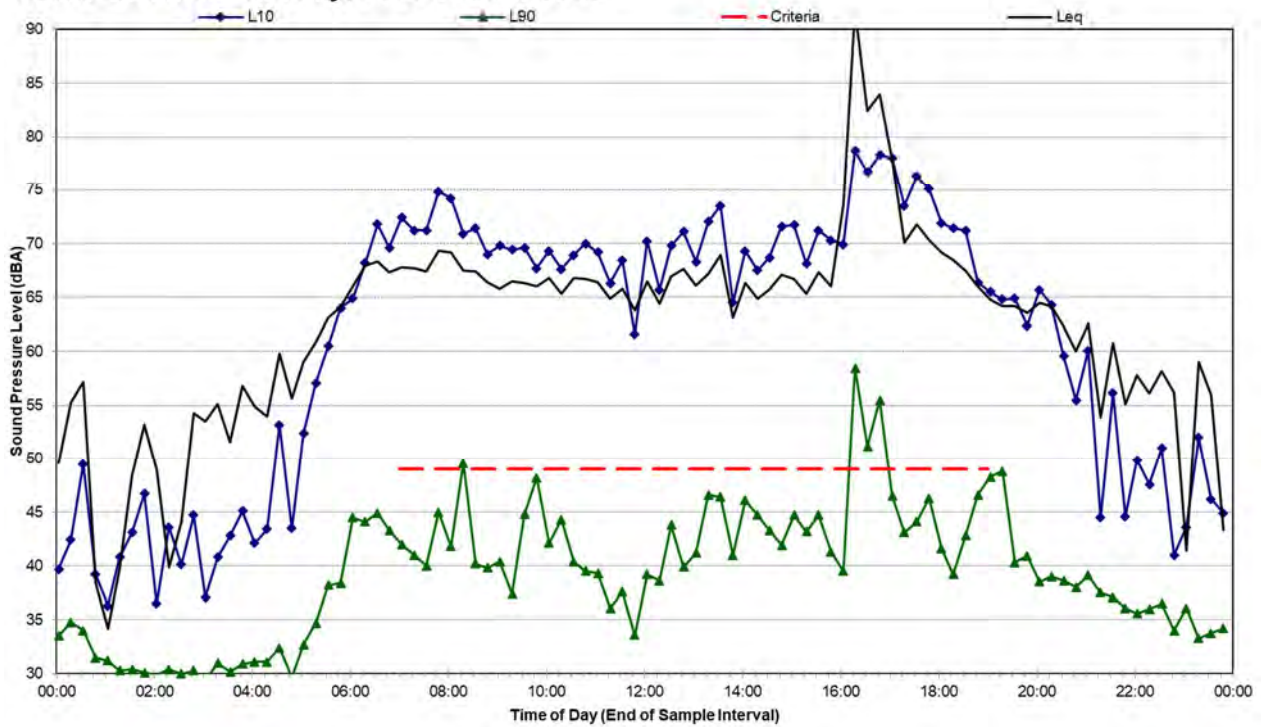
Statistical Ambient Noise Levels

South Location - Sunday, 29 November 2020



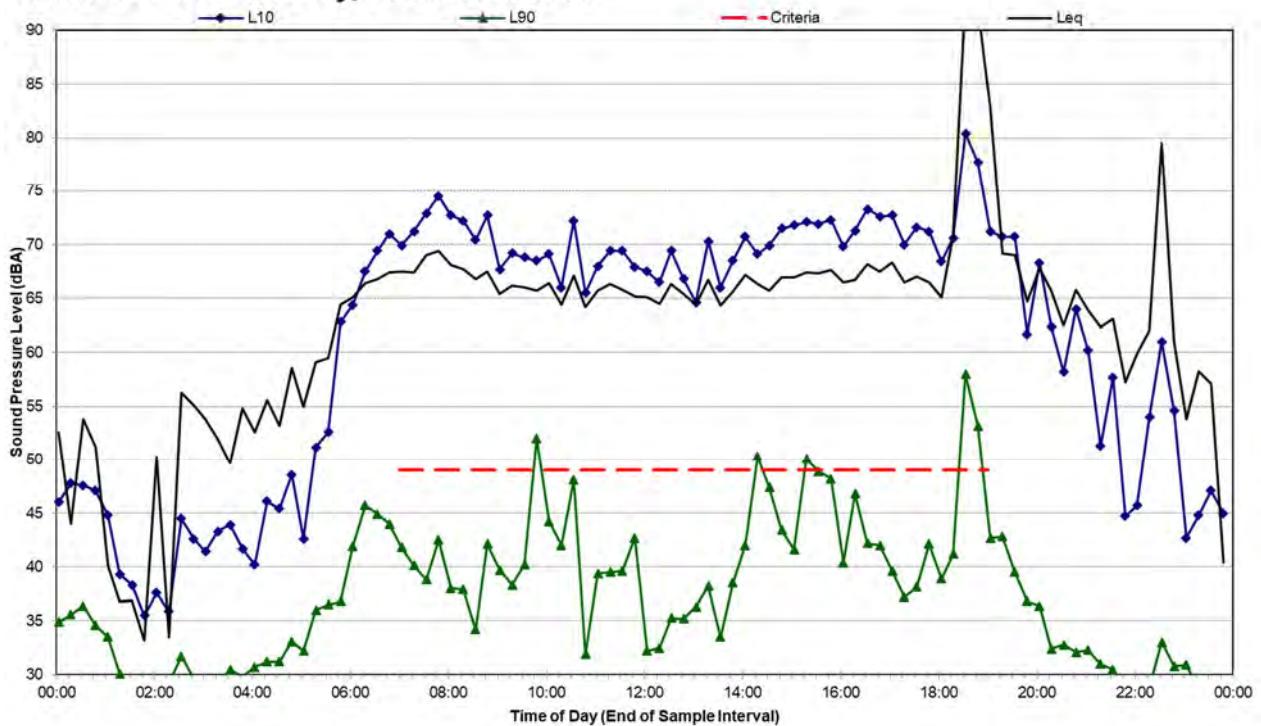
Statistical Ambient Noise Levels

South Location - Monday, 30 November 2020



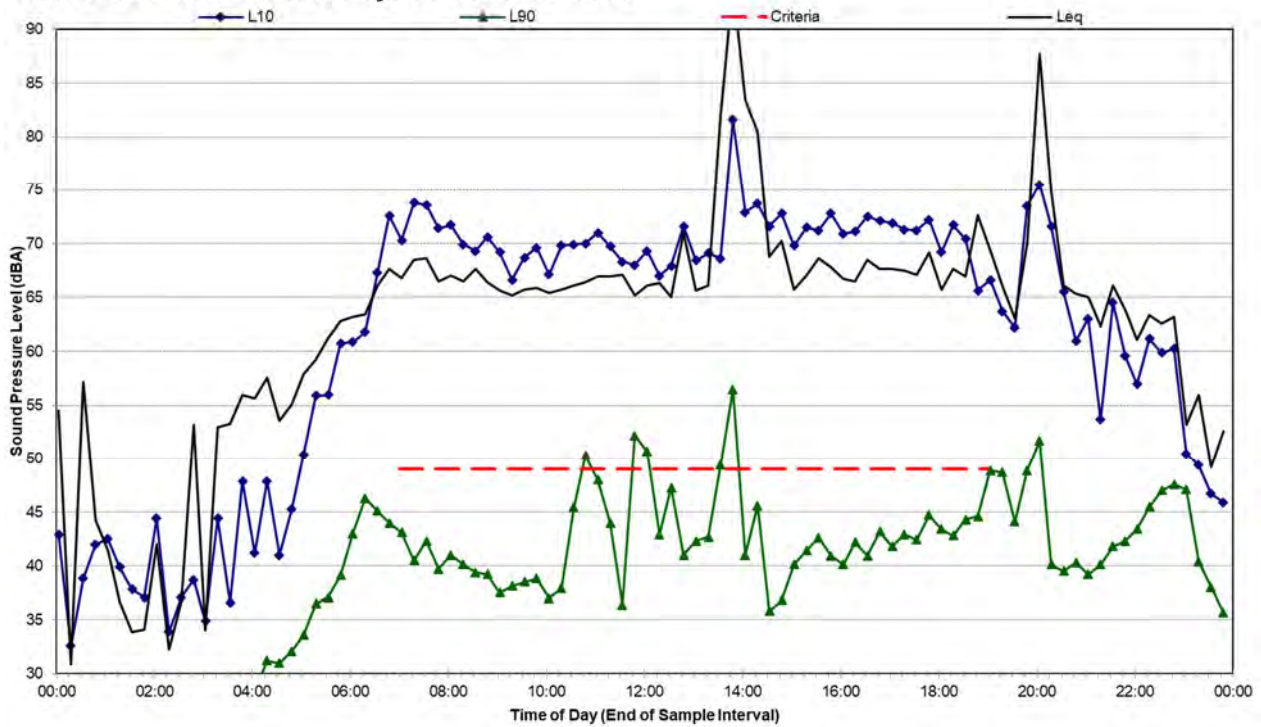
Statistical Ambient Noise Levels

South Location - Tuesday, 1 December 2020



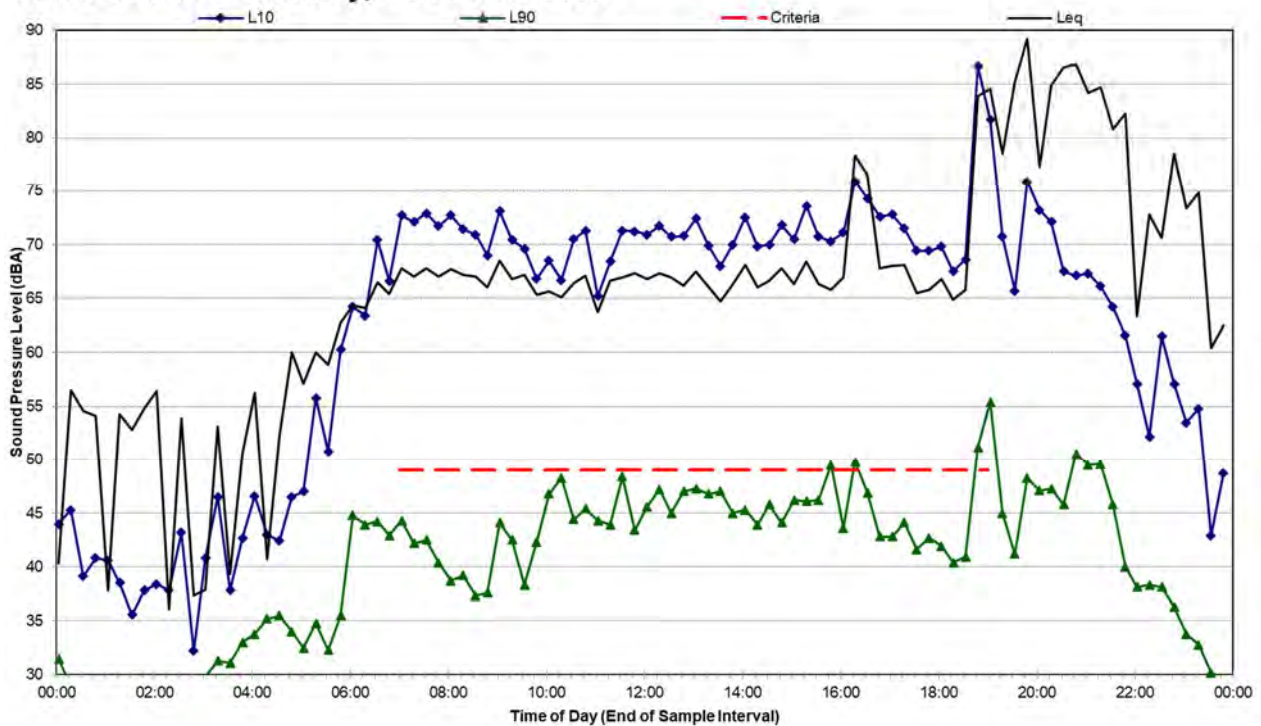
Statistical Ambient Noise Levels

South Location - Wednesday, 2 December 2020



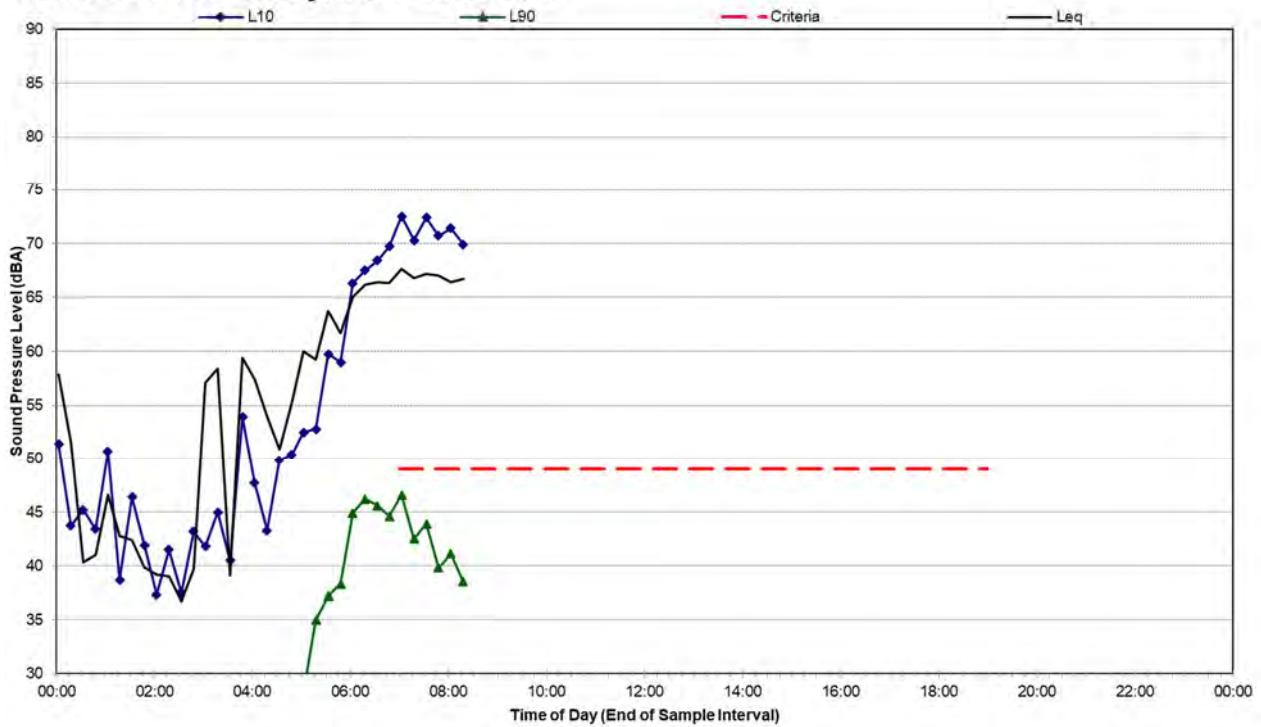
Statistical Ambient Noise Levels

South Location - Thursday, 3 December 2020



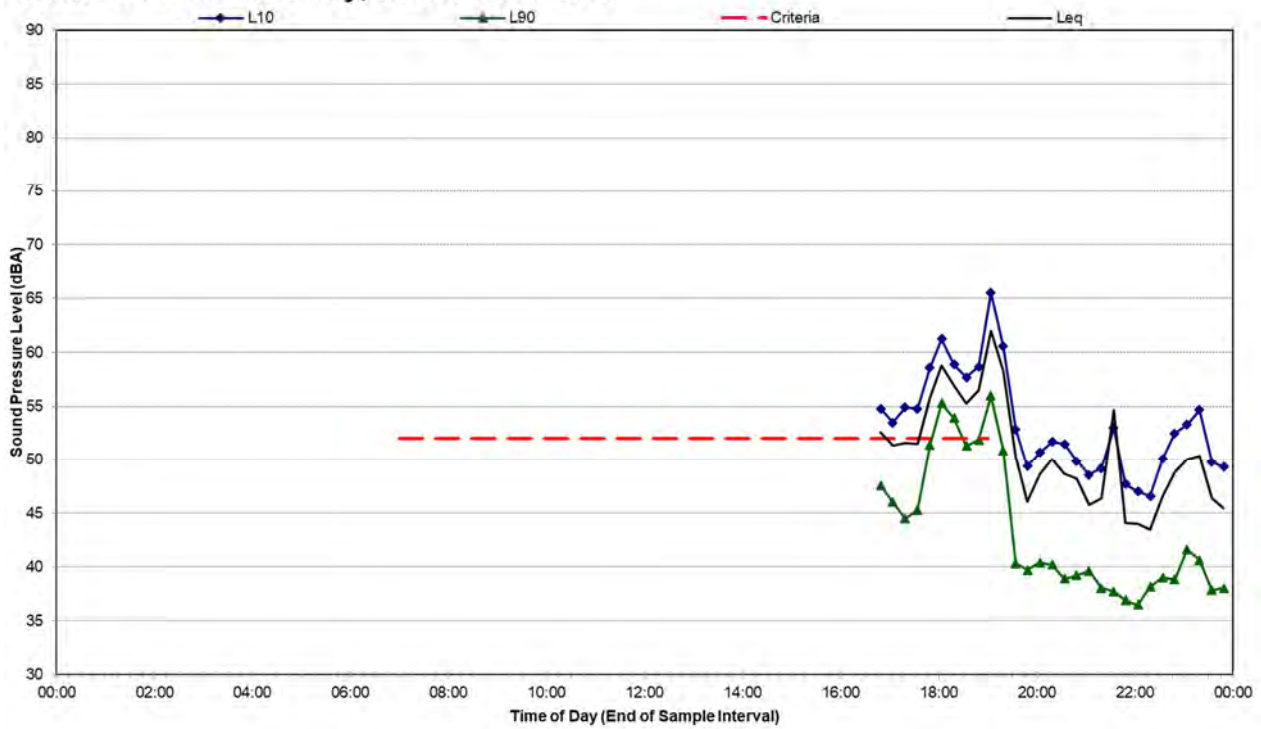
Statistical Ambient Noise Levels

South Location - Friday, 4 December 2020



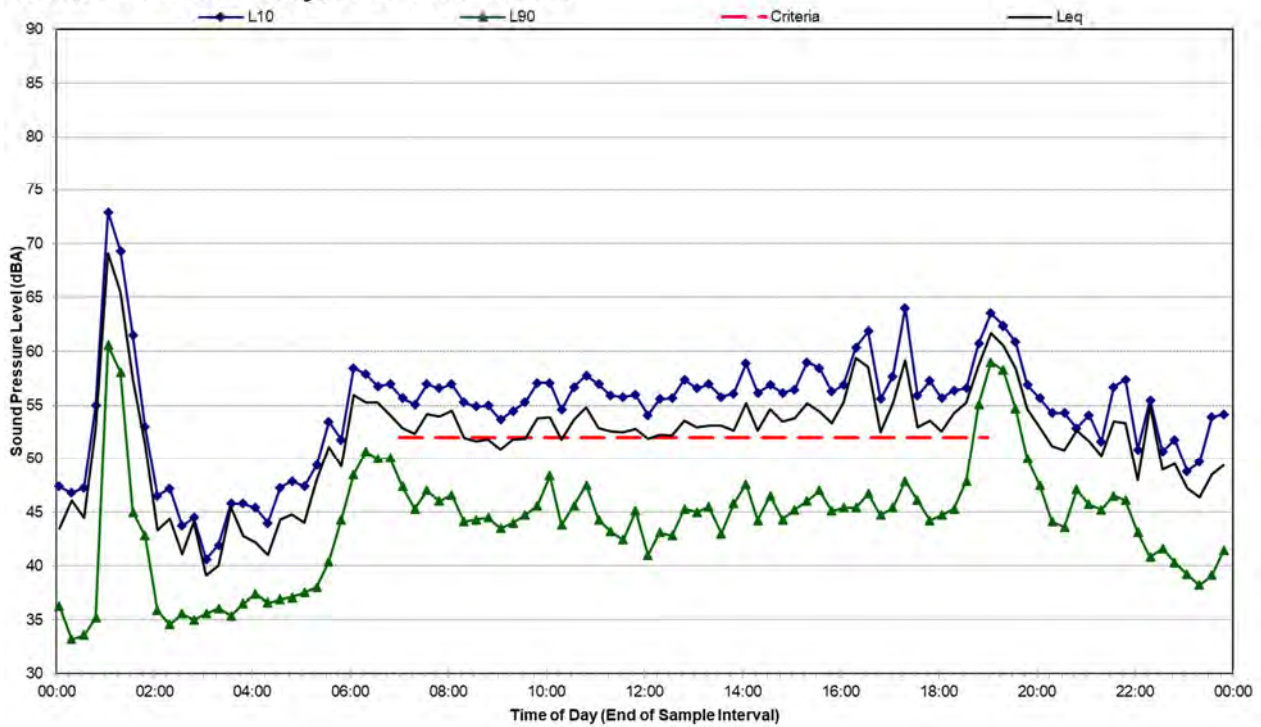
Statistical Ambient Noise Levels

North Location - Thursday, 26 November 2020



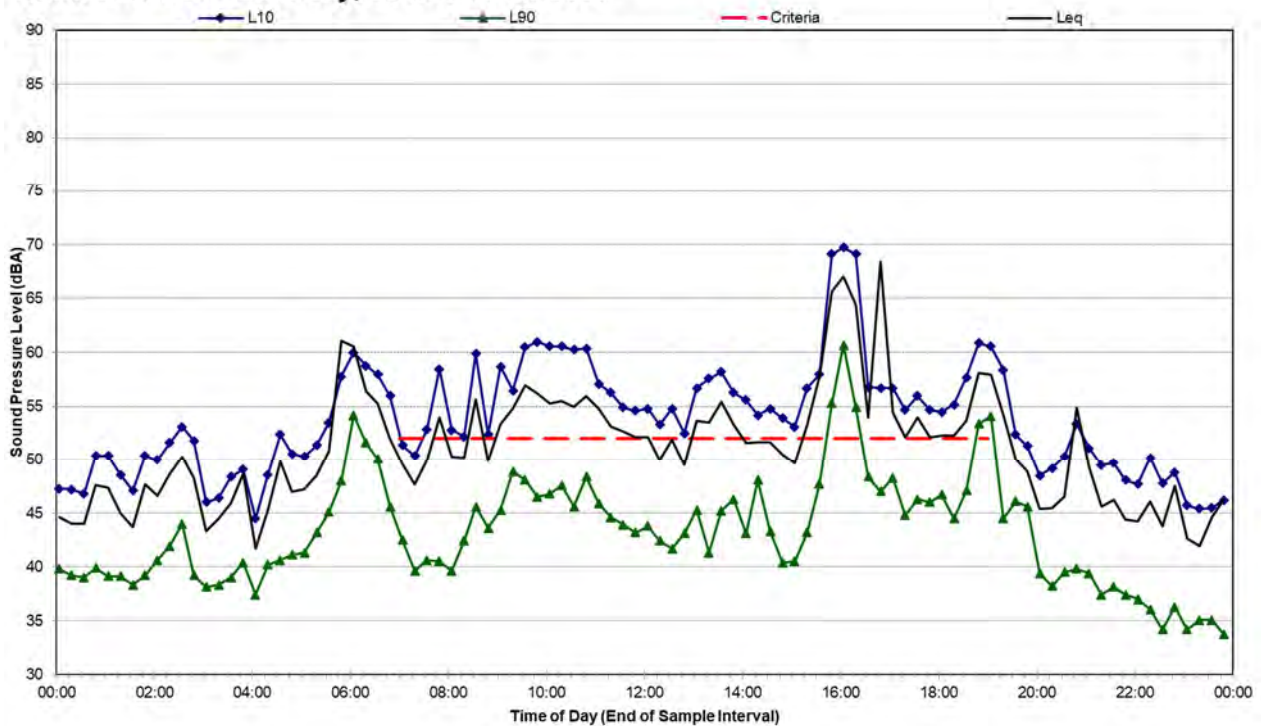
Statistical Ambient Noise Levels

North Location - Friday, 27 November 2020



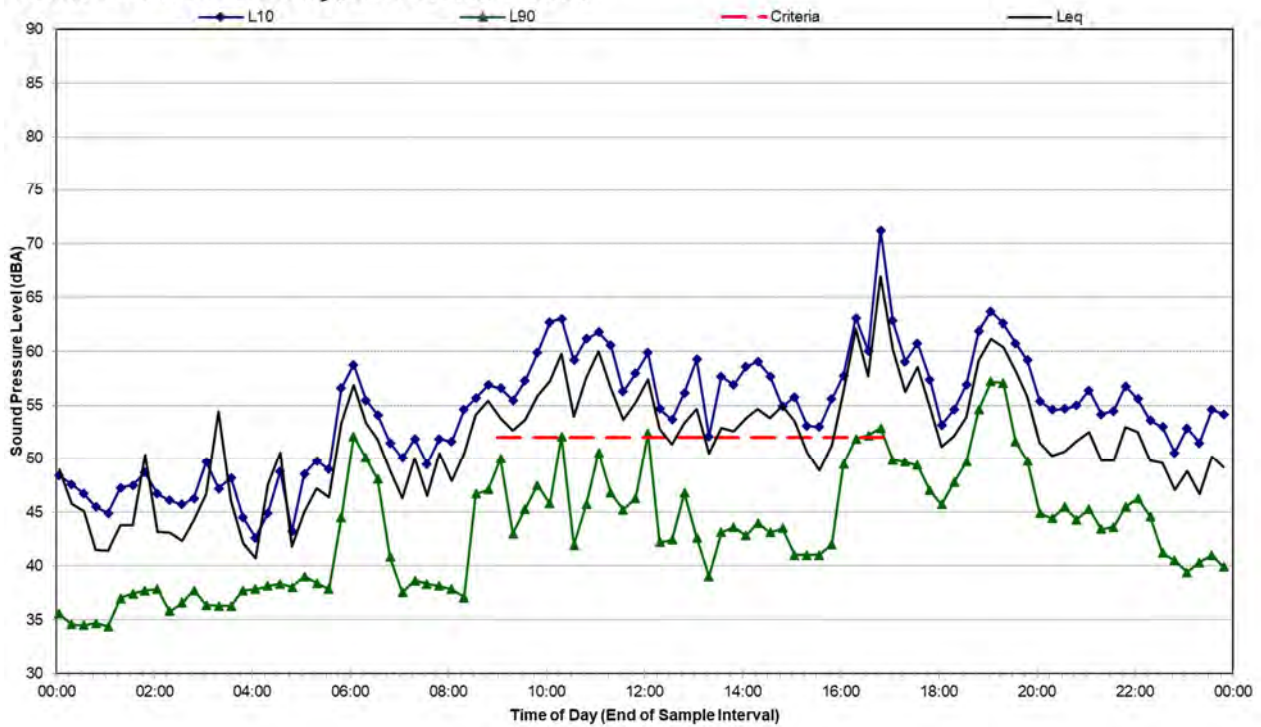
Statistical Ambient Noise Levels

North Location - Saturday, 28 November 2020



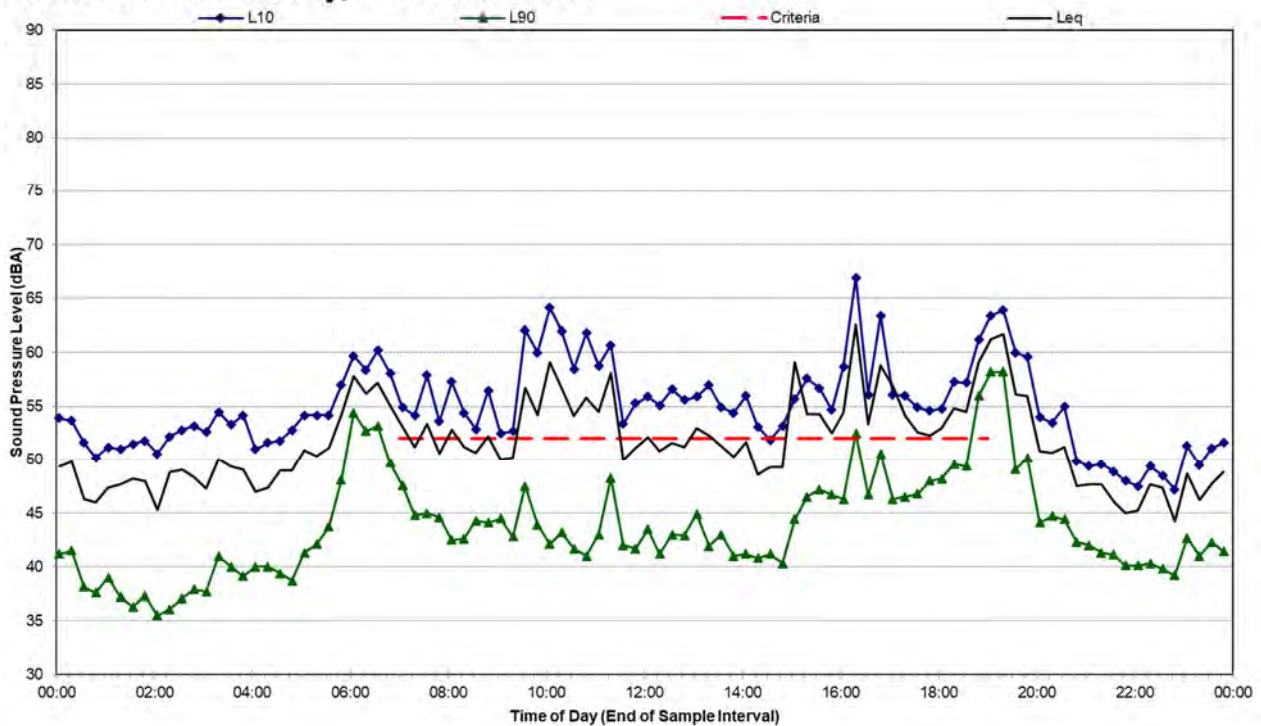
Statistical Ambient Noise Levels

North Location - Sunday, 29 November 2020



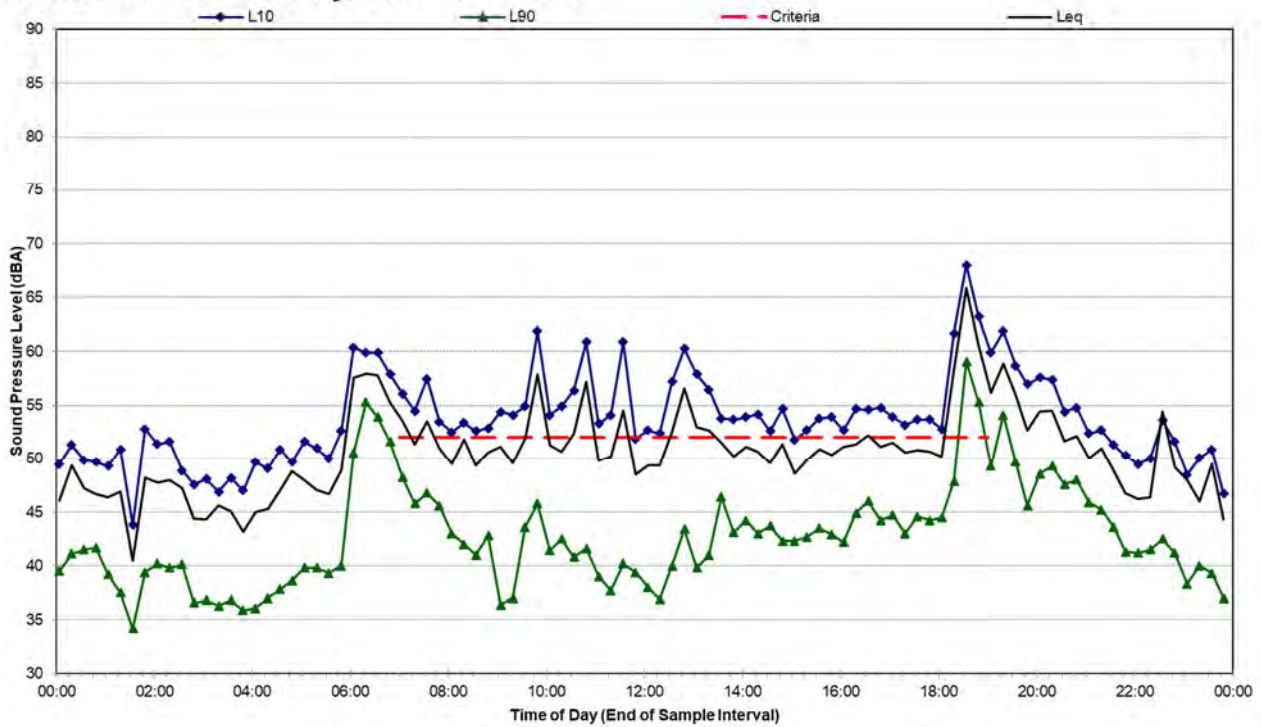
Statistical Ambient Noise Levels

North Location - Monday, 30 November 2020



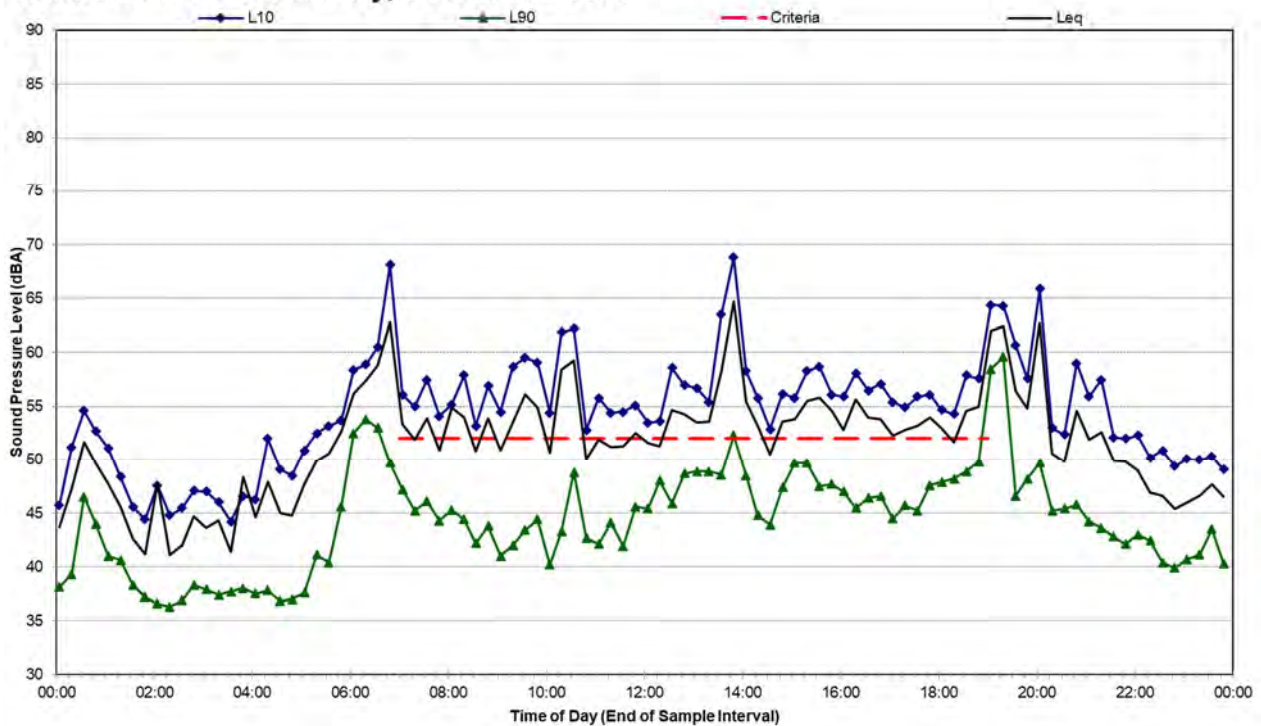
Statistical Ambient Noise Levels

North Location - Tuesday, 1 December 2020



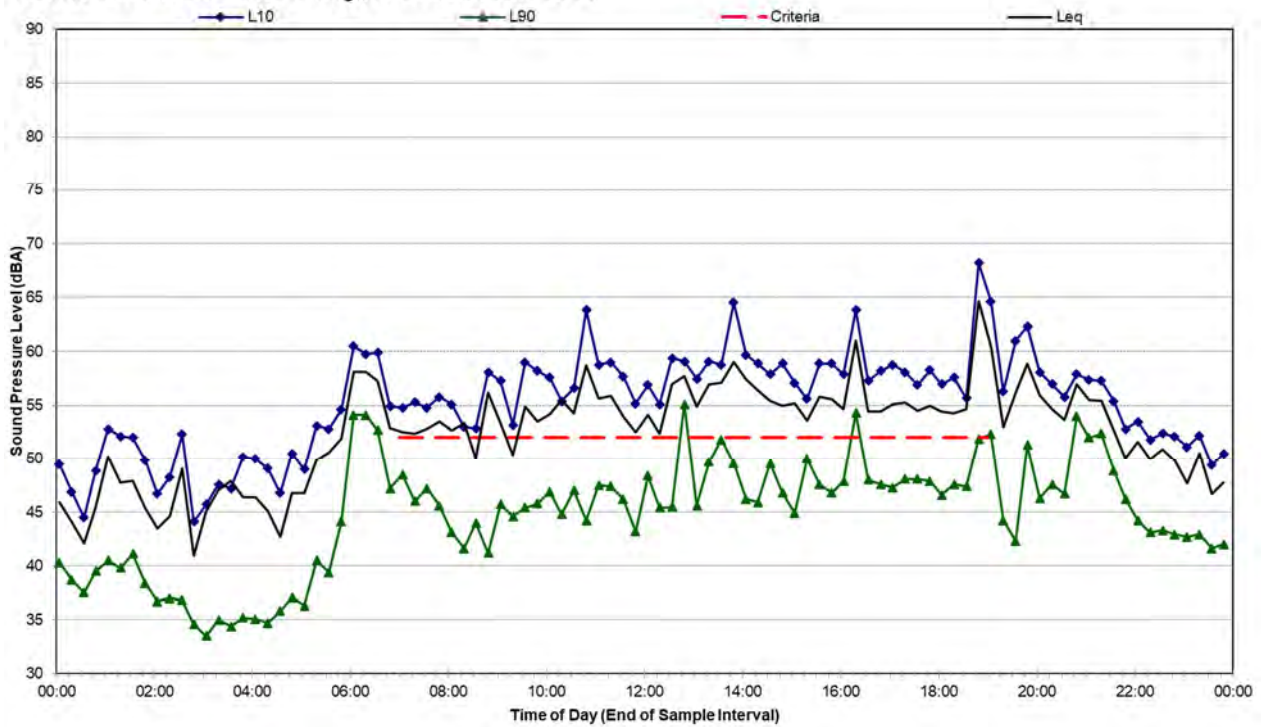
Statistical Ambient Noise Levels

North Location - Wednesday, 2 December 2020



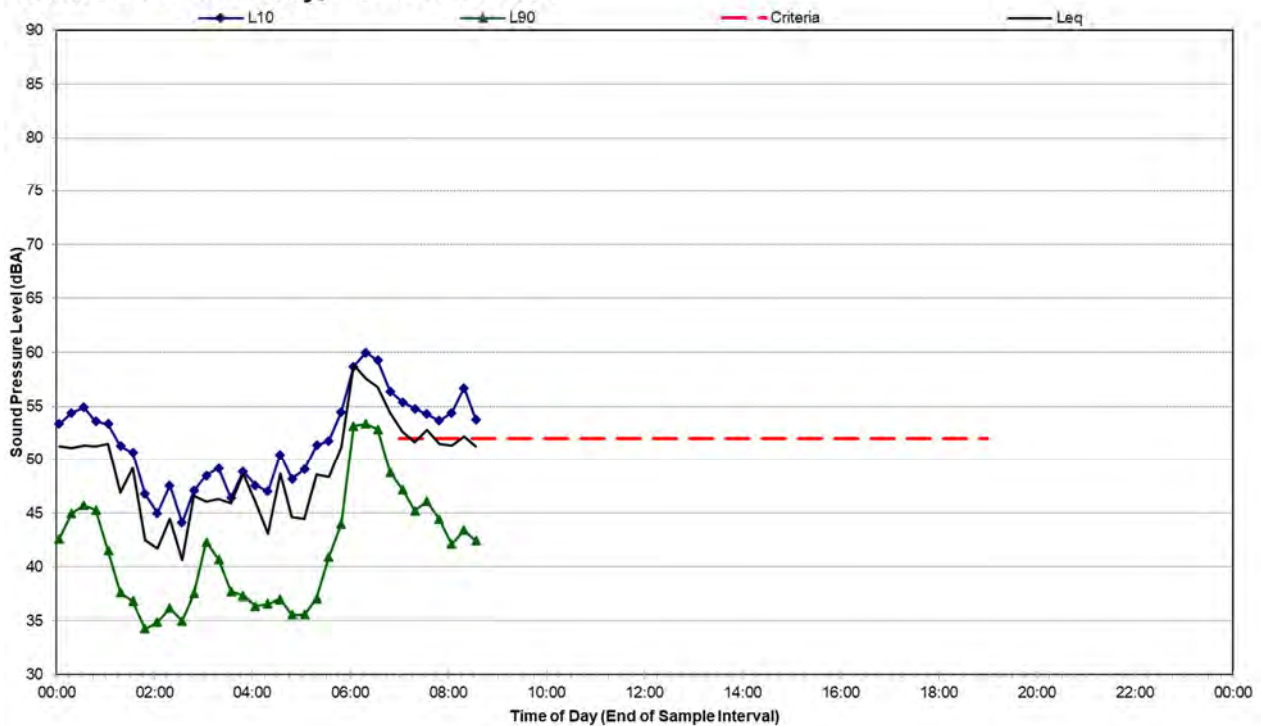
Statistical Ambient Noise Levels

North Location - Thursday, 3 December 2020



Statistical Ambient Noise Levels

North Location - Friday, 4 December 2020



APPENDIX L PRELIMINARY ADVICE FROM HERITAGE BRANCH

Manton Dam: Preliminary Advice on Heritage Matters

December 2020

INTRODUCTION

The Heritage Branch has been asked to provide preliminary advice about heritage aspects of Manton Dam and associated infrastructure, including a review of available resources, and an outline of the principles involved when making decisions about places of cultural significance.

The snapshot of important events that follows is taken from Alford's (2001) historical research, and this report also makes reference to a 2001 Interpretation Plan by Alford. Many of the strategies outlined in the Interpretation Plan have already been adopted for the site.

Of note is the fact that, at the time of writing, Manton Dam and associated infrastructure is not heritage listed under the *Heritage Act 2011*.



AUSTRALIAN WAR MEMORIAL 053134
Manton Dam 1939-1945



Manton Dam 2020

IMPORTANT EVENTS

The following is a snapshot of important events in the history of Manton Dam:

- The area around the Dam is located within the traditional lands of the Larrakia Aboriginal people.
- When Darwin (then known as Palmerston) was founded in 1869, the population was reliant on wells. The population petitioned the Northern Territory administration for a reliable water supply.
- A major defence build-up during the 1930s saw Manton Dam initiated.
- The Dam was to service the population of Darwin and new military infrastructure, including Larrakeyah Barracks, the RAAF Station, and East Point.
- Tenders for the dam were called for in 1937, with construction of the dam and laying of pipeline commencing in 1938.

- The construction was affected by industrial disputes, the financial collapse of the contractor, and divided priorities between defence and civilian administration.
- The construction was completed by the Commonwealth, with work complete in 1941.
- Japanese attacks in the Pacific saw the evacuation of civilians from Darwin in 1941.
- Japan entering the war saw measures taken to protect Manton Dam as a strategic site during World War II. Anti-torpedo net was strung across the Dam in mid-1943.
- The Dam was identified for demolition in the event of a Japanese invasion.
- More infrastructure was installed in 1945, including a larger pipeline and a power line.
- The water supply system was handed over for civilian use in the early post-war years
- The catchment area was fenced in the 1960s, and new pumping equipment installed in 1964.
- Manton dam became redundant following the opening of the Darwin River Dam (DRD) in 1972
- A recreation area for public use was opened in 1989 at Manton Dam.

PREVIOUS INTERPRETATION STRATEGY

- Manton Dam is identified as an historic precinct that supports community and educational use.
- Pumphouse No. 2 with equipment in-situ and given to its proximity to the Dam has been identified as 'a most interesting component of the Historic Precinct'¹.
- As well as mid-twentieth century development in the region, other themes across the site have been identified as; Aboriginal use, exploration, construction, the politics of the military v civil needs, WWII and community resources.
- PAWA corporate identifier at the time was: *Connected to the future.....remember the past*
- Managers, Traditional Owners and Visitors identified as stakeholders
- The possible audience for the site was identified as; PAWA, Larrakia Aboriginal people, Aboriginal groups (including Woolna, Kungarakany and Limilngan people), Aboriginal associations, neighbouring landowners, tour operators, tour groups, international visitors, interstate visitors, NT residents, visiting friends and relatives, backpackers, bushwalkers, schools, universities, educational groups, politicians, researchers, journalists, media representatives, community organisations, volunteer groups, professional organisations and NTG staff.
- The site is identified as being within proximity of tourism destinations and features in tourism brochures at that time.
- Values of the site identified as Aboriginal cultural, natural and historic areas.
- Bob Alford at the time recommended nomination to the NT Heritage Register to 'further enhance the values of the precinct through its continued conservation, its heritage value and its status'²

¹ Alford 2001

² Alford 2001

PHYSICAL DESCRIPTION

- 65k south of Darwin, off the Stuart Highway, close to the Manton Dam Rest Stop
- Road access along Manton River with underpass under the railway line that runs parallel, and to the west of, the Stuart Highway
- Buildings include: Caretaker residence & garage; Electrical Pumphouse; Toilet Block; Shed; Pumphouse No. 1, Pumphouse No. 2 and a handful of smaller buildings, structures and remnants from past and current uses for the site. These range from the 1938-1941 initial construction, WWII defence build-up, and the 1964 upgrades to more recent times.
- The Dam, intake tower and pipeline date back to the 1938-1941 construction.
- Remnants of the 1943 boom gate present.
- A picnic area and interpretive signs have been provided on site.

Photographic records compared to recent photographs



AUSTRALIAN WAR MEMORIAL
Pipeline to Darwin 1943



Remaining pipeline



AUSTRALIAN WAR MEMORIAL
Steam Pumphouse 2 - 1943



Remaining Steam Pumphouse 2



AUSTRALIAN WAR MEMORIAL
Steam Pumphouse 1 - 1943

053153



Remaining Steam Pumphouse 1



AUSTRALIAN WAR MEMORIAL
Fuel tank at Manton Dam - 1942

053156



Remaining tank base



AUSTRALIAN WAR MEMORIAL
Partly Finished Boom System 1943

053582



Remnants of boom system pylon footings



AUSTRALIAN WAR MEMORIAL 053132
General View of the Top of the Wall, Camouflaged 1943



Remaining infrastructure on intake tower



Territory Stories PH0106/0047
Example of 1 of the 2 Type 'G' residences



Remaining Type G residence

CONSERVATION PRINCIPLES

The Australia ICOMOS *Burra Charter* (2013) provides the best-practice standard for managing cultural heritage places in Australia. It encourages a cautious approach, “changing as much as necessary but as little as possible”.

Under the *Burra Charter* conservation is defined as:

“....all the processes of looking after a *place* so as to retain its *cultural significance*.”

Interpretation is one of the processes included within the definition of conservation, and the *Burra Charter* states that Interpretation:

“....means all the ways of presenting the *cultural significance* of a *place*.”

The Burra Charter goes on to say that:

“Interpretation may be a combination of the treatment of the fabric (e.g. maintenance, restoration, reconstruction); the use of and activities at the place; and the use of introduced explanatory material.”

This Preliminary Report suggests that Manton Dam has cultural significance, and that any decisions made about the future of the place should take into account the principles of the Burra Charter.

In a nutshell, this means not removing or dramatically altering components of the site that are considered to be of cultural significance, and developing an up-to-date interpretive strategy.

The map overpage suggests opportunities to interpret the history of Manton Dam and associated infrastructure. The dam wall, intake tower and pipeline are the main infrastructure of the area and represent the most significant features of the site. Particular attention is also drawn to Pumphouse No. 2 and the infrastructure and equipment that remains. It has previously been stated that:

It's proximity to the dam wall via both upper and lower pathways provides a highly visible linking of the storage and supply of water...³

Pumphouse No. 1 also has remnant infrastructure indicating a connection to the pipeline, and this assists in interpreting the operational history of Manton Dam.

Another important element is the Type 'G' caretaker's residence, which speaks to the previous occupation of the site and its isolation. Views to and from the residence should be considered.

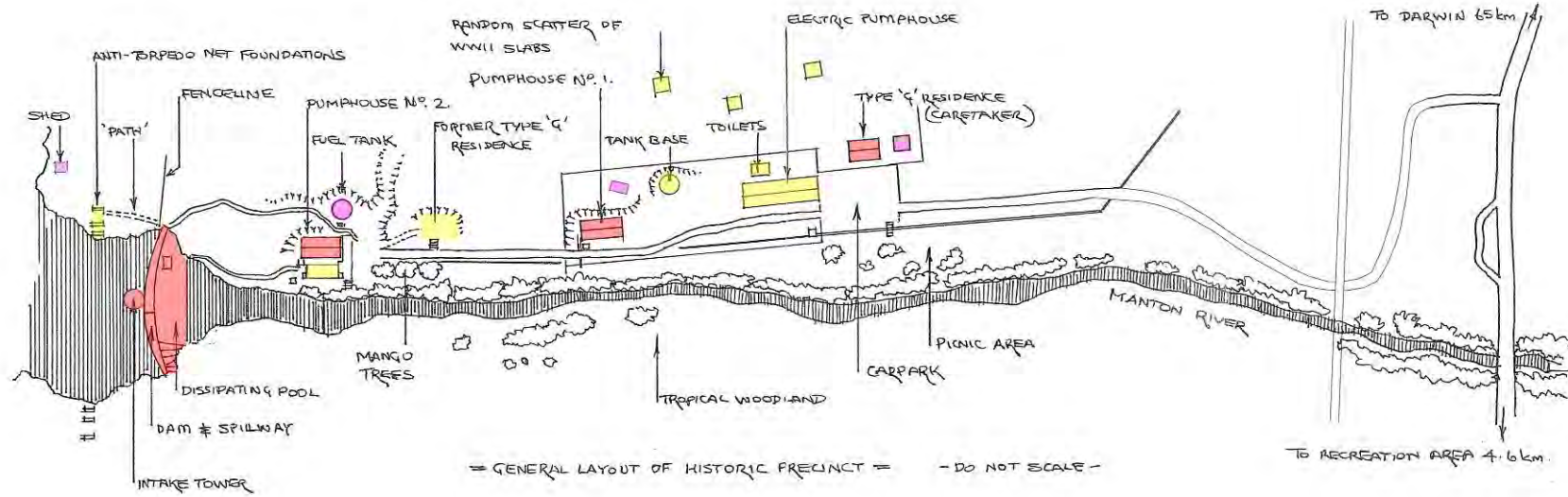
The owners of the site have the right to restrict access in line with operational requirements, but public access in some form would be encouraged.

PUBLICATIONS ACCESSED AS PART OF DESKTOP REVIEW

Alford B., 2001 A conservation and Management Plan

Alford B., 2001 A Communication and Interpretation Plan for the Manton Dam Historic Precinct

³ Alford 2001



- High potential for interpretation
- Potential for interpretation
- Low potential for interpretation





DEPARTMENT OF TERRITORY
FAMILIES, HOUSING AND
COMMUNITIES

ATTACHMENT A – THE BURRA CHARTER PROCESS

The Burra Charter Process

Steps in planning for and managing a place of cultural significance

The Burra Charter should be read as a whole.

Key articles relevant to each step are shown in the boxes. Article 6 summarises the Burra Charter Process.

