GROOTE EYLANDT MINING COMPANY (GEMCO)

J Quarry Haul Road Realignment

Environment Protection Act Referral

November 2020

Volume 2

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

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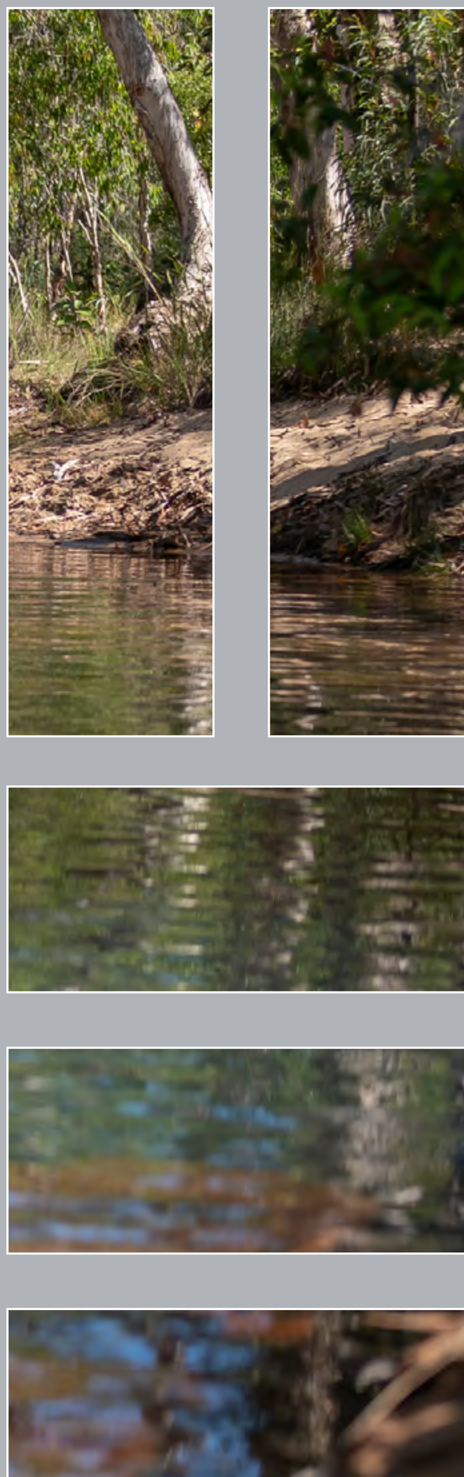
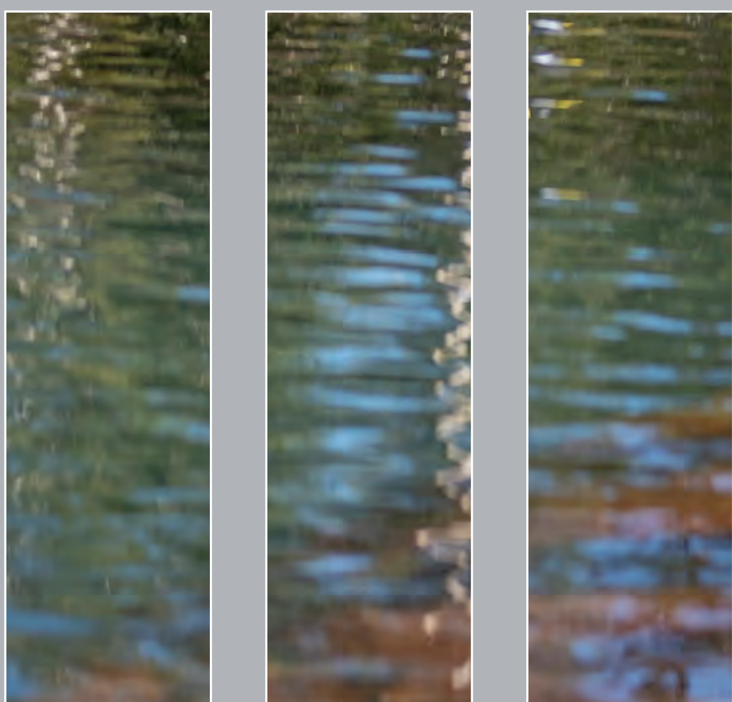
A

Hydrology and Hydraulics Assessment Report





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J Quarry Haul Road

Hydrology & Hydraulics Assessment Report

Prepared for:
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0	Issued for Use	Drew Crossley	Mike Liu	23/07/2020

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Abbreviations

Abbreviation	Definition
AEP	Average Exceedance Probability
AHD	Australian Height Datum
AWS	Automatic Weather Station
ARF	Aerial reduction factor
ARR	Australian Rainfall and Runoff
ARI	Average Recurrence Internal
BOM	Bureau of Metrology
CL	Continuing loss
CSP	Corrugated Steel Pipe (culvert)
DEM	Digital Elevation Model
FFA	Flood Frequency Analysis
GEMCO	Groote Eylandt Mining Company
GIS	Geographic Information System
HAT	Highest Astronomical Tide
IL	Initial Loss
IFD	Intensity Frequency Duration
Km2	Kilometre square
LIDAR	Laser Imaging, Detection, and Ranging
m/s	metre per second
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
NT	Northern Territory
REE	Red Earth Engineering
RFFE	Regional Flood Frequency Estimation
RCB	Reinforced Concrete Box (culvert)
RORB	Runoff and Routing Model

1.0 Introduction

Red Earth Engineering (REE) was commissioned by the Groote Eylandt Mining Company Pty Ltd (GEMCO) to complete a hydrology and hydraulic assessment as part of the environmental approval application for the J Quarry Haul Road (the project). The proponent of the project is GEMCO, which has two shareholders - South32 Limited (60%) and Anglo Operations (Australia) Pty Ltd (40%).

GEMCO operates an existing manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650km south-east of Darwin. The mine has been operating since the 1960s in multiple mineral leases known as the Western Leases (**Figure 1**). These tenements were granted in the 1960s, 1970s and 1980s. GEMCO's existing operations in the Western Leases are located on the northern side of the Emerald River. In 2023, mining is scheduled to progress into the southernmost mineral lease (ML961), which contains a future mining area known as J Quarry, located on the southern side of the Emerald River (**Figure 2**). ML961 includes an access corridor connecting the existing mine to J Quarry. However, GEMCO is unable to develop a haul road within the access corridor because of restrictions relating to an Aboriginal sacred site. An alternative alignment for the access corridor is therefore required.

The project involves the development of a haul road within an alternate alignment of the access corridor. The key elements of the project are shown in Figure 3 and are limited to project elements and activities that are located beyond the existing tenements. The project involves:

- Construction of a haul road that links existing mining operations to J Quarry. On the northern side of the Emerald River, within the floodplain of the river, the road will be constructed on an embankment. On the immediate southern side of the river, it will be constructed as a causeway on the floodplain. A bridge will be required for crossing the Emerald River. The haul road will also traverse an ephemeral tributary of the Emerald River, known as the Southern Tributary (**Figure 3**), via a causeway and a series of culverts.
- Development of a construction access track to enable construction equipment to access the area to the south of the Emerald River.
- Realignment of an existing public access track to enable safe public access to the western coast of Groote Eylandt. The realignment includes construction of an underpass of the haul road.

The project site for the purposes of environmental assessment is the area to be disturbed by these project elements (**Figure 3**). The project site is approximately 24ha. All haul road development activities (and associated mining activities) located within the Western Leases are authorised under existing approvals and are not included in this assessment.

The land within the access corridor is Aboriginal land, designated under the *Aboriginal Land Rights Act (Northern Territory) 1976* (Cth). The project site comprises natural bushland dominated by Eucalyptus and Melaleuca open woodlands, as well as riparian woodlands along the Emerald River and the Emerald River Southern Tributary.

The township of Angurugu is located approximately 10km to the north of the J Quarry Haul Road and is the closest residential community (**Figure 1**). The Yedikba outstation is located approximately 450m to the east of the haul road and is intermittently used by Traditional Owners (**Figure 2**).

Figure 1: Location plan

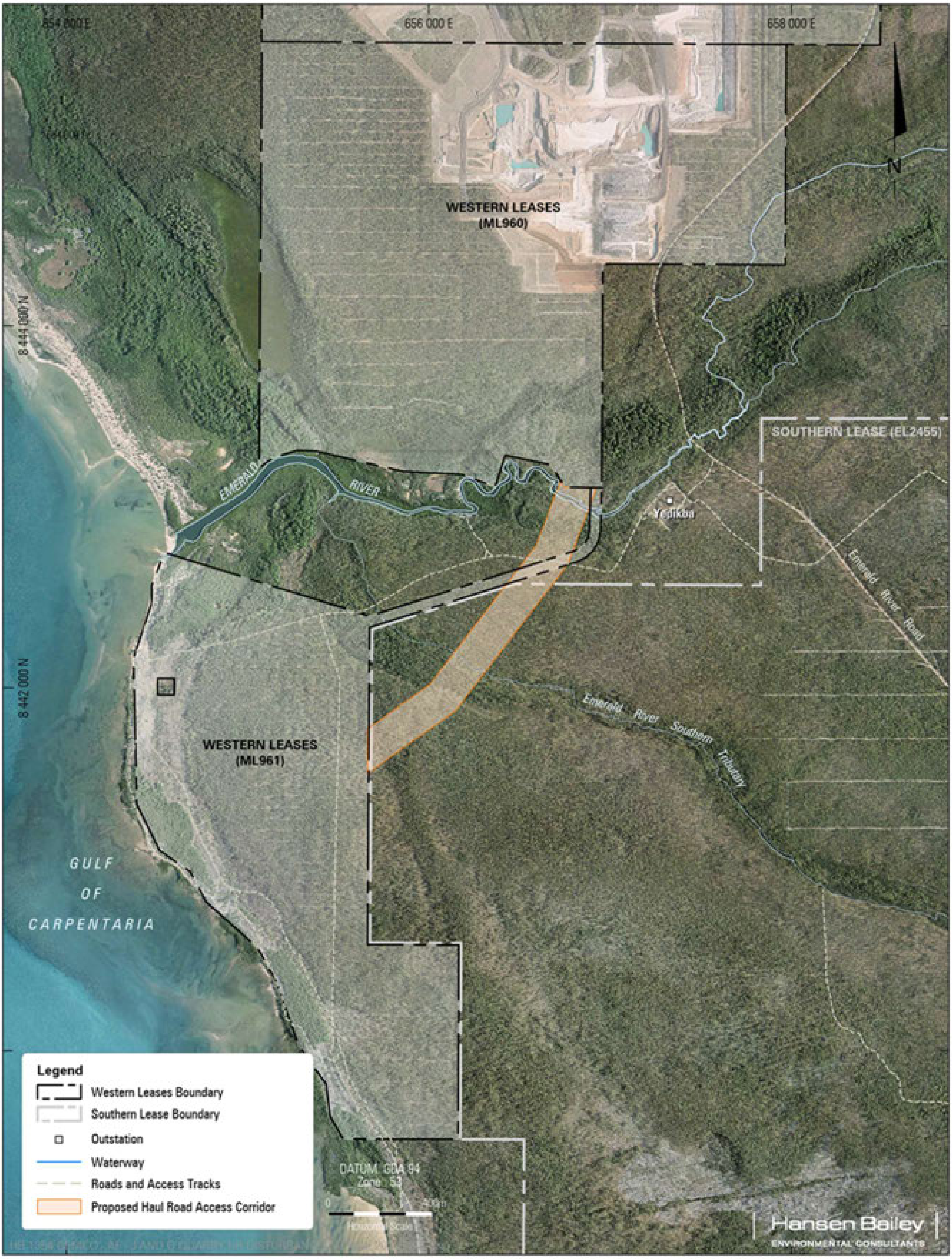

Figure 2: Location of Access Corridor

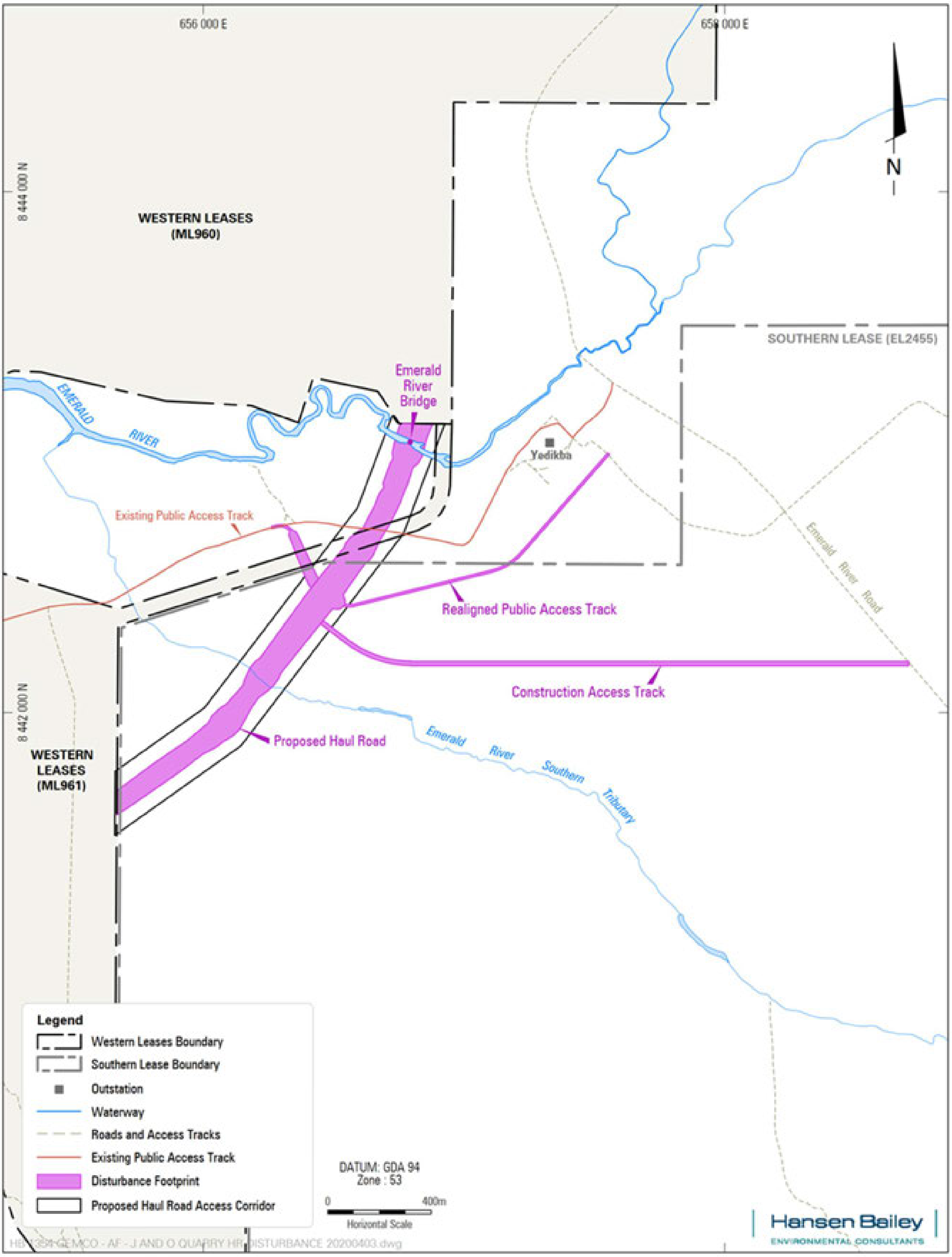

Figure 3: Project layout

2.0 Scope and methodology

The proposed J Quarry Haul Road (haul road) traverses the Emerald River and its tributaries, requiring a bridge, causeway and culvert crossings.

This report provides a hydrological and hydraulic assessment of existing catchment conditions and potential surface water impacts associated with the haul road.

The key scope of work for this assessment is summarised below:

- Development of RORB runoff-routing models for the Emerald River catchment to generate flood hydrographs for design storm events ranging from 50% Annual Exceedance Probability (AEP) to 1% AEP.
- Calibration of the RORB model to a Flood Frequency Analysis (FFA) conducted for the ER-GS-01 gauging station, which is located approximately 1km upstream of the proposed Emerald River bridge crossing.
- Development of TUFLOW hydraulic models to review flood characteristics of existing and design conditions using flood hydrographs derived from the calibrated RORB model.
- Assessment of potential surface water impacts associated with the haul road.

3.0 Catchment description

The Emerald River catchment has an area of approximately 96km^2 and is shown in **Figure 4**. Its headwaters are formed in the central area of Groote Eylandt where the catchment is generally covered by sparse vegetation and rock outcrops. As the river travels towards the western coastline, the topography flattens onto a wide alluvial floodplain, characterised by tributary inflows that feed a central meandering channel which outlets into the Gulf of Carpentaria. The floodplain is covered with dense vegetation including large mangrove areas and off-channel wetlands along the tidal reach. The estuarine reach of the Emerald River extends approximately 4km upstream of the outlet.

There are two major tributaries which contribute to the Emerald River, both on the southern side of the river. Tributary #1 has a catchment area of around 24km^2, which represents 25% of the total river catchment. It flows from east to southwest joining the Emerald River at approximately 1km upstream of the proposed bridge crossing. Tributary #2 (referred to as the 'Southern Tributary') has a catchment of approximately 19km^2 and flows in a north-westerly direction until its confluence with the Emerald River, approximately 1.5km downstream of the proposed bridge location, near the mouth of the river.

The project is located in the western part of the Emerald River catchment. The haul road transverses a wide floodplain zone crossing the Emerald River and Southern Tributary, approximately 3km upstream of the river mouth.

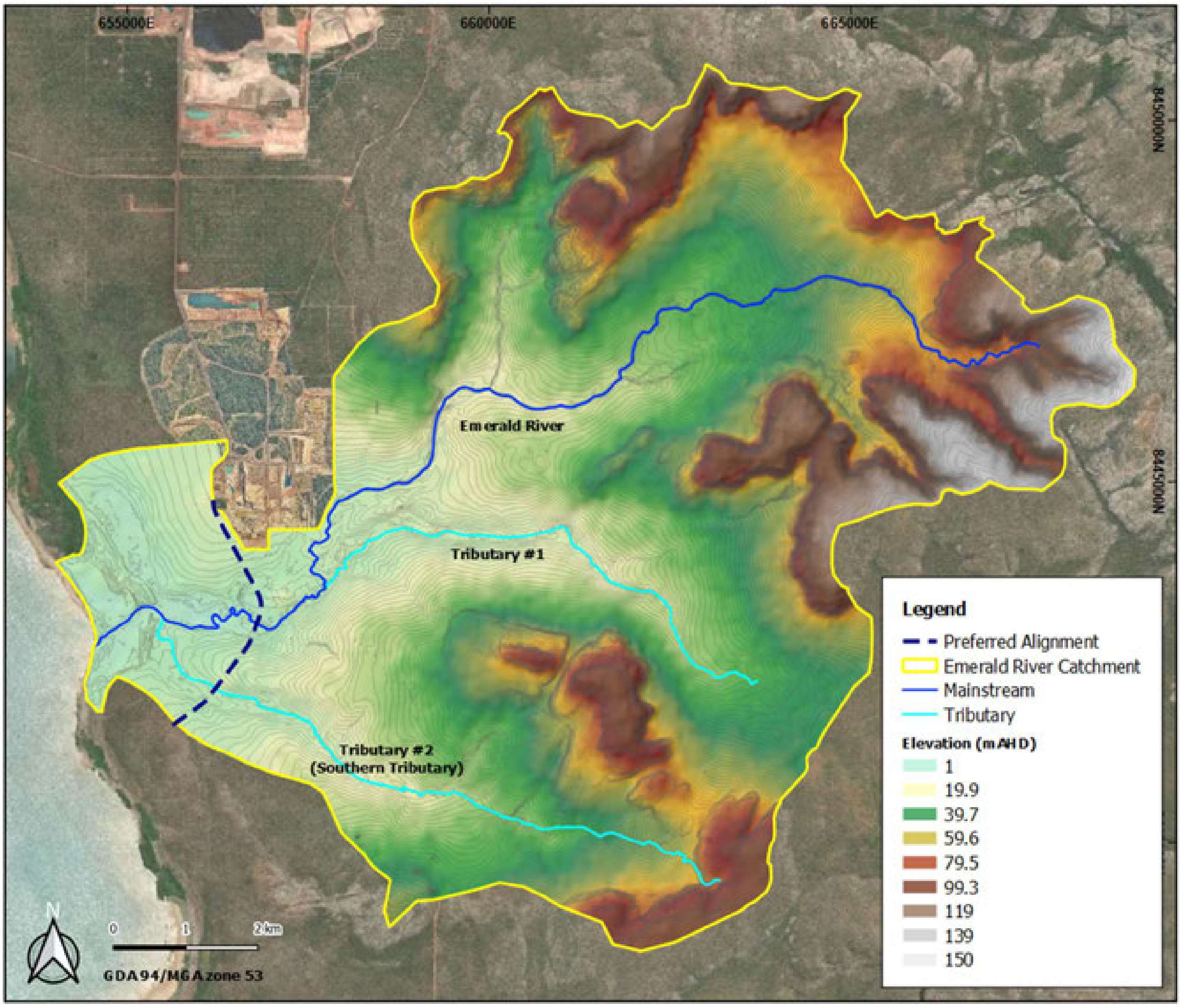

Figure 4: Study area

4.0 Flood exceedance probability

The latest edition of Australian Rainfall and Runoff (ARR) guideline (ARR 2019a) recommends the use of Annual Exceedance Probability (AEP) to describe the likelihood of a flood event. The AEP is defined as a percentage risk that that a specific flood event may occur in any one year. The use of the 1 in X year Average Recurrence Interval (ARI) flood terminology is discouraged in ARR, as it is not a direct conversion for frequent events in seasonal climates and leads to confusion with the public for rare events. The AEP and the equivalent ARI is summarized in **Table 1** below.

ARR describes the 50% and 20% AEP storms as being frequent events, the 5% and 2% AEP storms as rare events and the 10% AEP storm on the border of frequent and rare. This is illustrated in **Table 1**.

Table 1: Flood frequency descriptor

FREQUENCY DESCRIPTOR	AEP (%)	ARI (1 in X year)
Frequent	50	1.44
	20	4.48
Rare	10	10
	5	20
	2	50
Very Rare	1	100
	0.5	200
	0.2	500

This hydrological and hydraulic assessment focuses on storm events in the frequent (50% AEP) to rare (1% AEP) range in order to review potential impacts.

5.0 Hydrological assessment

5.1 RORB modelling

RORB software has been used to undertake hydrological modelling of the Emerald River catchment. RORB is a runoff and streamflow routing program that calculates flood hydrographs from rainfall depths. It uses a loss model to simulate the rainfall losses mainly caused by catchment storage and infiltration. Initial loss (IL) occurs in the beginning of the storm, prior to surface runoff. Continuing loss (CL) is the average rate of loss throughout the remainder of the storm. Losses are subtracted from rainfall to produce rainfall-excess for a catchment and routes the rainfall excess through channel storage to produce hydrographs (flow versus time) at points of interest.

The attenuation and translation effects of channel storage on runoff hydrographs is a function of catchment non-linearity, parameter ‘m’ (0.8 typically adopted), and parameter ‘Kc’ based on reach travel distance.

The model supports the 2016 version Australian Rainfall and Runoff guideline (ARR 2019a) and application of Bureau of Meteorology (BOM 2016) intensity-frequency-duration (IFD) design rainfalls.

5.2 Methodology

The general methodology adopted for hydrological assessment comprised:

1. Catchment delineation using a Geographic Information System (GIS) platform, defining drainage lines and contributing catchment areas with subsequent review based on aerial imagery and topographical contour data. Subsequent development of runoff-routing RORB models based on the delineated catchment characteristics.
2. Generation of design rainfall depths, temporal patterns, areal reduction factors, and losses from ARR online Data Hub (2019b) and BOM Design Rainfall Data System (2016).
3. Review of historical data.
4. Model calibration using FFA.
5. Running the RORB model for a range of storm events using the ensemble event approach described in ARR (2019a) to determine critical storm durations and representative rainfall temporal patterns.
6. Exporting of critical duration design hydrographs at selected locations.

5.3 Catchment delineation

Catchment datafiles were developed to define sub-catchment areas and reach lengths based on catchment delineation completed using the QGIS platform[1].

Datafiles were created for the following scenarios:

- **Existing condition:** based on the 2013 Lidar Digital Elevation Model (DEM) and the 2019 aerial photography.
- **Design condition:** the existing catchment delineation was revised to incorporate catchment boundaries formed by the haul road.

The catchment delineation and reach network for the existing scenario is presented in **Figure 5** with corresponding catchment areas summarised in **Table 2** below. The existing catchment delineation only required minor adjustment adjacent to the haul road to align with the proposed design.

[1] QGIS is an open-source, cross-platform, desktop geographic information system application, that supports viewing, editing, and analysis of geospatial data. The application is used internationally in academic and professional environments

Table 2: Sub-catchment areas

Sub-catchment	Area (km²)	Sub-catchment	Area (km²)	Sub-catchment	Area (km²)
C1	8.35	**C15**	2.7	**C29**	0.42
C2	3.11	**C16**	3.2	**C30**	0.35
C3	2.36	**C17**	1.35	**C31**	2.71
C4	5.16	**C18**	2.29	**C32**	0.62
C5	6.22	**C19**	0.44	**C33**	0.41
C6	1.76	**C20**	0.08	**C34**	0.46
C7	3.07	**C21**	0.77	**C35**	0.59
C8	7.49	**C22**	0.35	**C36**	0.81
C9	3.86	**C23**	0.75	**C37**	0.91
C10	11.01	**C24**	0.18	**C38**	0.44
C11	5.43	**C25**	2.04	**C39**	1.31
C12	9.18	**C26**	0.73	**C40**	1.67
C13	0.94	**C27**	0.57	**-**	-
C14	1.24	**C28**	0.34	**-**	-

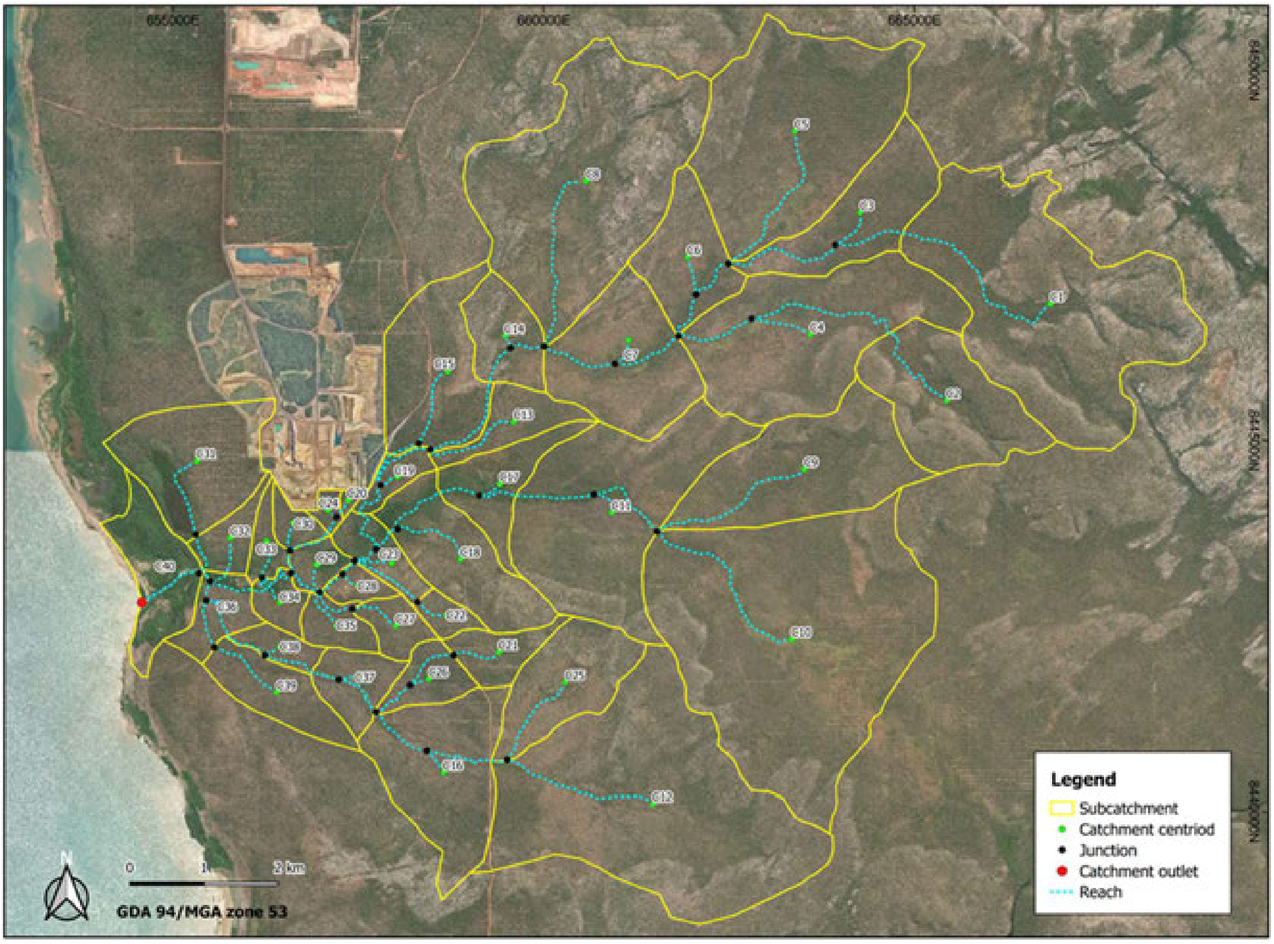

Figure 5: RORB catchment delineation: existing condition

5.4 *Design Rainfall Depths*

The spatial pattern of design rainfall depths across the catchment was reviewed using rainfall depth grids obtained from the BOM Design Rainfall Data System (2016). **Figure 6** illustrates the BOM design rainfall grid for the 1% AEP 12-hour storm event. As the spatial variation of rainfall depths over the study catchment was found to be negligible, a uniform spatial pattern was adopted for all design events.

Catchment averaged design rainfall depths were calculated for a range of storm event AEPs and durations. Results are summarised in **Table 3** below.

Table 3: Catchment averaged design rainfall depths (mm)

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
3 hours	81.9	36.9	128	144.4	165	179.8
6 hours	93.1	55.2	154	177	207.9	231
9 hours	99.5	76.6	170	199	237	268.2
12 hours	105.1	98.3	183.8	216.5	261.7	298.4
18 hours	114.5	110	206.3	245.6	301.5	347.5
24 hours	123.2	130	225.4	270.4	334.2	387.2
36 hours	139.4	141	258.2	311.5	386.8	449.2
48 hours	154.4	151	285.7	345.2	427.8	495.8
72 hours	180.4	167	330	396.5	487.6	560.8

The calculated catchment averaged rainfall depths shown in **Table 3** relate to specific points in a catchment rather than the whole catchment area. For flood estimation of catchments larger than 1km^2 in area, the point design rainfall depth needs to be multiplied by an Area Reduction Factor (ARF). In RORB, the ARFs were calculated using the built-in ARF equations (ARR 2019a) and the ARF parameters obtained from the ARR Data Hub (2019b). The resulting design rainfall depths were applied uniformly over the catchment.

Temporal patterns are used to distribute the design rainfall depth over time. For catchments larger than 75km^2, ARR (2019a) recommends use of areal temporal patterns. As the areal temporal patterns obtained from the ARR Data Hub (2019b) are only available for storm durations longer than 12 hours, ARR Data Hub (2019a) point rainfall temporal patterns were applied for shorter duration storm events. Ten temporal patterns were run for each duration. The median flow results were then compared to determine the critical storm duration.

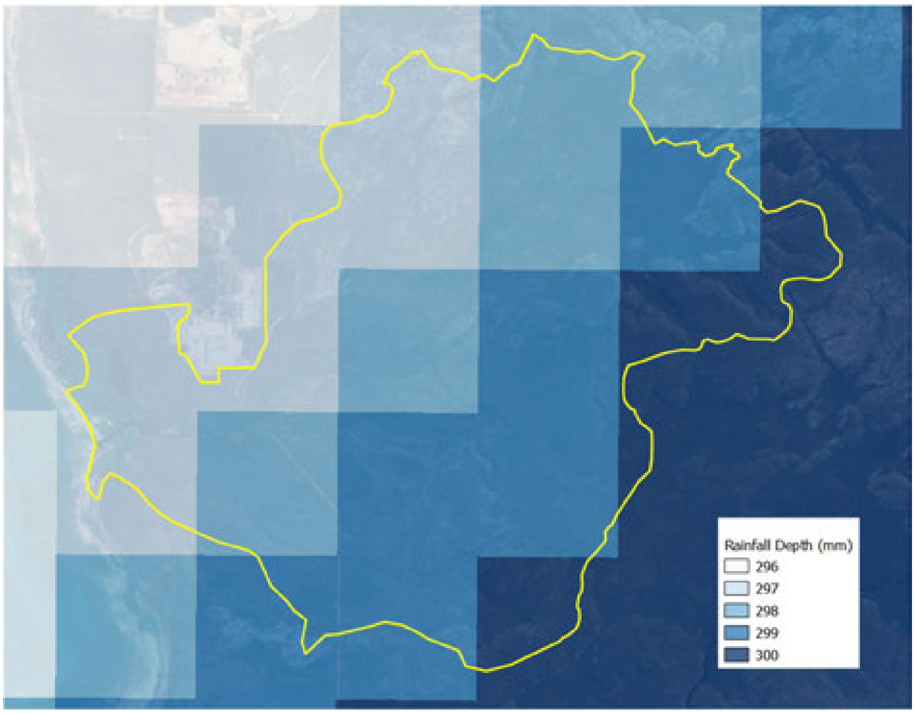

Figure 6: BOM design rainfall grid for 1% AEP 12 hours storm

5.5 Review of historical data

Available rainfall and stream flow gauging data was reviewed to assess its suitability for calibration purposes. Calibration involves the correlation of both sub-daily rainfall data that reflects the temporal distribution of rainfall over the period of a storm event as well as stream flow data as a result of the event.

Table 4 below summarizes the available rainfall data collected from the BOM Groote Eylandt Airport weather station (014518) and the Automatic Weather Stations located within the study catchment. The locations of the AWS rain gauges (owned by GEMCO) within the study catchment are shown in **Figure 7** below.

Table 4: Available rainfall data

Gauge name	Period	Data Intervals
AWS-ER-01	2018 Aug - 2019 Jun	5 minutes interval
AWS-ER-02	2018 Aug - 2019 Jun	5 minutes interval
AWS-ER-03	2018 Aug - 2019 Jun	5 minutes interval
AWS-WL-07	2017 Oct - 2019 Jun	5 minutes interval
BOM Groote Eylandt Airport (014518)	2015 Jun - 2019 Jun	10 minutes interval
	1999 - 2019	Daily

Stream flow data was available at two gauging stations located in the Emerald river catchment. **Figure 7** below shows the location of the two gauging stations and their upstream catchments.

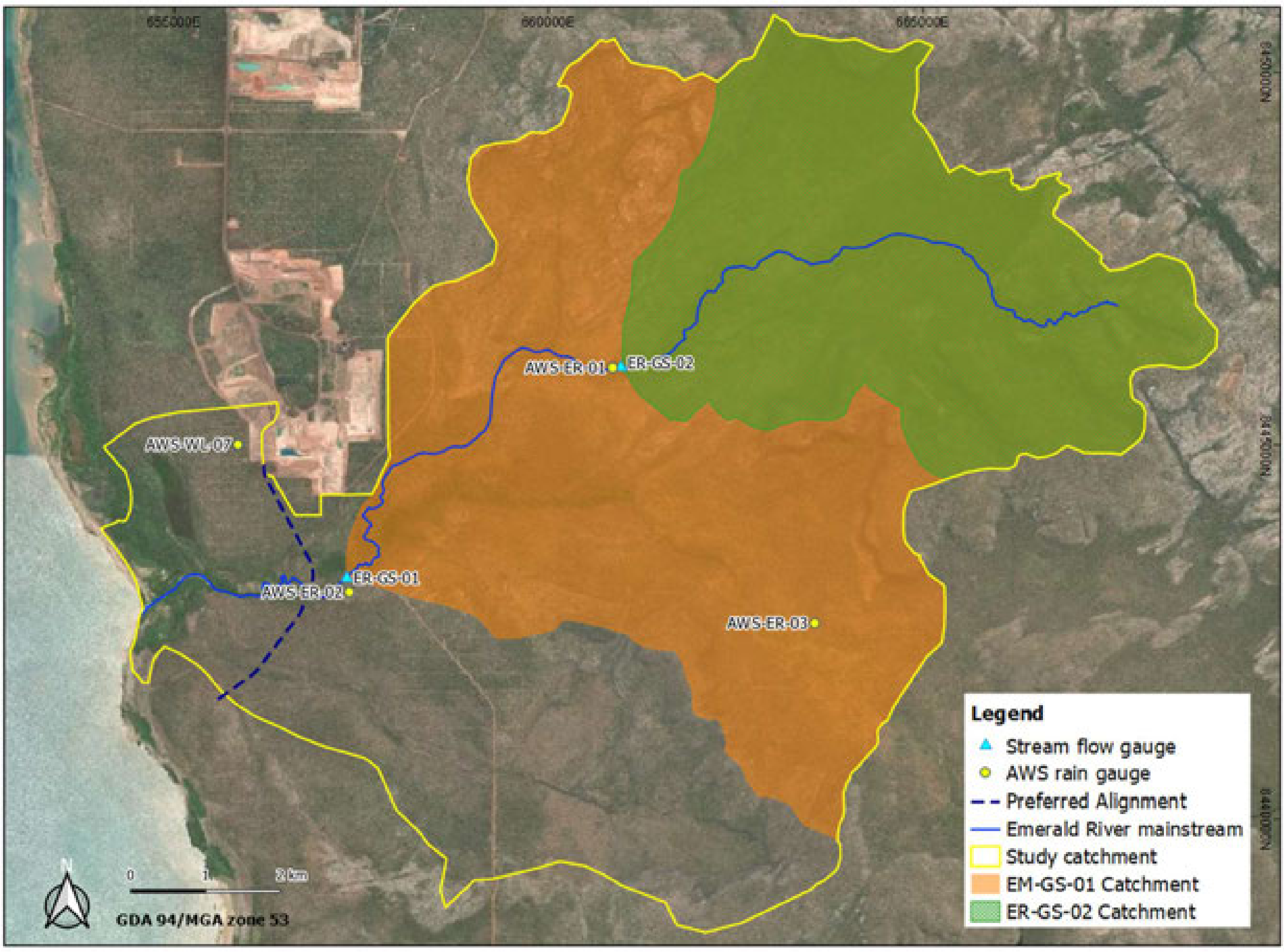

Figure 7: Gauge locality

The ER-GS-02 gauging station is located within the upper reaches of the Emerald River main channel and has an upstream catchment area of approximately 28km^2. Data was collected by this gauge from 17/07/2015 to 27/12/2018. This data is not used in this assessment as this gauging station is located within the ephemeral reaches of the Emerald River main channel and is not considered to be representative of the perennial downstream reaches where the bridge crossing is located.

The ER-GS-01 (originally named as G9290211 Old BHP Camp) is located approximately 200m downstream of the existing Emerald River bridge. The gauging station was installed by the NT Government in 1969 but decommissioned in 1988. The data collected during this period is shown in **Figure 8**. The hydrograph shows that peak flows were artificially capped at 7.3m^3/s as the measured water level exceeds the limit of the rating curve.

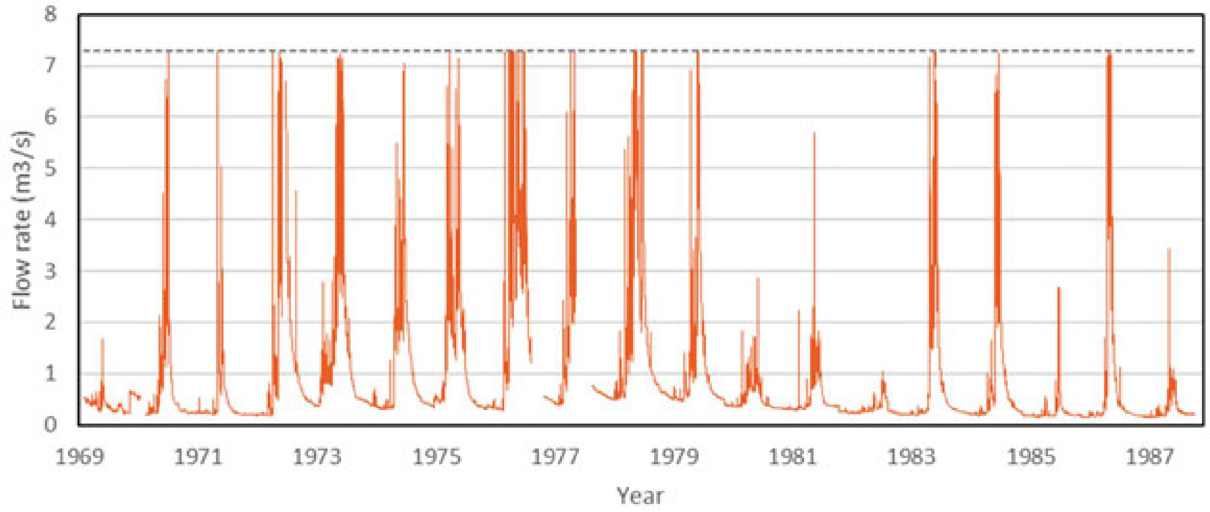

Figure 8: ER-GS-01 (originally G9290211) gauged flow rates from 22/11/1969 to 26/07/1988

The ER-GS-01 gauging station was upgraded and recommissioned by GEMCO in 2016. The data collected between 03/06/2016 and 04/06/2019 was made available for this study. The recorded flow data is presented in **Figure 9** and shows that only small/frequent bank-full flows have been recorded and not larger events.

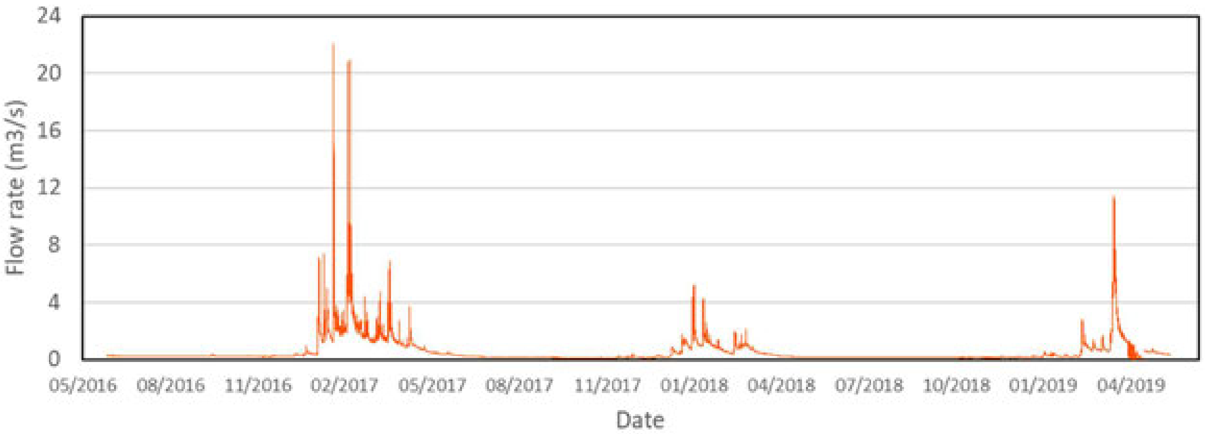

Figure 9: ER-GS-01 (Recommissioned) gauged flow rates from 03/06/2016 to 04/06/2019

Figure 10 presents a photo of a recent bank-full event (7th April 2019) immediately downstream of the existing Emerald River Road bridge crossing. The discharge record at the ER-GS-01 shows this bank-full event has a peak discharge of 11.44m^3/s which is close to the peak discharge of a 50% AEP event as determined in the FFA assessment, as described in **Section 5.6.2.**

Although the discharges recorded at ER-GS-01 between 22/11/1969 to 26/07/1988 was capped due to the limited NT Government rating curve, the recorded water levels at this gauge are complete. An extended rating curve has been developed to convert the recorded water levels to discharges. The redeveloped discharge time series between 22/11/1969 to 26/07/1988 combined with the discharge time series recorded by the recommissioned gauge between 03/06/2016 to 04/06/2019 has been used to inform a FFA assessment as described in **Section 5.6.2**.

Figure 10: Bank-full flow downstream of the existing Emerald River Road bridge (07 April 2019)

5.6 Model Calibration

Calibration of the RORB model was attempted using ER-GS-01 (G9290211) gauge data via the following approaches:

- Parameter calibration based on frequent flow hydrographs; and
- Flood frequency analysis based on an extended rating curve.

5.6.1 Calibration of frequent events

The largest two recent events recorded at gauge ER-GS-01 (G9290211) were selected for calibration. The first was from the 22/01/2017 to 25/01/2017 and the second from the 6/02/2017 to 7/02/2017. The AEP of the two calibration events is estimated to be between 50% to 20% AEP based on the comparison of their peak discharges to the FFA assessment results detailed in **Section 5.6.2**. The rainfall data that coincided with the selected calibration events was extracted from the Groote Eylandt Airport weather station approximately 12km north of the river gauge. The calibration event hydrographs and the coincident rainfall data are indicated in **Figure 11** and **Figure 12** below.

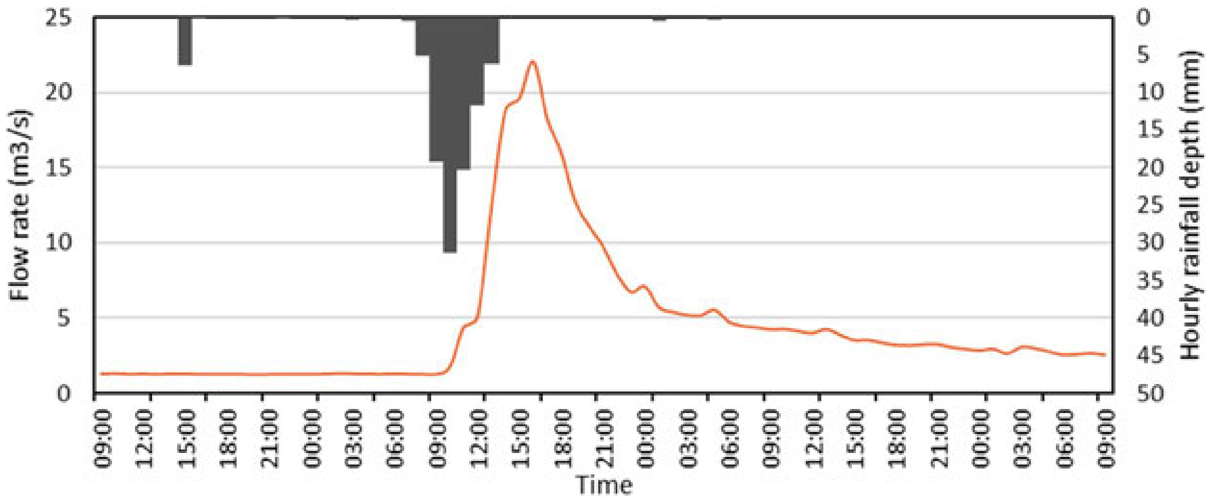

Figure 11: Calibration event 1: 22/01/2017 (09:00) to 25/01/2017 (09:00)

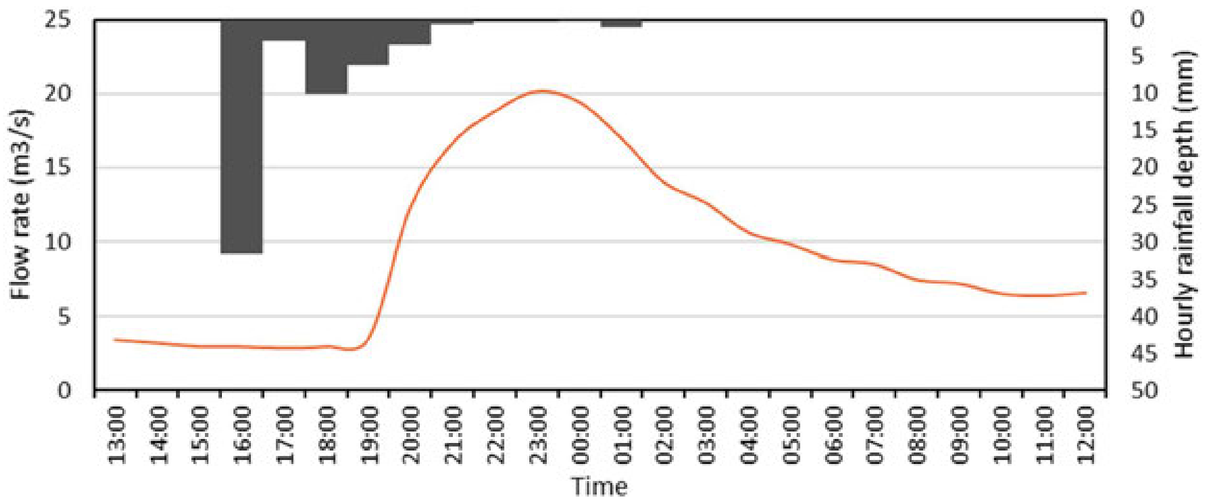

Figure 12: Calibration event 2: 6/02/2017 (13:00) to 7/02/2017 (12:00)

The following calibration approach was adopted:

1. The baseflow was estimated and removed from the historical hydrograph using the Lyne and Hollick methodology documented in ARR Project & Report (ARR 2009). The historical flow measured by gauging stations comprises quick flow (runoff generated during storm event) and baseflow (caused by groundwater flow recharging into stream channels). As the RORB model only simulates quick flow, removal of the baseflow provides a more accurate result.

2. A storm file containing the historical rainfall data was developed and used as the rainfall input of the RORB model. The historical hydrographs of the calibration events were assigned to the model node matching the gauge location.

3. In a "fit run" simulation, Kc and initial losses (IL) were manually entered, while the continuing loss (CL) values were internally adjusted by the program to match the simulated hydrograph to the historical hydrograph.

The Kc value was initially estimated using empirical equations and the IL was set to the value obtained from ARR Data Hub (2019b). The Kc and IL values were tuned until the best match was achieved between the simulated and the historical hydrographs for each event.

The calibrated parameter values for the two calibration events are shown in **Table 5** below. Plots of recorded versus predicted discharge for the two calibration events are presented in **Figure 13** and **Figure 14**.

Table 5: RORB calibration result

Event	Calibrated parameters			Errors between calculated and gauged hydrographs		
	Kc	IL (mm)	CL (mm/hr)	Peak flow rate	Time to peak	Flow volume
Event 1	10.81	40	17.31	-1%	0	-0.2%
Event 2	10.81	30	4.36	-9.7%	0	-5.5%

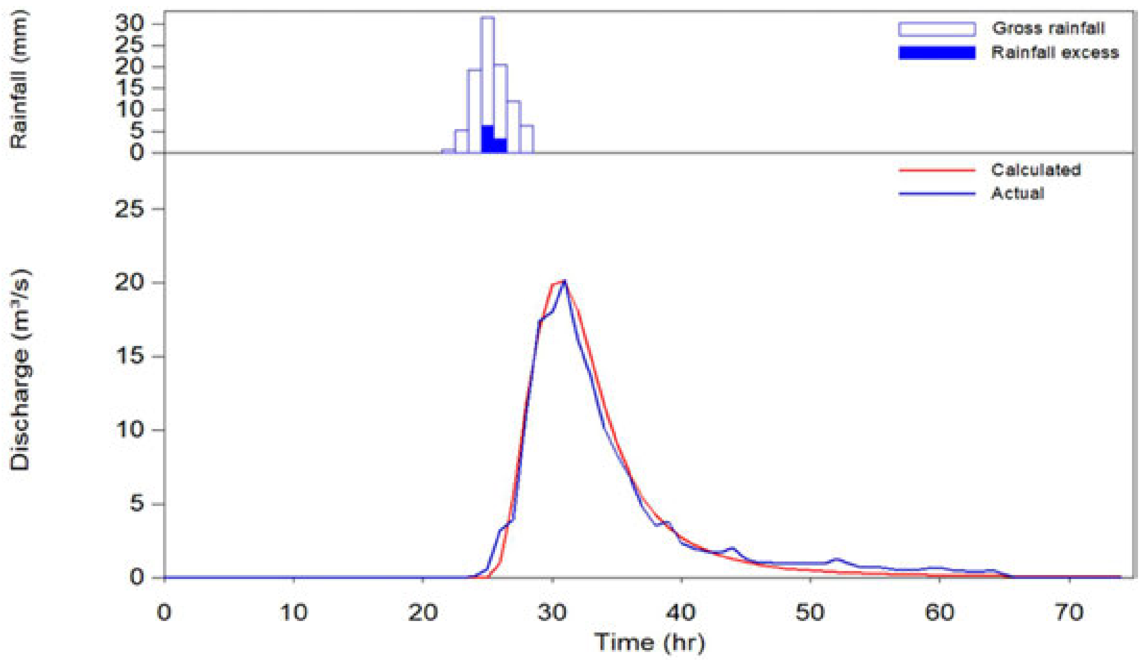

Figure 13: Recorded versus predicted discharge for event 1

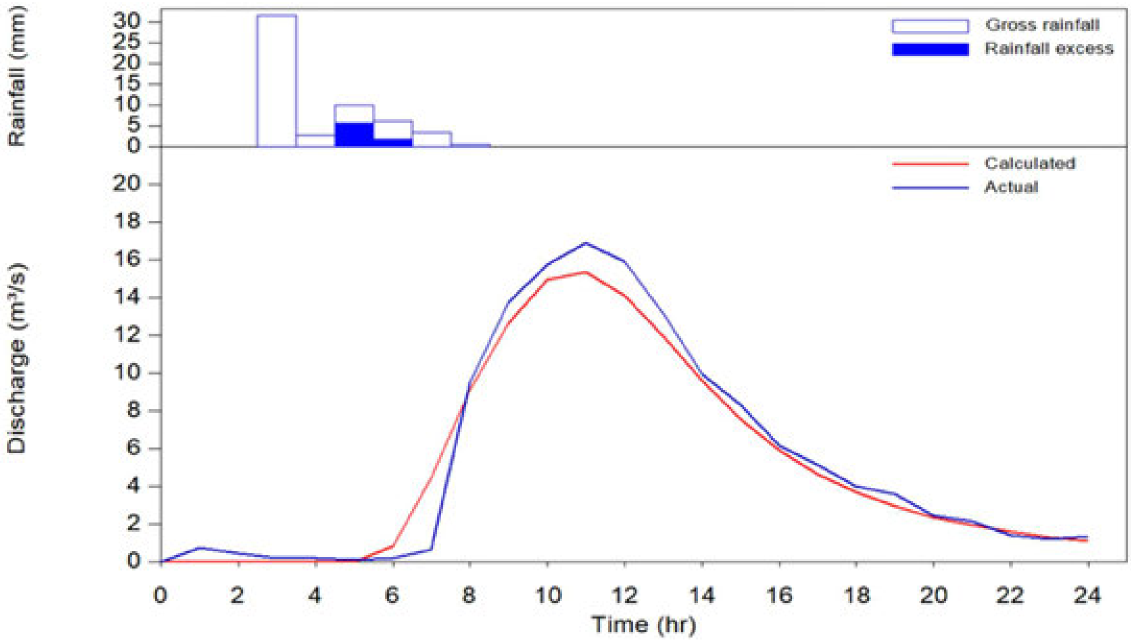

Figure 14: Recorded versus predicted discharge for event 2

Results show a good fit in the timing of the flow peaks, indicating the routing parameter Kc estimated using an empirical equation (Dyer et al. 1994) is reasonable for the Emerald River catchment. Although peak flow rates and volumes fit for the individual events, the fitted CL (17.31mm/hour) for event 1 is very high and significantly different to the fitted CL (4.36mm/hour) for event 2. The difference between the two CL values could be attributed to the adopted rainfall being inconsistent with the catchment rainfall or the catchment characteristics being very complex. As these discrepancies can't be resolved with the limited rainfall and gauging record, the calibration rainfall losses are not considered reliable and have not been incorporated into the design RORB model.

5.6.2 Flood Frequency Analysis (FFA)

The 24 years (22/11/1969 to 26/07/1988 and 03/06/2016 to 04/06/2019) of data collected by the ER-GS-01 was used to undertake an FFA. The gauged discharges from 22/11/1969 to 26/07/1988 were artificially capped at 7.3m^3/s due to the limited NT Government rating curve. Although a new rating curve was developed by Sentinel in 2015 (Sentinel 2015) and covers a larger range of water levels, the upper limit of the new rating curve is still below some historical water levels. A TUFLOW rating curve model has therefore been developed to extend the Sentinel rating curve. The extended rating curve translates the historical water levels to discharges which are used for conducting the FFA.

Historical rating curves

Sentinel updated the old NT Government gauging station in 2015. According to the gauging station installation report (Sentinel 2015), a new system was installed and calibrated to the original datum from the old Government gauging station. During the installation of the system, a longitudinal and cross section survey was undertaken to determine the slope of the Emerald River in the area of the control. Sentinel then used PC Convey software to generate a theoretical rating using Manning's equation. A roughness coefficient of 0.045 was assumed. The Sentinel rating curve is presented in **Figure 15** below.

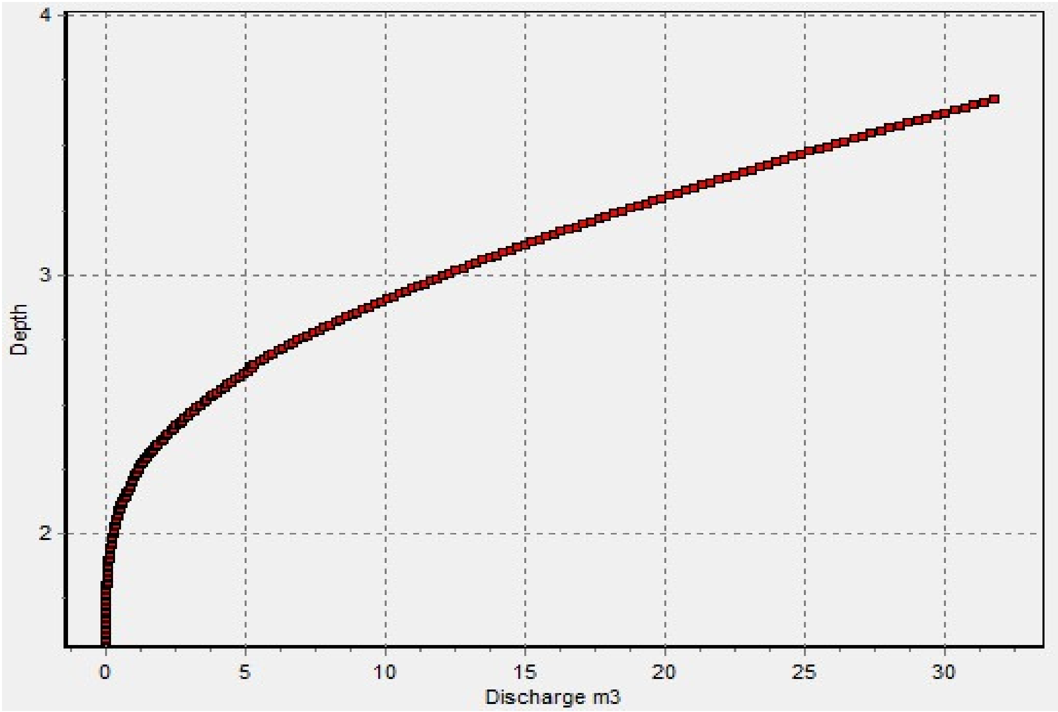

Figure 15: Sentinel rating curve (Sentinel 2015)

Rating curve development

The TUFLOW model developed for the Emerald River catchment (described in **Section 6.3**) was modified to extend the rating curve at the ER-GS-01 gauging station location. A single inflow boundary was assigned to the upstream boundary of model mesh. A gradually increasing inflow was applied to reproduce near steady-state flow conditions. Discharges through channel, and floodplain and water levels at the gauging station location was calculated and used to derive a rating curve. **Figure 16** below shows a comparison of the extended TUFLOW derived rating curve compared to the Sentinel rating curve.

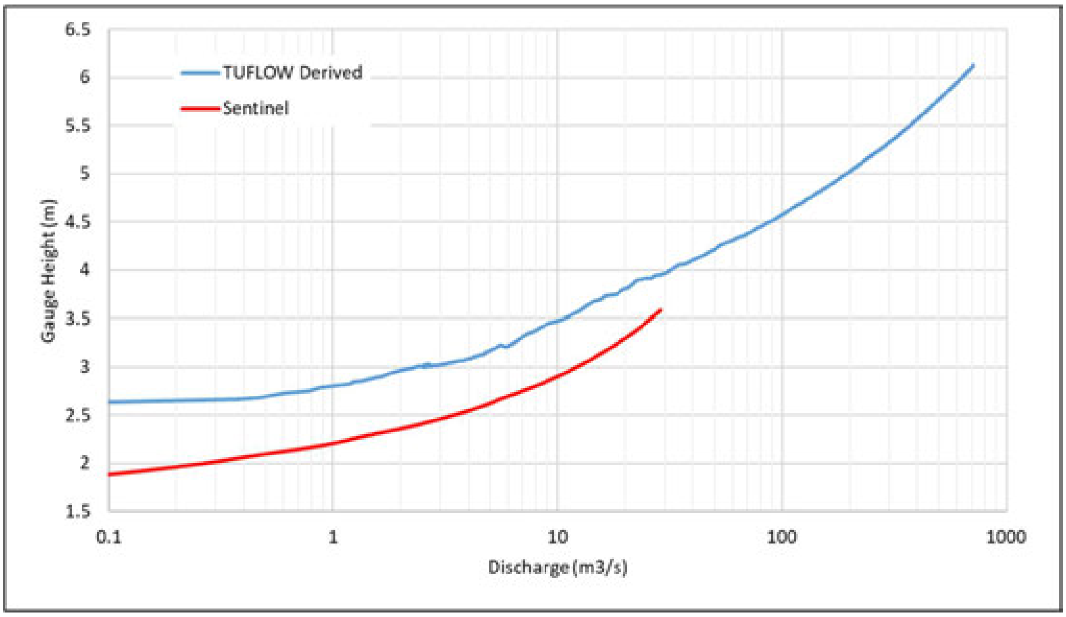

Figure 16: Comparison of TUFLOW derived rating curve to Sentinel rating curve

Comparison of the TUFLOW derived rating curve to the Sentinel rating curve, shows approximately 0.5m elevation discrepancy in the datum, with the datum of the Sentinel rating curve higher than the datum of the TUFLOW rating curve, which was based on the 2019 bathymetry survey. The datum of the TUFLOW rating curve was therefore adjusted based on comparison of the two river cross sections.

Figure 17 below shows the comparison between the adjusted TUFLOW rating curve and the Sentinel rating curve with the extrapolation of the Sentinel rating curve. The comparison shows the TUFLOW rating curve is more conservative as it results in higher discharges than the Sentinel rating curve for water levels higher than 3.6m. Therefore, the Sentinel rating curve was adopted for gauged levels lower than 3.6m and the adjusted TUFLOW rating curve was adopted for water levels above 3.6m, in order to produce the highest or most conservative discharges for a given water level. The extended rating curve is presented in **Figure 17** below.

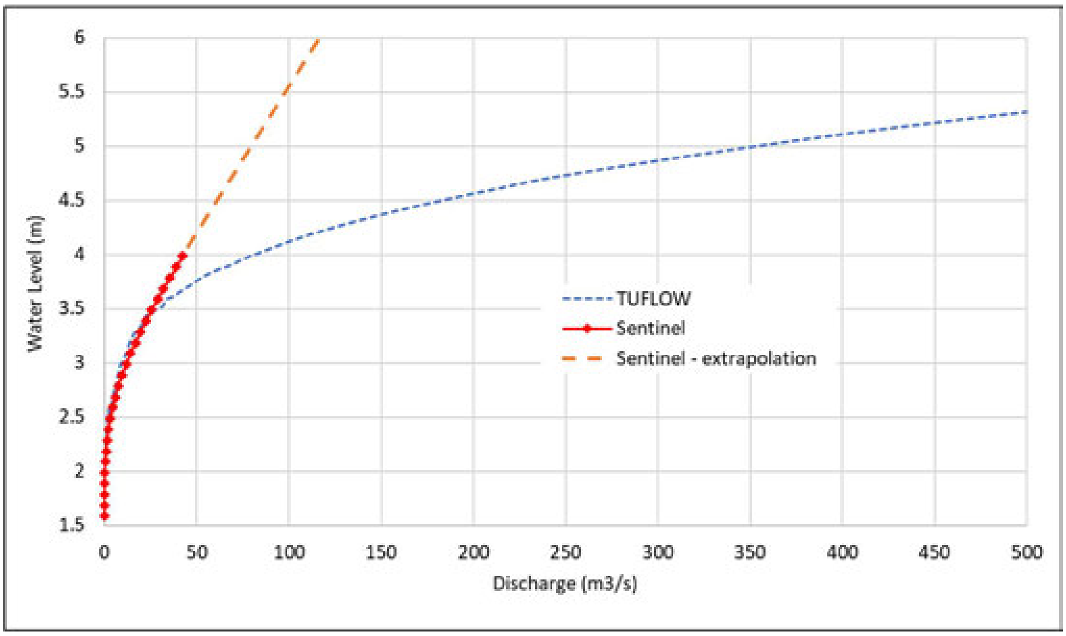

Figure 17: Extended rating curve

The recorded water levels between 22/11/1969 to 26/07/1988 were converted to discharges using the extended rating curve. The FFA was conducted using TUFLOW FLIKE, fitting the annual peak discharges to a Log Pearson Type III distribution using the Bayesian methodology as recommended by ARR (ARR 2019c). The fitted distribution is shown in **Figure 18**. It should be noted that the peak discharges of year 1969 and 2016 were not included in the dataset as there are only November and December records in 1969 and no readings in 2016. **Table 6** below presents the summary of the FFA quantile peak results and the corresponding 10% and 90% confidence limits.

Table 6: Flow comparisons of RORB design peak flows to FFA estimates

AEP	FFA expected parameter quantile peak flow (m3/s)	10%, 90% confidence limits
50%	11	(5, 22)
20%	54	(25, 135)
10%	131	(53, 447)
5%	283	(96, 1392)
2%	694	(182, 6158)

1%	1289	(269, 17909)

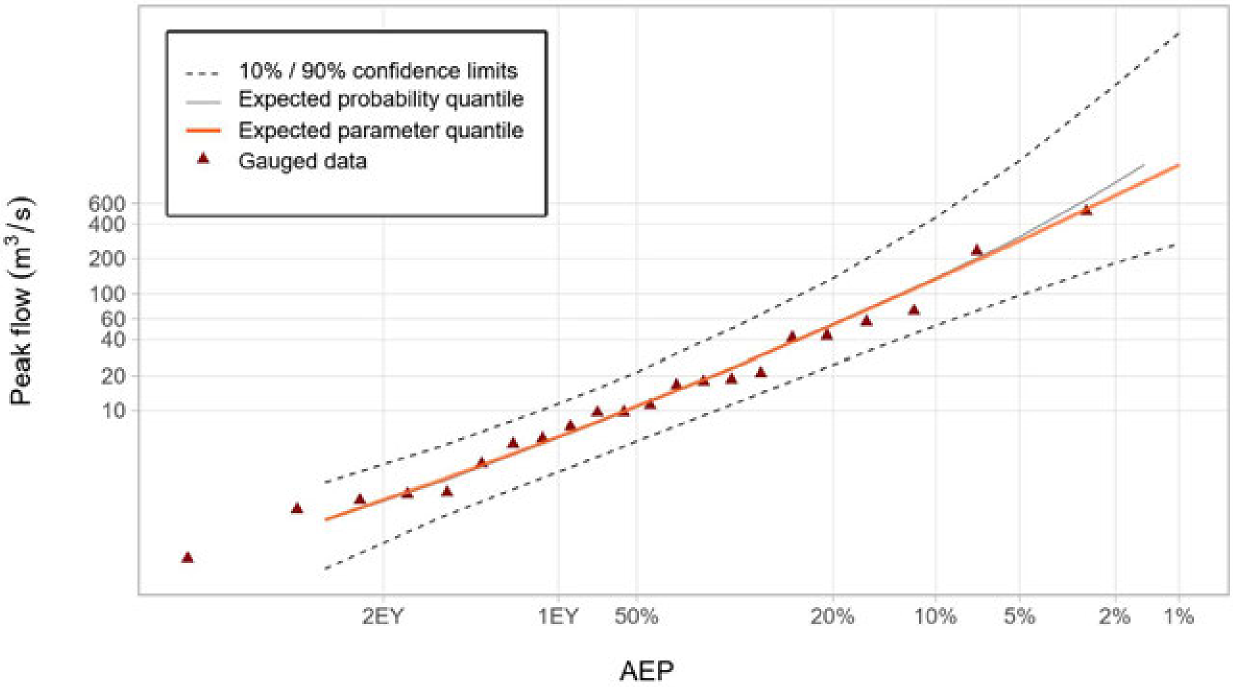

Figure 18: Flow comparison between FFA and RORB results

FFA results indicate that peak flow estimates may not be reliable for events less frequent than a 10% AEP event due to large confidence limits. Hence, only the FFA estimates for 50%, 20% and 10% AEP events were considered for calibration of the hydrological model.

5.6.3 Initial Loss (IL) and Continuing Loss (CL)

The 50%, 20% and 10% AEP event peak flow rates were calibrated to the FFA quantile estimates by adjusting ILs. For the 5%, 2% and 1% AEP events, use of the ARR regional IL parameters were maintained. The ARR regional CL of 0.8mm/hr was adopted for all design events. The 0.8mm/hr CL is relatively low however the catchment is characterised by large areas of rocky outcrops and inferred low permeability clayey subsoils which potentially limit CLs. The adopted RORB parameter values are summarised in **Table 7** below.

Table 7: Adopted RORB parameters for design event hydrograph simulation

<table>
<tr><th>AEP</th><th>IL (mm)</th><th>CL (mm/hr)</th><th>m</th><th>Kc</th></tr>
<tr><td>50%</td><td>92</td><td>0.8</td><td rowspan="4">0.8</td><td rowspan="4">10.81</td></tr>
<tr><td>20%</td><td>120</td><td>0.8</td></tr>
<tr><td>10%</td><td>122</td><td>0.8</td></tr>
<tr><td>5%, 2% and 1%</td><td>28</td><td>0.8</td></tr>
</table>

5.6.4 Parameter m and Kc

The parameter 'm' is a measure of the catchment's nonlinearity, and a value of unity implies a linear catchment. An 'm' value of 0.8 was adopted as recommended by ARR (2019b) for catchments without robust calibration.

The Kc value is usually determined via calibration. However, as the original recorded hydrograph data is limited, the Kc value was estimated by the empirical equation for Australian catchments (Dyer et al. 1994):

$$Kc = 1.14 \times Dav$$

The factor Dav is the mean catchment travel distance (km) calculated from the catchment datafile. The above RORB model calibration shows the Kc value (10.81) estimated using the empirical equation is a reasonable representation of the catchment runoff-routing characterises. This Kc value is adopted for all catchment scenarios.

5.6.5 Regional flood frequency estimation

ARR (2019a) suggests that Regional Flood Frequency Estimation (RFFE) can provide an alternate method of model validation for peak flow estimates for small to medium size catchments. This transfers flood frequency characteristics from a group of gauged catchments to the location of interest. However, the Groote Eylandt area does not lie within the group of catchments on which the ARR online RFFE tool was developed and hence was not considered appropriate for validation purposes.

5.7 Hydrological modelling results

RORB simulations were run using 10 different rainfall temporal patterns for each design event and catchment scenario. Review of the simulated peak flows at the proposed bridge location indicates that the critical duration is 12 hours for all event frequencies and catchment scenarios. The predicted peak flow rates at the proposed bridge crossing are summarised in **Table 8**.

Table 8: Critical duration median peak flows at the proposed bridge crossing

	Median Peak Flows (m^3/s)					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Existing condition	12	54	127	462	594	684
Design condition	12	54	127	465	592	683

6.0 Hydraulic modelling

6.1 General

Hydraulic modelling has been undertaken to review flood characteristics of existing conditions and allow subsequent review of potential surface water impacts at the proposed Emerald River and Southern Tributary crossings shown in **Figure 19** below.

The following sections provide an overview of methodology and results of the assessment.

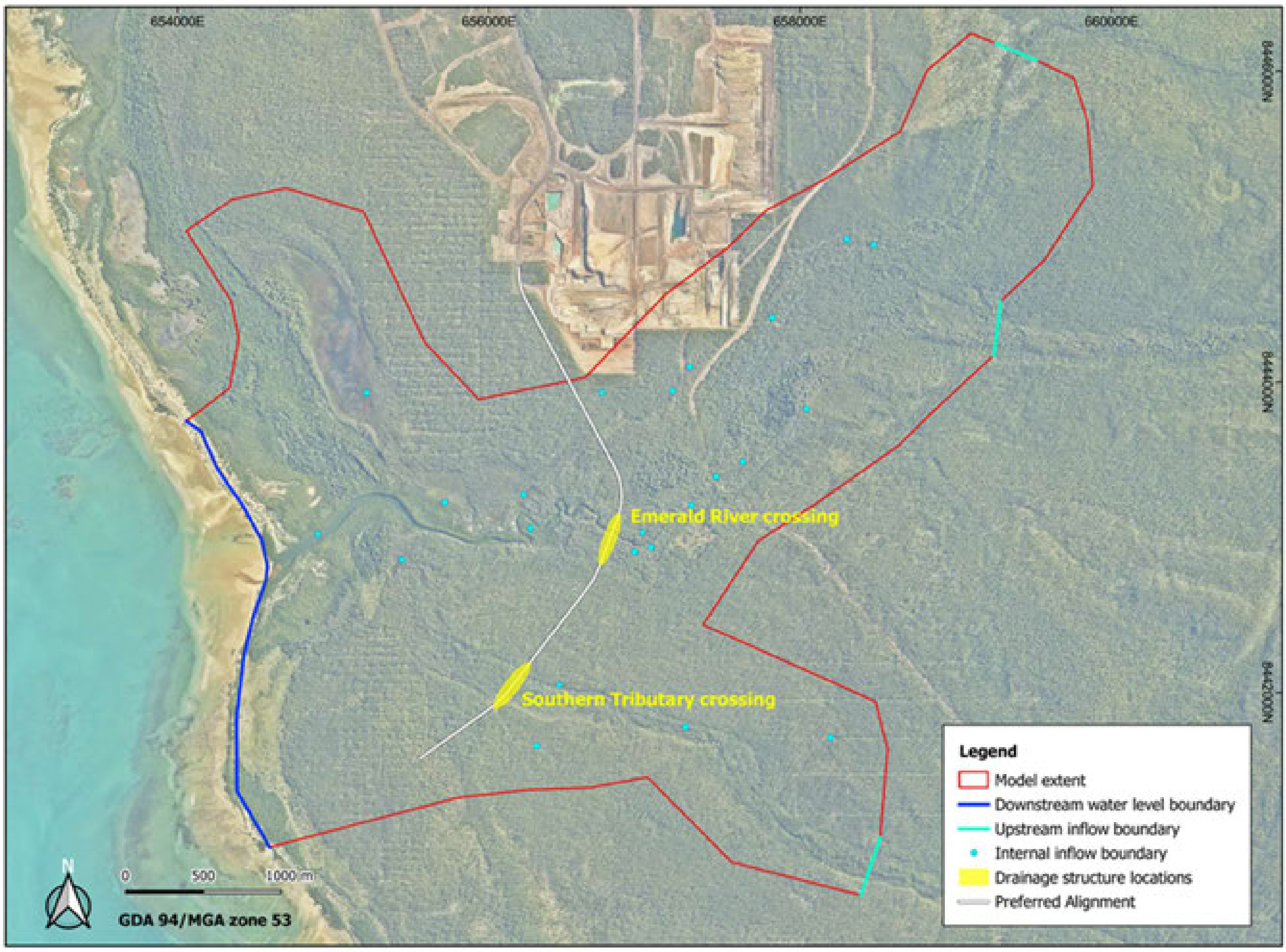

Figure 19: General TUFLOW model layout

6.2 Methodology

TUFLOW software was used to develop a number of hydraulic models. TUFLOW is a computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions of the free-surface flow equations to simulate flood and tidal wave propagation. Hydraulic models were created for the following scenarios and run for various flood events using design hydrographs developed in RORB:

1. **Existing condition model** used to confirm locations requiring cross-drainage structures and used as the baseline for impact assessment of the haul road.

2. **Design condition model** used to assess the impact of the haul road on the flooding behaviour in the Emerald River and Emerald River Southern Tributary.

6.3 TUFLOW model set-up

6.3.1 Model extent

The hydraulic model was developed to cover the tidal reach section of the Emerald River and the Southern Tributary, extending to the river outlet into the Gulf of Carpentaria. The mesh boundary extends more than 3km upstream from the proposed Emerald River bridge to provide enough distance for the model to stabilise before inflows reach the locations of interest.

6.3.2 Elevation data

The hydraulic model uses a Digital Elevation Model (DEM) which is made up of 6m x 6m square grid elements containing ground elevations sampled from the 2013 Lidar DEM at 3m spacing.

Detailed survey along the preferred haul road alignment and a bathymetry survey of the Emerald River at the proposed bridge location was completed in October/November 2019. The survey data was processed into a DEM and merged with the existing 2013 Lidar DEM to create an updated surface for the TUFLOW hydraulic model. As the bathymetry survey only covers 500m upstream and downstream of the proposed bridge location, the bathymetry of the remaining Emerald River downstream was extrapolated from the supplied bathymetry at the proposed bridge location.

The 2013 DEM omits the Emerald River Road located to the east of the proposed bridge location (**Figure 2**). The road currently acts as a flood levee, hence, to reflect the impact of the road/levee on flood behaviour, the DEM was modified to include an infinitely high wall preventing flood water flowing further east of the road.

6.3.3 Boundary conditions

6.3.3.1 Upstream boundary condition

Design hydrographs derived from the RORB model were added to the hydraulic model at selected inflow locations at the upstream mesh boundary and within the mesh. The boundary conditions at the upstream mesh boundary were used to add inflow from the upper catchments of the Emerald River. The inner boundary conditions were used to add sub-catchment hydrographs directly to the locations of sub-catchment outlets and culvert inlets.

6.3.3.2 Downstream boundary condition

The haul road traverses through the lower reaches of the Emerald River and is subject to both tidal and storm influences which impact the water level at the outlet of Emerald River into the Gulf of Carpentaria. Flood water elevations and velocities are dependent on these downstream water levels, referred to as 'tailwater' levels.

The following tailwater levels are typically considered:

- Mean high/low water springs (MHWS/MLWS) - this is the long-term mean of the heights of two successive high/low waters during those periods when the range of tide is greatest during the full and new moon (approximately once a fortnight).
- Highest astronomical tide (HAT) – this is the highest expected tide level which occurs theoretically once every 19 years, although at some sites may occur several times per year.
- Storm tide – this is the atmospherically forced ocean response caused by high surface winds and low surface pressures associated with severe and/or persistent offshore storm events.

Consideration of the probability of tailwater coincidence with an Emerald River design flood event was undertaken via the assessment of the combinations summarised in **Table 9** below.

Table 9: Coincident tailwater levels

Design flood event	Coincident tailwater level (m AHD)	Comment
50% to 5% AEP	Limiting low water level – 1m	A limiting low water level has been adopted to assess both high and low tailwater levels as existing sand dunes at the outlet of Emerald River appear to restrict low water levels to approximately 1m. It is noted that HAT is estimated to be 1.1m AHD.
2% to 1% AEP	Storm tide (2% AEP) – 2.0m Storm tide (1% AEP) – 2.2m	High tailwater level assessment based on storm tide levels incorporating projected climate change impacts to 2050 sourced from GHD 2013 'Report for Gulf of Carpentaria Storm Tide and Inundation Study'.

6.3.4 Model roughness

The hydraulic roughness of the model surface is commonly represented using Manning's n values. The study catchment was separated into several land-use type areas based on aerial photography, and a unique Manning's n value was assigned to each land-use type based on previous modelling experience and literature values (Chow 1959). The land-use type and associated Manning's n values are summarised in **Table 10**.

Table 10: Land use types and Manning's n values

Land-use type	Manning's n value
Channel	0.04
Dense vegetation	0.08
Ponds and other open water surface	0.03
Roads	0.03
Unassigned areas (pasture and less dense vegetation)	0.06

6.3.5 Hydraulic Structures

The proposed Emerald River crossing incorporates a 36m bridge with a 90m causeway on the lower section of the floodplain to the south of the bridge.

The Southern Tributary crossing comprises a set of 1.2m x 1.2m box culvert (7 cells) across the main stream channel and a set of 1.3m CSP culvert (6 pipes) in the lower section of the floodplain south of the main channel with a 100m causeway between the two sets of culverts.

The proposed structures are shown in **Figure 20** below**.** A rendered image showing the Emerald River bridge and causeway is presented in **Figure 21.**

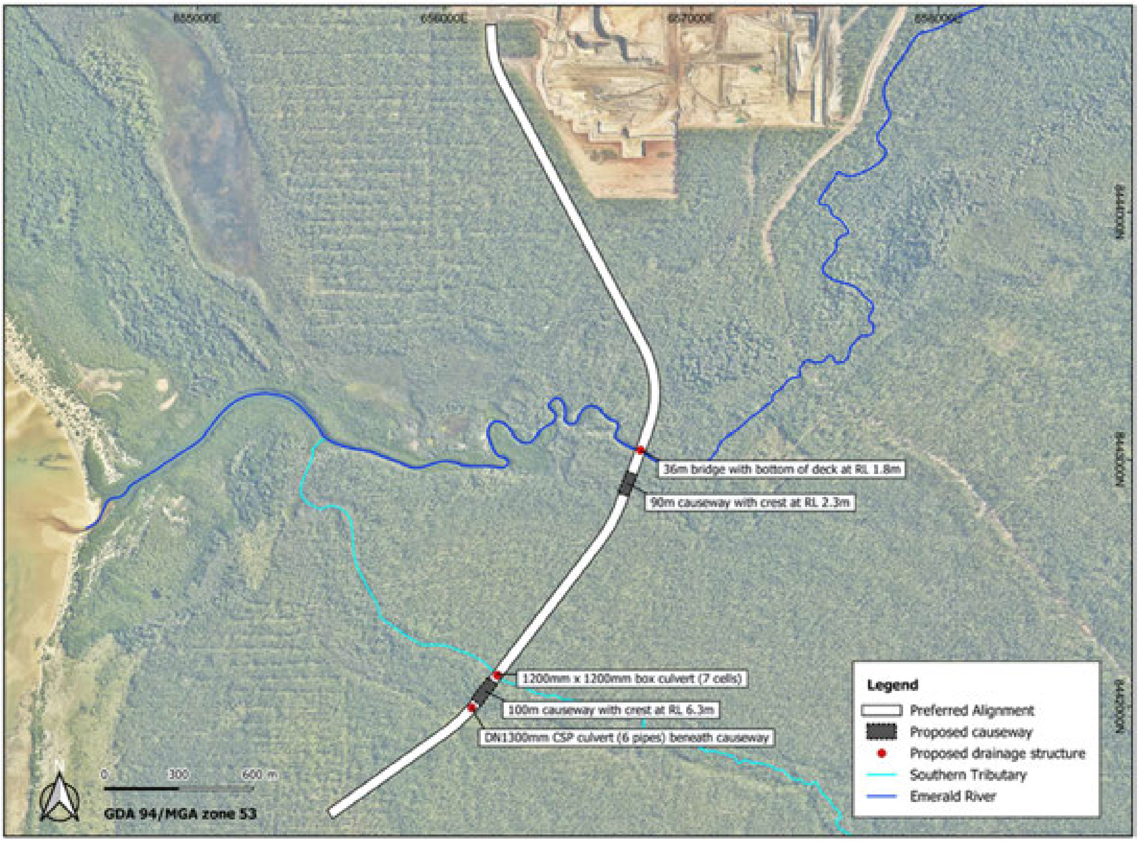

Figure 20: Hydraulic structure arrangement

Figure 21: Rendered image showing the Emerald River bridge and causeway

6.3.5.1 Cross-drainage structure representation

All culverts were modelled as 1D drainage network elements linked to the 2D mesh using 1D/2D connections.

The proposed Emerald River bridge was represented as a 1D bridge component linked to the 2D model grid via 1D/2D links. The schematisation is illustrated in **Figure 22**. The 1D bridge component was set as the "BB" bridge type. BB bridges automatically calculate the form (energy) losses associated with the approach and departure flows as the water constricts and expands. It also automatically applies bridge deck losses associated with pressure flow. The built-in equations and coefficients used by BB bridges are based on the Austroads (1994) - *Waterway Design Guide*.

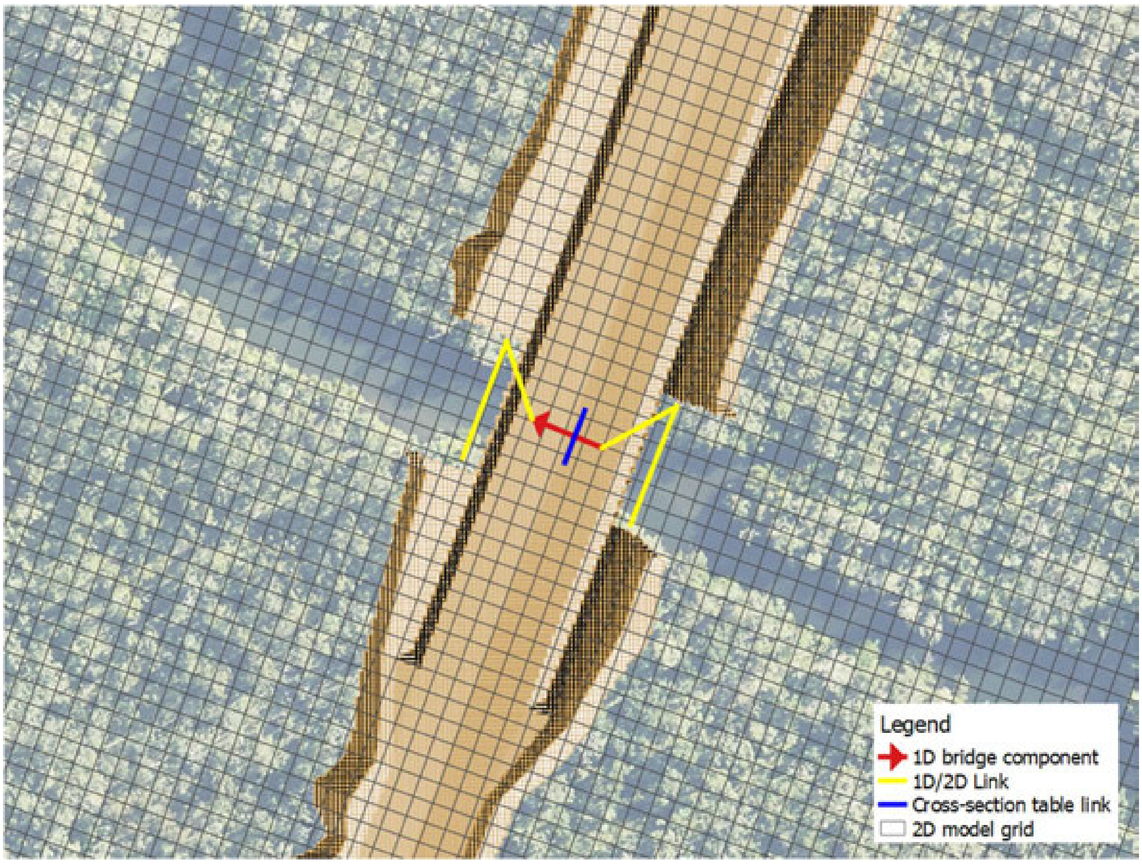

Figure 22: 1D/2D bridge schematisation

6.4 Hydraulic modelling results

The following sections present key flood depth, flood level and flow velocity results for the existing condition model and design condition model at the Emerald River crossing and the Southern Tributary crossing, including review of afflux (difference between design and existing condition results).

Inundation mapping with flood level contours for these simulations are presented in **Attachment 1 - Figure 29** to **Figure 40**. Flood level afflux mapping for 1% and 2% AEP events is presented in **Attachment 1 - Figure 41**.

6.4.1 Existing condition model results

The existing condition model was run for 50% (1:2) to 1% (1:100) AEP flood events to confirm locations requiring cross-drainage structures and provide a baseline for review of the haul road. Mapping in **Attachment 1** indicates bank-full flow conditions in the Emerald River are reached at relatively low flow events with 20% AEP results showing inundation of large parts of the floodplain. Review of 5% AEP results indicate a floodplain width of approximately 1km at the proposed bridge location and 300m at the Southern Tributary crossing. This highlights the degree to which flows will be concentrated when funnelled through the proposed cross-drainage structures.

Flood maps presented in **Attachment 1** - **Figure 31** to **Figure 34** also highlight the existence of a ridge approximately 1km upstream of the coast which acts to constrict flows in the Emerald River floodplain to a narrow channel prior to out-letting into the Gulf on the downstream side of the ridge.

Flow velocity mapping for the existing condition model scenario at the proposed bridge location is presented in **Figure 23**. Results show most channel velocities are below 1m/s for 50% AEP flood. For less frequent floods, localised channel areas experience velocities within the 2-3m/s range with the majority of channel flows falling in the 1-2m/s range. The lower than expected channel velocity results for the 2% and 1% AEP events are a function of backwater effects caused by the downstream river constriction and higher tailwater level due to storm tide boundary conditions.

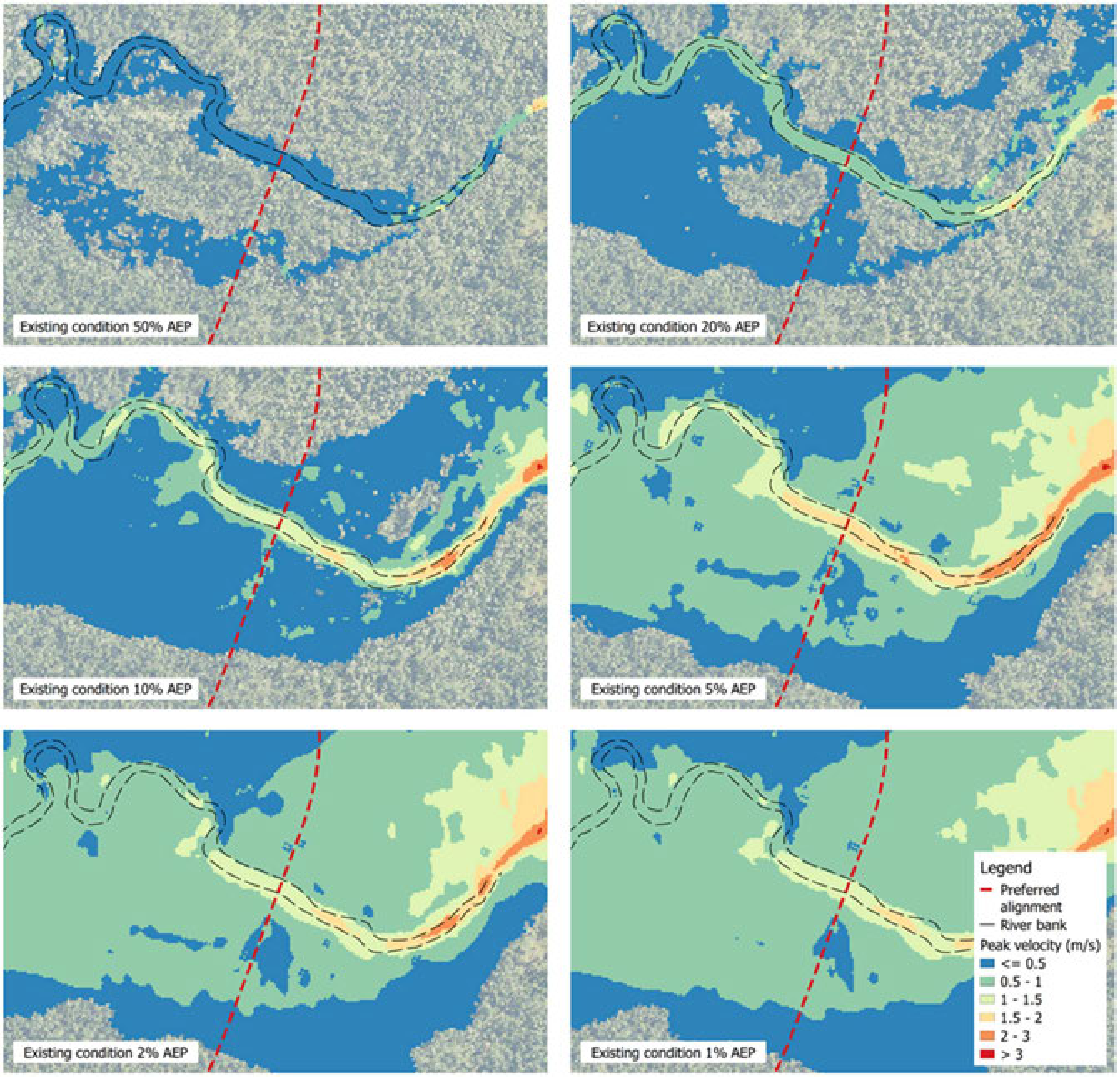

Figure 23: Existing conditions model velocity plot at the proposed Emerald River crossing

Existing condition velocity mapping at the Southern Tributary crossing location is presented in **Figure 24**. Results show peak channel velocities are generally below 1.5m/s for 50% to 10% AEP flood. For flood events less frequent than 10% AEP, peak channel velocities are within the 1.5-2.0m/s range.

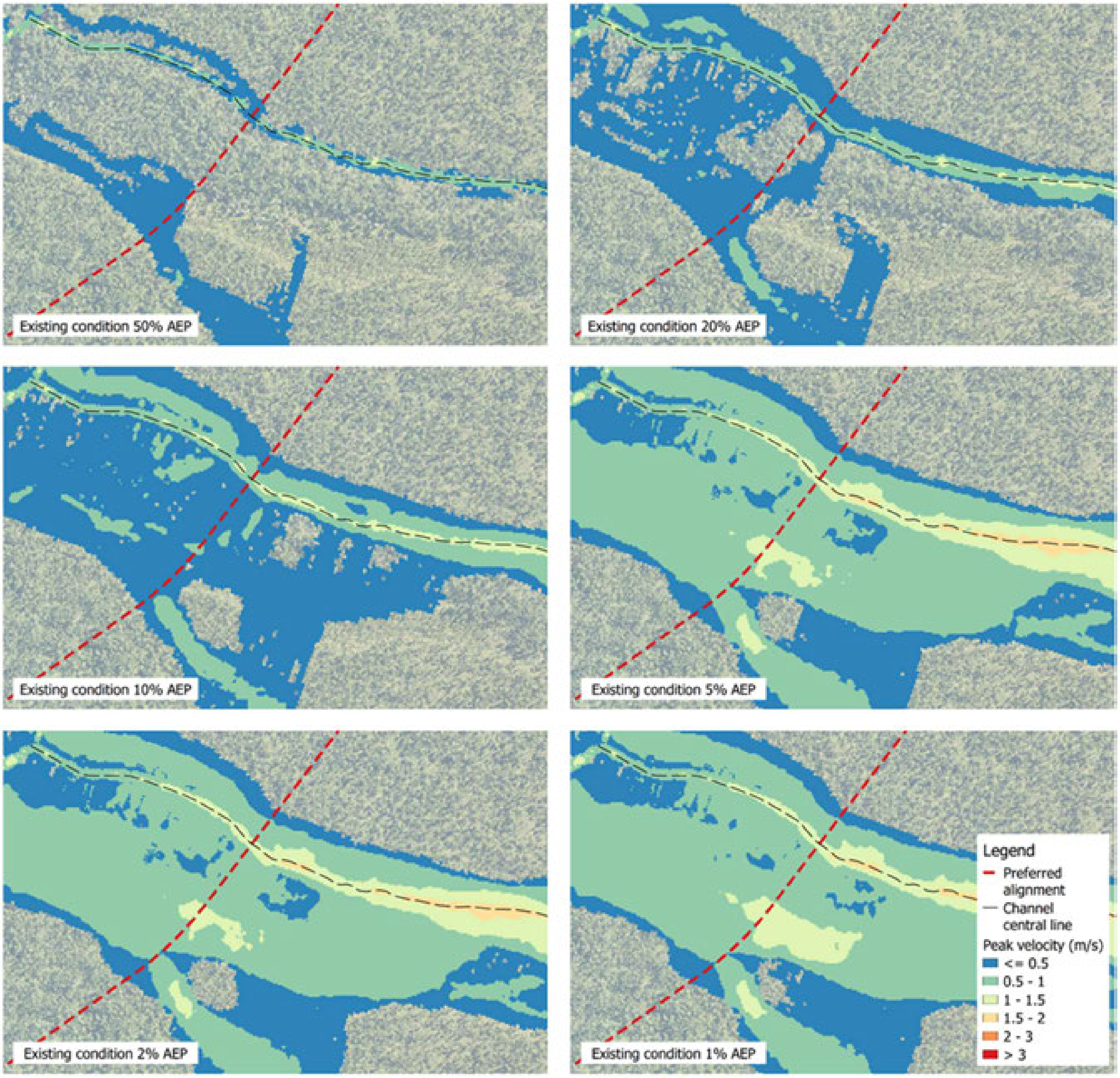

Figure 24: Existing conditions model velocity plot at the proposed Southern Tributary crossing

6.4.2 Design condition model results – Emerald River crossing

6.4.2.1 Velocity Results

The design condition model was run for a range of storm events to assess potential impacts at and downstream of the proposed Emerald River bridge. **Figure 25** presents the velocity mapping for the 50 % AEP to 1 % AEP flood events. The maximum velocity over the causeway surface is 1.5m/s, with higher velocities occurring on the downstream batter of the causeway for smaller events. Localised higher velocities, in the order of 2 to 3m/s also occur at the northern end of the causeway where the road transitions up to the bridge. It is proposed to utilise rock protection (riprap) on either side of the causeway and in any areas of localised higher velocities.

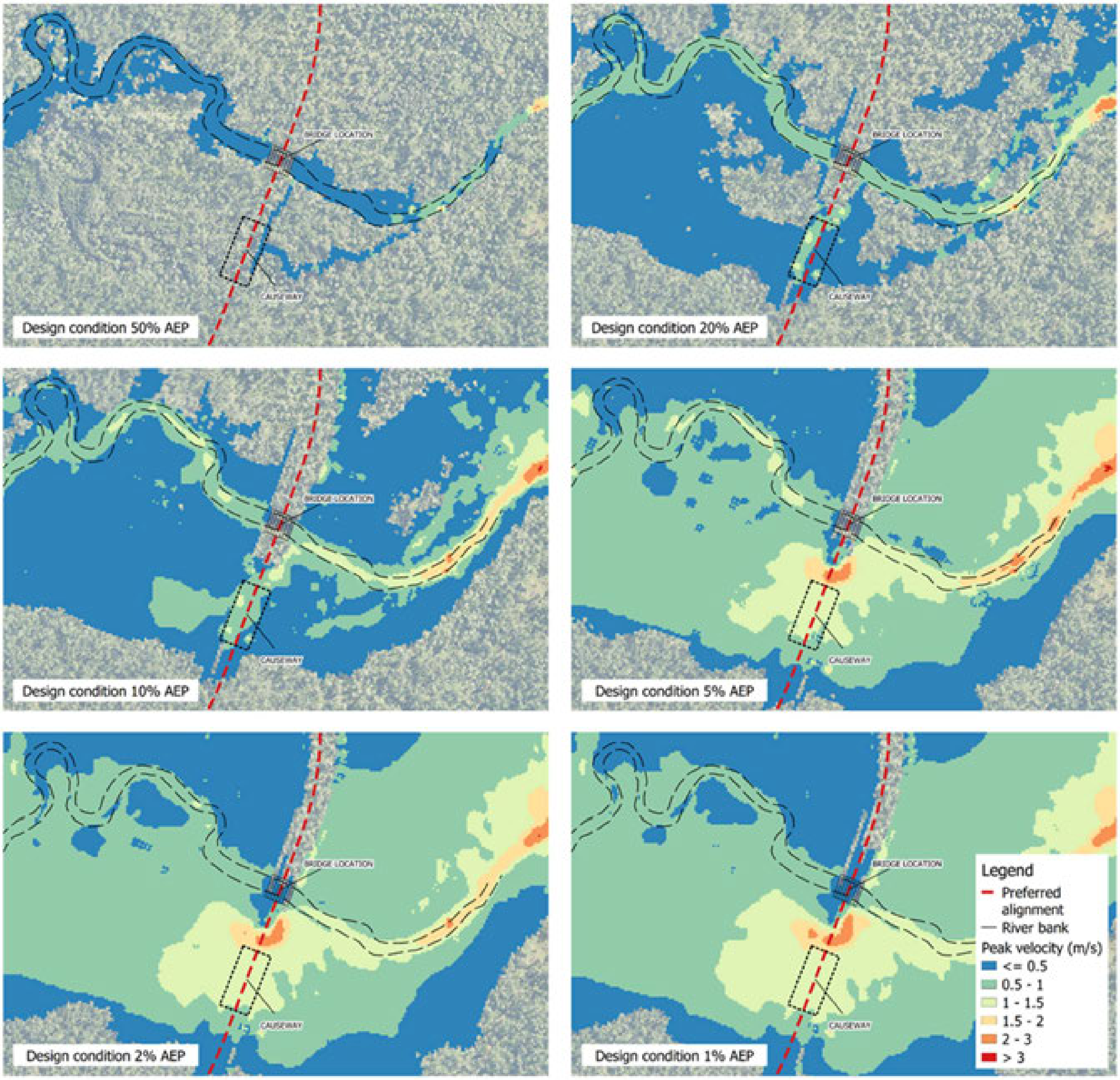

Figure 25: Design condition model velocity plots at the proposed Emerald River crossing

The peak velocities at the location of the proposed bridge (under the bridge deck) are extracted from the 1D bridge component and are summarized in **Table 11**. It should be noted that the 1D/2D bridge model representation does not conserve the momentum of flow transferred from the 1D bridge to the downstream 2D model mesh, resulting in an underestimation of 2D flow velocity result immediately downstream of the 1D bridge. The channel velocity immediately downstream of the bridge is expected to be similar to the velocity under the bridge deck shown in **Table 11**.

Table 11: Peak flow velocities under the bridge deck

Peak flow velocities at the bridge location (or under bridge deck) (m/s)						
SCENARIO	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Existing condition	0.4	1.0	1.4	1.8	1.4	1.4
Design condition	0.4	1.4	2.0	2.3	2.2	2.0

Comparison between the existing condition model and design condition model results indicates no change in the peak channel flow velocity at the proposed bridge location (under the bridge deck) during a 50% AEP flood event. Increases in peak channel velocity (under the bridge deck) for flood events ranging between 20% AEP and 1% AEP were estimated to be 0.4m/s to a maximum of 0.8m/s respectively.

Comparison between existing and design condition velocities upstream and downstream of the proposed bridge are presented in **Figure 26** below.

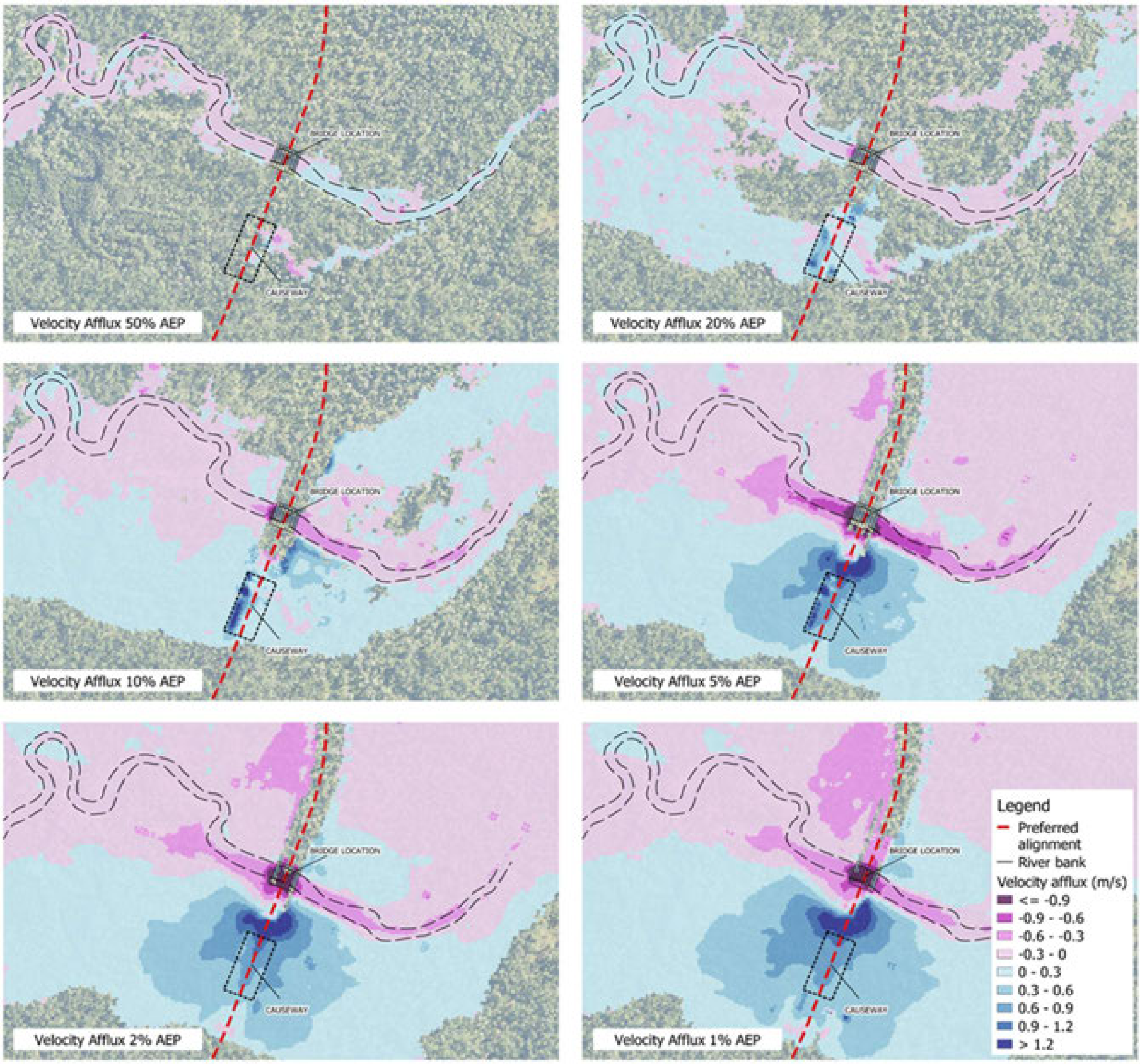

Figure 26: Change in velocity plots at the proposed Emerald River crossing

Velocity change mapping illustrates lower flow velocities within the main channel and corresponding higher floodplain velocities at the causeway during flood events larger than 50% AEP. This is due to the proposed bridge constricting the river flows and causing the majority of flow to be diverted to the floodplain. Erosion potential at the causeway is proposed to be controlled via the use of rock rip rap protection.

It should be noted that, as mentioned above, the 1D/2D bridge model representation does not conserve the momentum of flow transferred from the 1D bridge to the downstream 2D model mesh, resulting in an underestimation of 2D flow velocity result immediately downstream of the 1D bridge. Therefore, any velocity based impact assessment around the bridge should rely on the 1D bride velocity output shown in **Table 11**.

6.4.2.2 Flood elevation results

The water level results at the proposed bridge location are summarised in **Table 12** below. The underside of the proposed Emerald River bridge sits at approximately 1.7m AHD (southern end) to 2.1m AHD (northern end) and the top of the wearing surface is at approximately 4.4m (southern end) AHD to 4.7m AHD (northern end). The simulated upstream water surface reaches the bottom bridge structure at 50% AEP flood event. The wearing surface is submerged during a 5% AEP or greater event.

The causeway was designed to have a relatively low elevation and sufficient length to minimise the obstruction to flood flows due to the construction of the proposed haul road. The modelling results show that the haul road results in minor afflux (up to 0.3m) up to the 10% AEP event, increasing to 0.5m afflux during the 1% AEP upstream of the proposed bridge location. The 2% and 1% AEP flood level afflux mapping presented in **Figure 41** in **Attachment 1**, indicates the haul road causes a minor increase in flood inundation extents for larger events.

Table 12: Water level results at Emerald River crossing

	Emerald River crossing water level results (m AHD)					
SCENARIO	**50% AEP**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**
Existing condition	1.8	2.6	3.2	4.5	4.9	5.1
Design condition	1.8	2.9	3.5	4.9	5.3	5.6

6.4.3 Design condition model results – Southern Tributary crossing

6.4.3.1 Velocity Results

The design condition velocity results for the Southern Tributary crossing are presented in **Figure 27** below. A comparison between existing and design condition velocities upstream and downstream of the proposed Southern Tributary crossing are presented in **Figure 28** below.

Figure 28 indicates the velocities over the causeway are relatively low during frequent flood events. The causeway velocity remains below 1.5m/s for events up to 10% AEP, increasing to 2 to3m/s for the 5% to 1% flood events, due to the majority of river flow passing over the causeway, compared to the culverts. Higher, localised velocities of 2 to 3m/s also occur at the end of the causeway where it transitions up the main haul road. Rock protection will be required to prevent erosion of the haul road embankments and the upstream and downstream sides of the causeway.

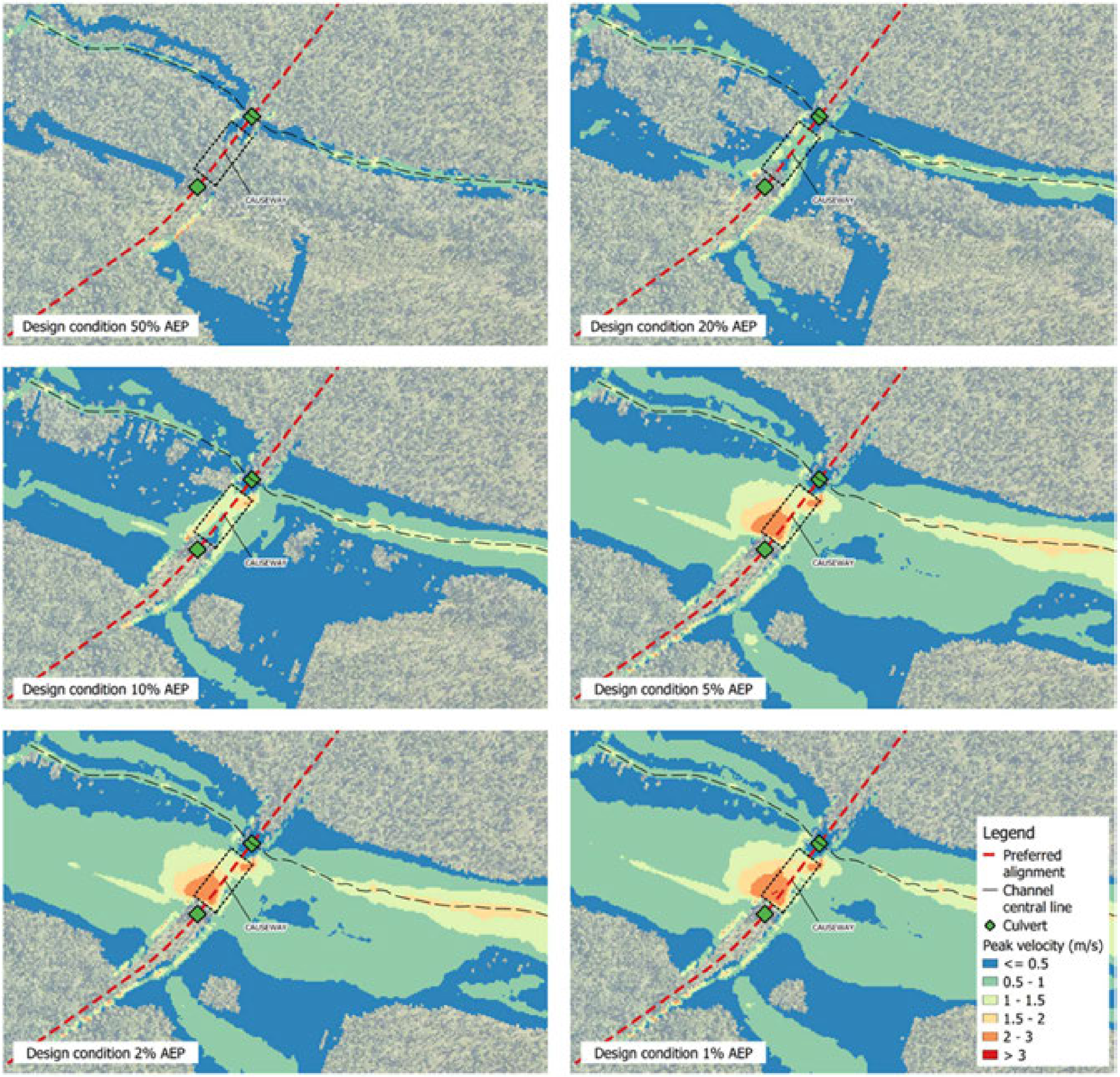

Figure 27: Design conditions model velocity plot at the proposed Southern Tributary crossing

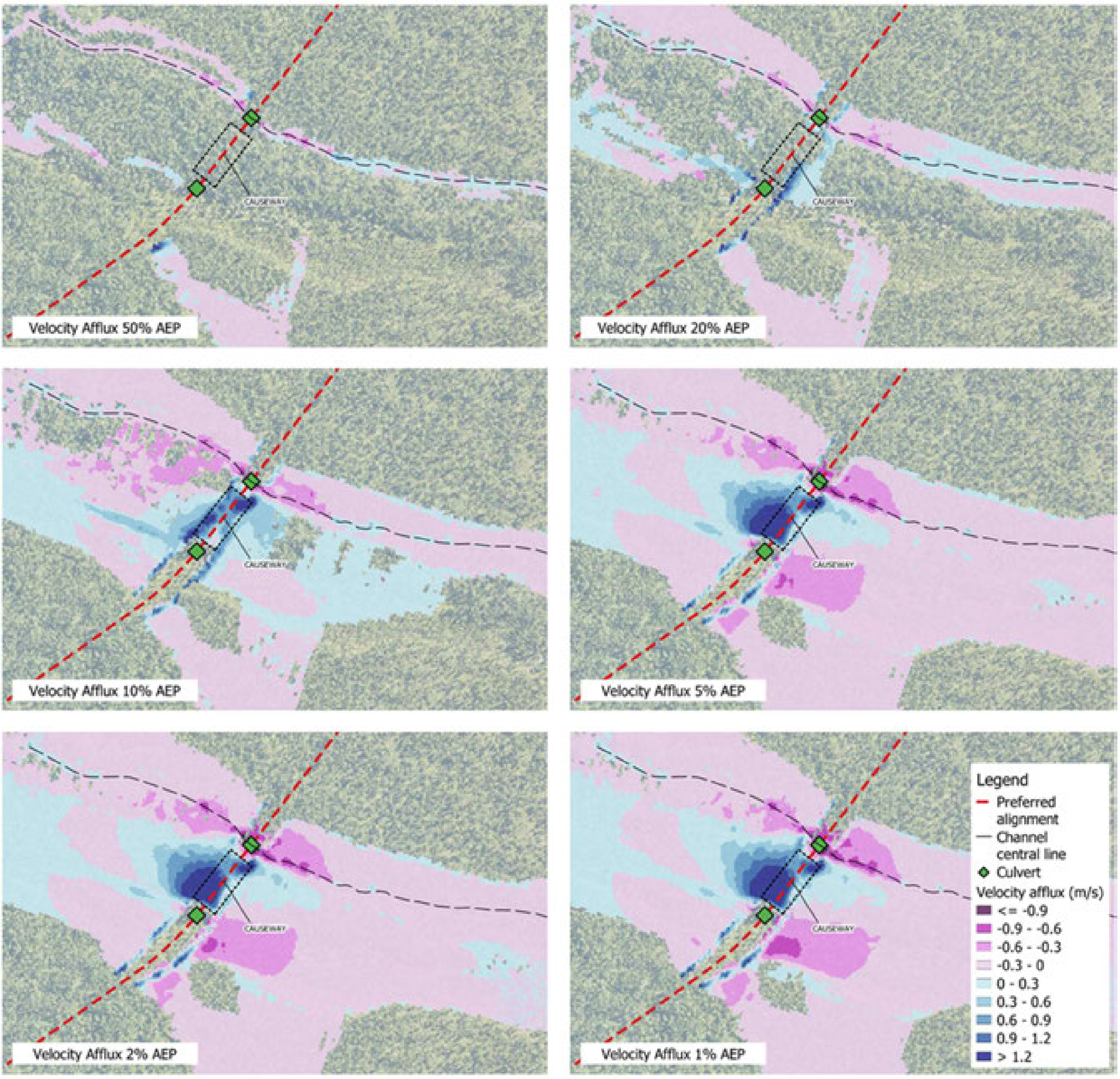

Figure 28: Change in velocity plots at the proposed Southern Tributary crossing

Similar to the proposed Emerald River crossing, velocity change mapping illustrates lower flow velocities within the Southern Tributary main channel and corresponding higher floodplain velocities at the causeway. This is due to the proposed culvert constricting tributary flows causing the majority of flows to be diverted to the causeway.

The peak velocities through the culvert crossing are presented in **Table 13** below. Culvert velocities for flood events ranging between 50% AEP and 1% AEP were estimated to be from a minimum of 0.7m/s to a maximum of 2.9m/s.

Erosion potential at the causeway and culvert locations is proposed to be controlled via the use of rock rip rap protection.

Table 13: Peak flow velocities through Southern Tributary culverts

	Southern Tributary crossing peak culvert flow velocities (m/s)					
Culvert location	**50% AEP**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**
Southern Tributary main channel culverts (7/1.2m x 1.2m RCBC culverts)	0.7	1.8	2.2	2.5	2.5	2.5
Southern Tributary floodplain culverts (6/1.3m CSP culverts)	1.1	1.9	2.5	2.9	2.9	2.9

6.4.3.2 Flood elevation results

The simulated maximum water levels immediately upstream of the Southern Tributary crossing are summarised below.

Table 14: Water level results at Southern Tributary crossing

	Southern tributary upstream water level results (m AHD)				
SCENARIO	**50% AEP**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**
Existing condition	6.2	6.6	6.9	7.1	7.1
Design condition	6.2	6.9	7.2	7.6	7.6

Review of the water level results indicates the haul road results in minor afflux (up to 0.3m) up to the 10% AEP at the Southern Tributary crossing. Higher afflux (up to 0.5m) was recorded during the 5% and 2% AEP flood events.

7.0 Conclusion

A hydrology and hydraulic assessment was undertaken for the Emerald River catchment to establish existing condition flow characteristics and assess potential surface water impacts associated with the proposed haul road where it traverses through the Emerald River and Southern Tributary.

The proposed Emerald River crossing incorporates a 36m bridge across the main channel with a 90m causeway on the lower southern side of the floodplain. For storms larger than the 50% AEP event, the bridge forms a constriction which results in a redistribution of the majority of flows to the proposed causeway south of the bridge. This arrangement minimises the impact of the haul road on the flow velocities within the main channel of the Emerald River and minimises upstream afflux.

The proposed Southern Tributary crossing comprises a set of 1.2m x 1.2m box culvert (7 cells) across the main tributary channel and a set of 1.3m CSP culvert (6 pipes) in the lower section of the floodplain south of the main channel, with a 100m causeway between the two sets of culverts. Similar to the Emerald River crossing, the Southern Tributary causeway arrangement provides minimisation of velocity and afflux impacts.

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Attachment 1

Flood Maps

Project	J Quarry Haul Road
Title	Existing condition model: Flood Inundation 50% AEP
A4	Project No. Figure 29 — Version REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

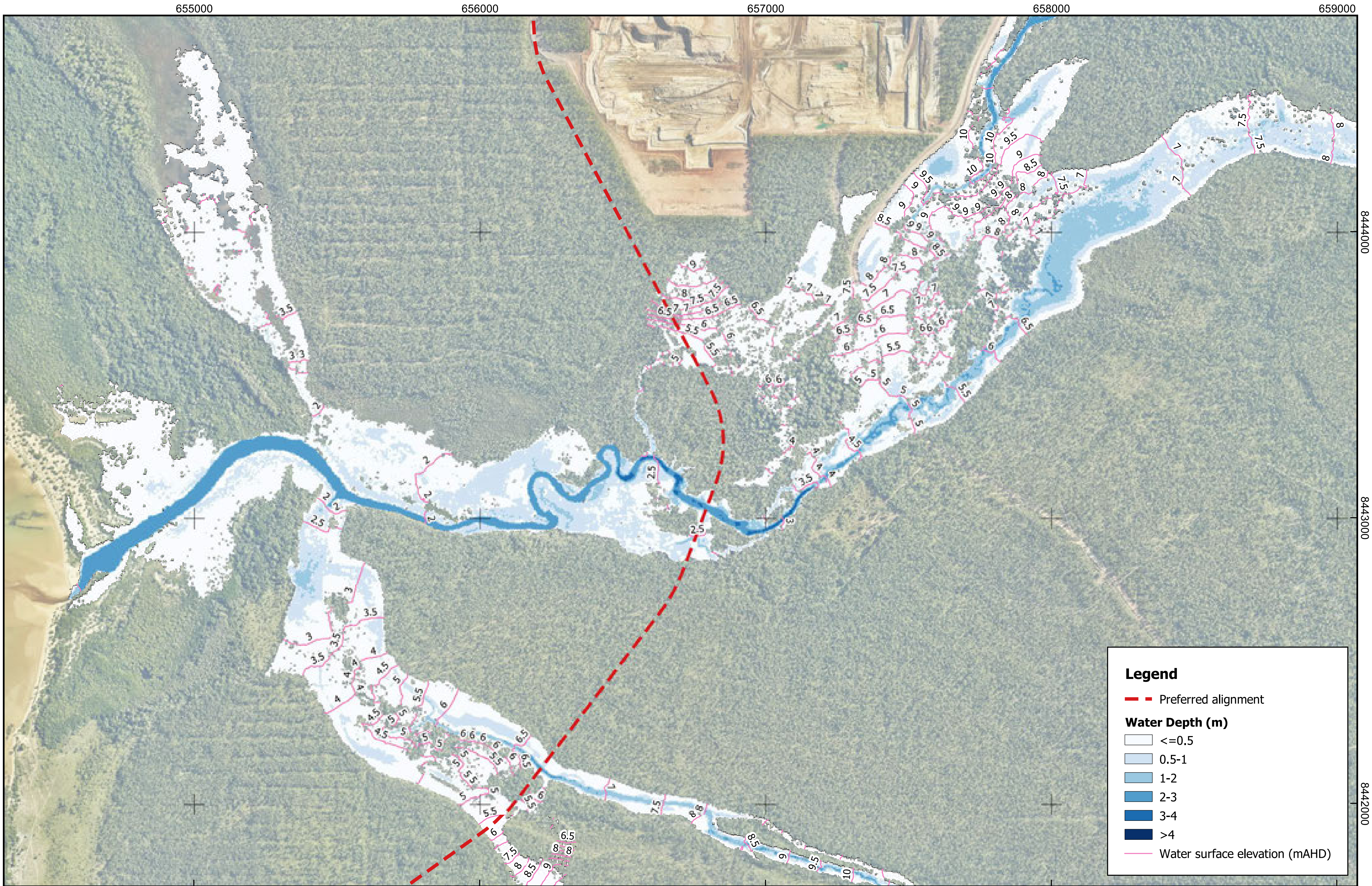
100 0 100 200 300 m

Scale 1:12000

N

red earth engineering

Red Earth Engineering Pty Ltd
ABN: 17 136 007 746
Phone: +61 7 3173 1714
admin@redearthengineering.com.au
9/541 Boundary Street, Spring Hill, QLD 4000



Project	J Quarry Haul Road
Title	Existing condition model: Flood Inundation 20% AEP
A4	Project No. Figure 30
Version	REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

100 0 100 200 300 m

Scale 1:12000

N

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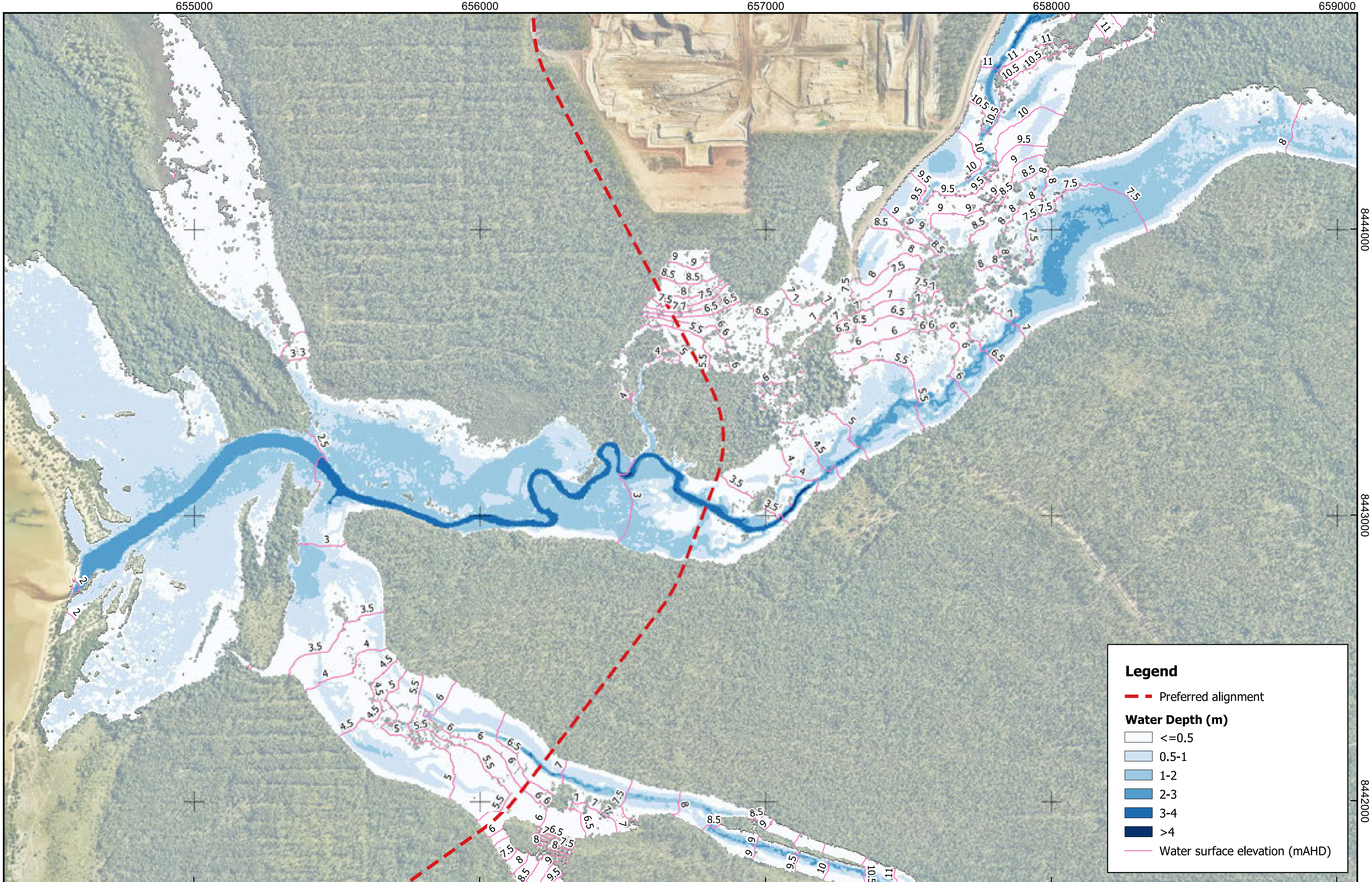
9/541 Boundary Street, Spring Hill, QLD 4000



Project	J Quarry Haul Road	
Title	Existing condition model: Flood Inundation 10% AEP	
A4	Project No. Figure 31	Version REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

100 0 100 200 300 m

Scale 1:12000

N

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Phone: +61 7 3173 1714
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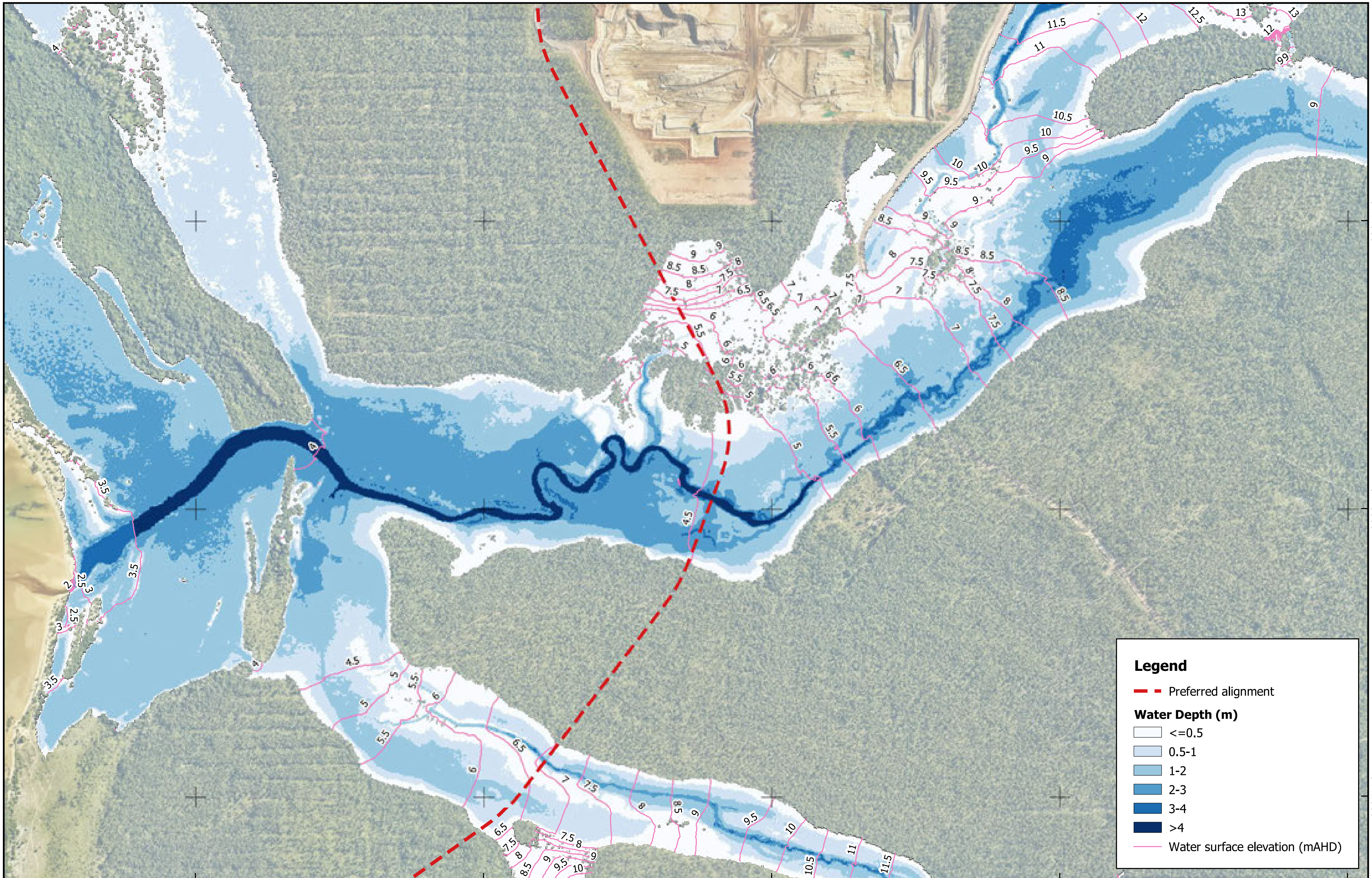
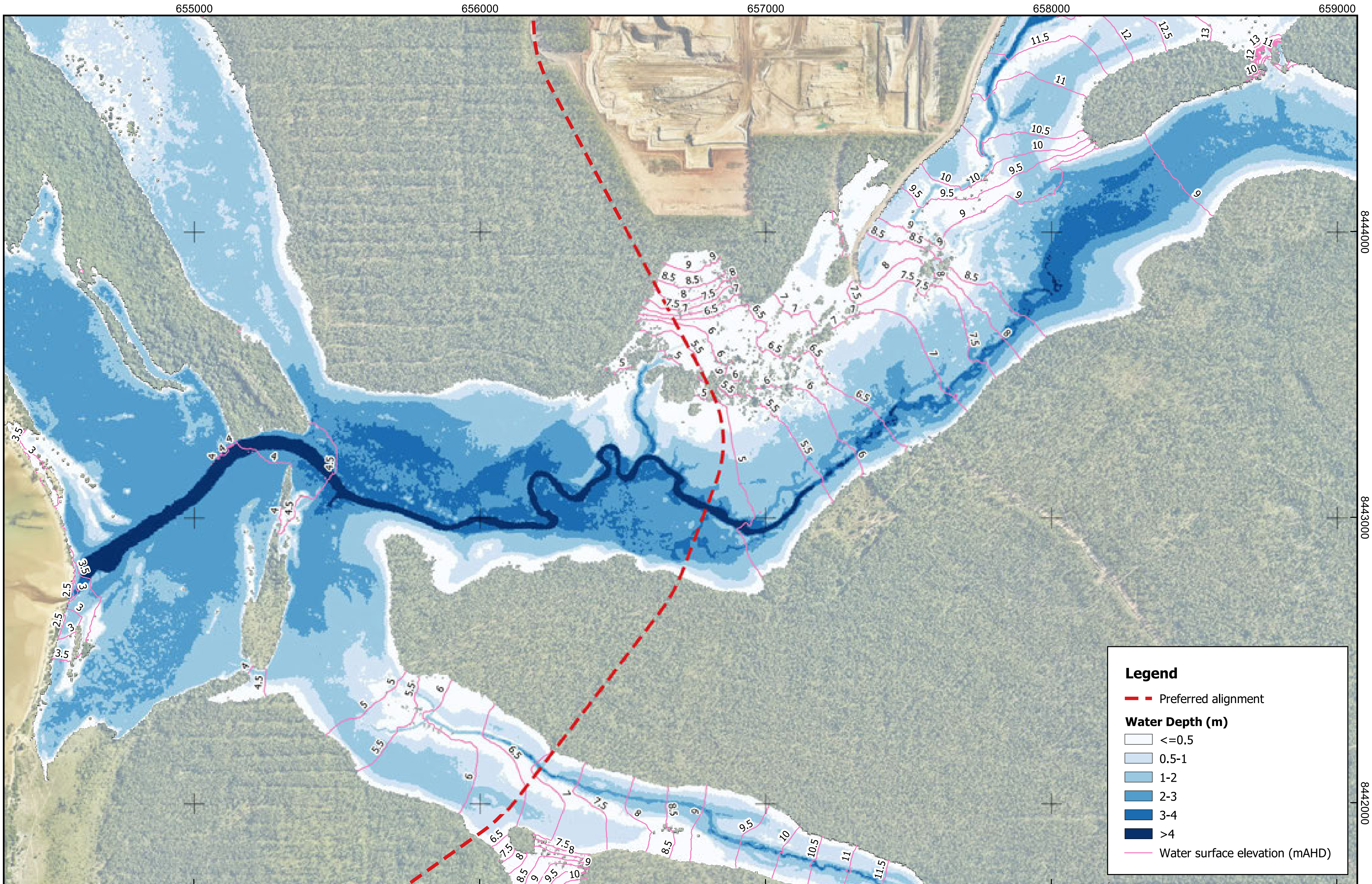
9/541 Boundary Street, Spring Hill, QLD 4000



Project: J Quarry Haul Road	Date: 23 June 2020	100 0 100 200 300 m	N	Red Earth Engineering Pty Ltd
Title: Existing condition model: Flood Inundation 5% AEP	Datum: GDA94 MGA Zone 53	Scale: 1:12000		ABN: 17 136 007 746
A4 · Project No.: Figure 32 · Version: REV - B				Phone: +61 7 3173 1714
				admin@redearthengineering.com.au
				9/541 Boundary Street, Spring Hill, QLD 4000



Project J Quarry Haul Road

Title Existing condition model: Flood Inundation 2% AEP

A4 Project No. Figure 33 Version REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

100 0 100 200 300 m

Scale 1:12000

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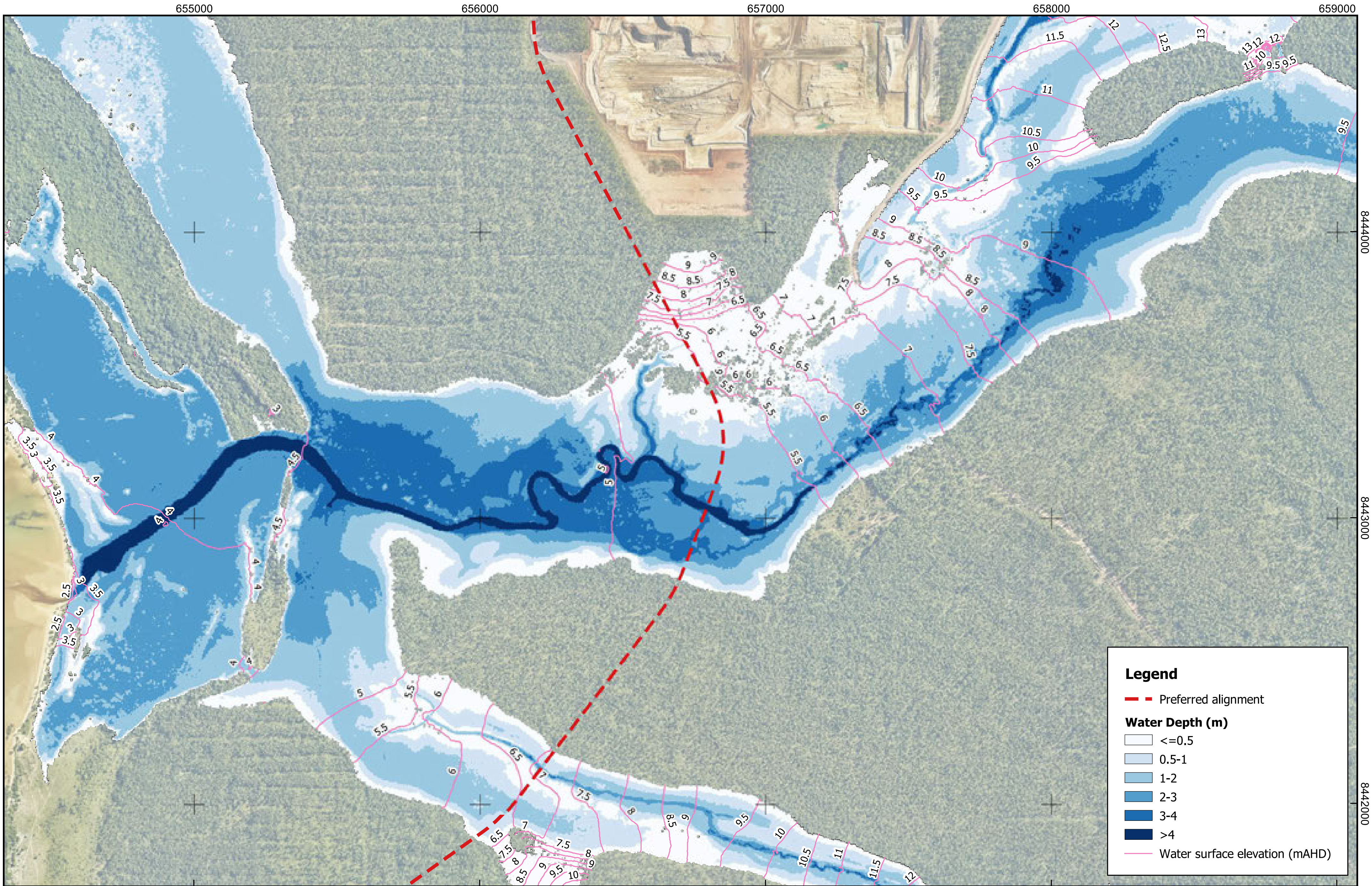

Project: J Quarry Haul Road

Title: Existing condition model: Flood Inundation 1% AEP

A4 | Project No. Figure 34 | Version REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

100 0 100 200 300 m

Scale 1:12000

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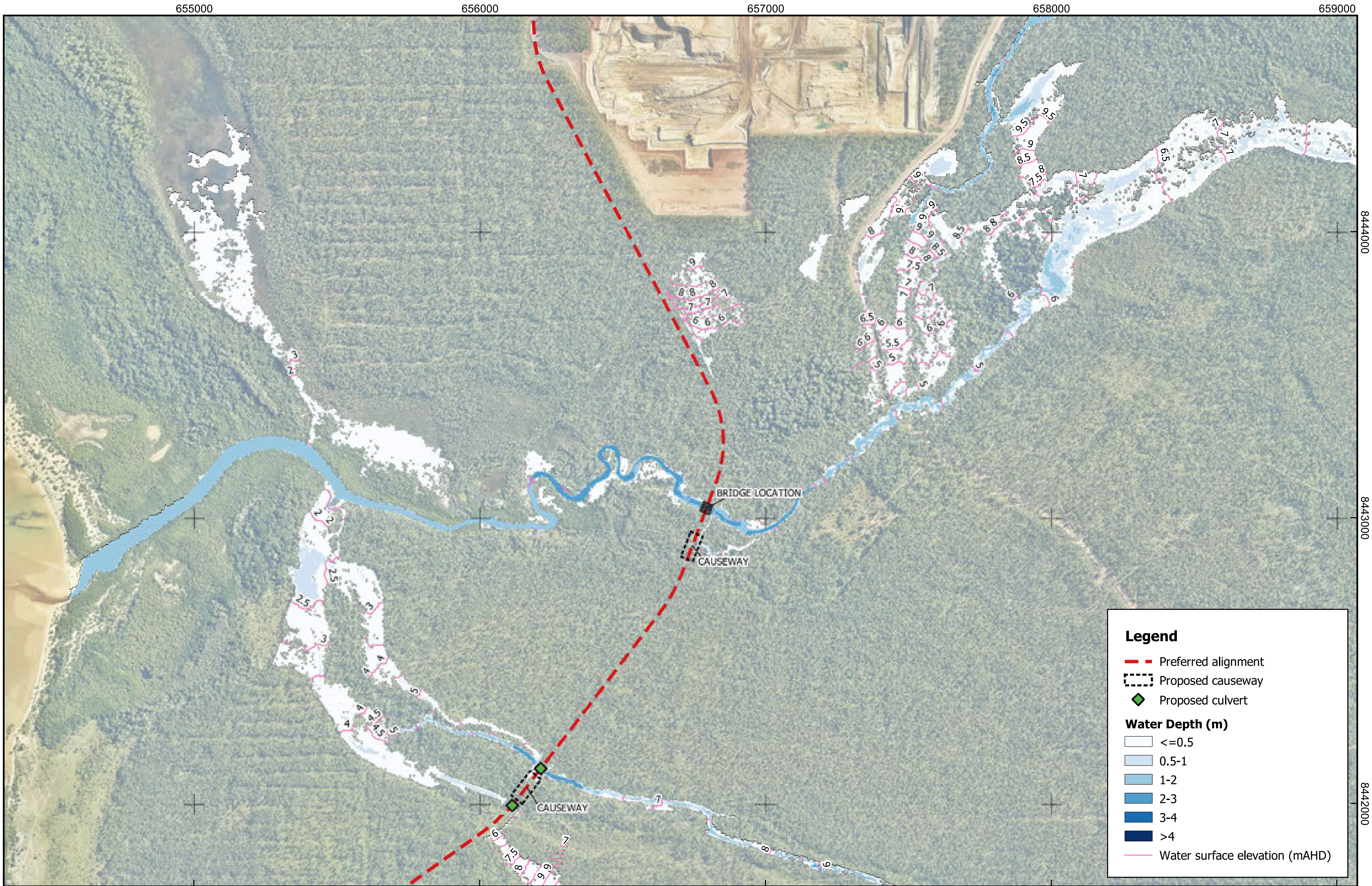

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Title: Design condition model: Flood Inundation 50% AEP		Scale: 1:12000	
A4 · Project No.: Figure 35 · Version: REV - B			

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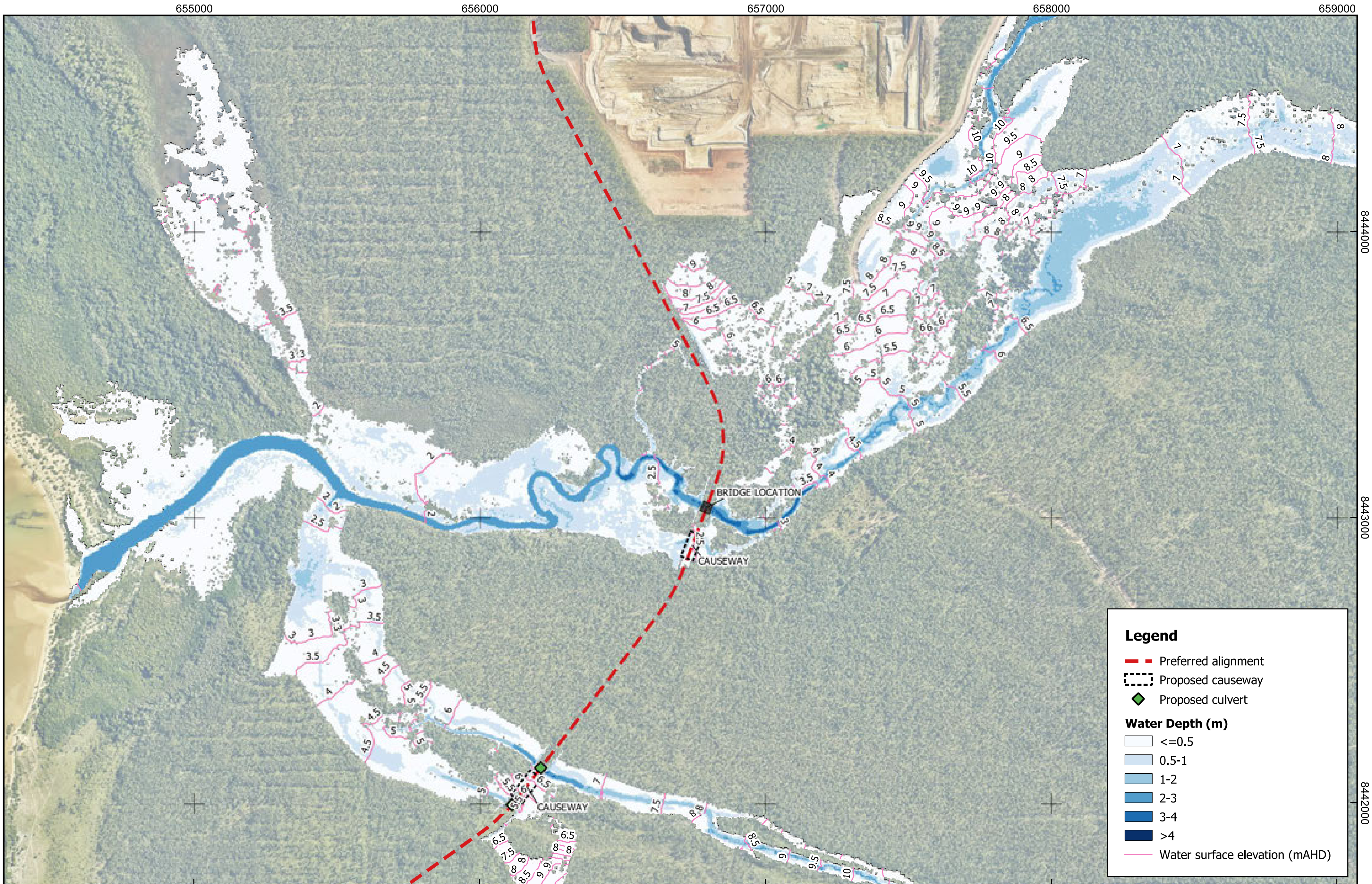

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Title: Design condition model: Flood Inundation 20% AEP			
A4 Project No.: Figure 36	Version: REV - B		

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Project: J Quarry Haul Road	Date: 23 June 2020 Datum: GDA94 MGA Zone 53	100 0 100 200 300 m	N
Title: Design condition model: Flood Inundation 10% AEP		Scale: 1:12000	
A4 — Project No.: Figure 37 — Version: REV - B			

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Project: J Quarry Haul Road	Date: 23 June 2020 Datum: GDA94 MGA Zone 53	100 0 100 200 300 m	N	red earth engineering	Red Earth Engineering Pty Ltd ABN: 17 136 007 746 Phone: +61 7 3173 1714 admin@redearthengineering.com.au 9/541 Boundary Street, Spring Hill, QLD 4000
Title: Design condition model: Flood Inundation 5% AEP		Scale: 1:12000			
A4 · Project No.: Figure 38 · Version: REV - B					

Project J Quarry Haul Road

Title Design condition model: Flood Inundation 2% AEP

A4 Project No. Figure 39 Version REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

100 0 100 200 300 m

Scale 1:12000

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Project: J Quarry Haul Road		Date: 23 June 2020	Scale: 100 0 100 200 300 m
Title: Design condition model: Flood Inundation 1% AEP		Datum: GDA94 MGA Zone 53	Scale 1:12000
A4 Project No. Figure 40	Version REV - B		

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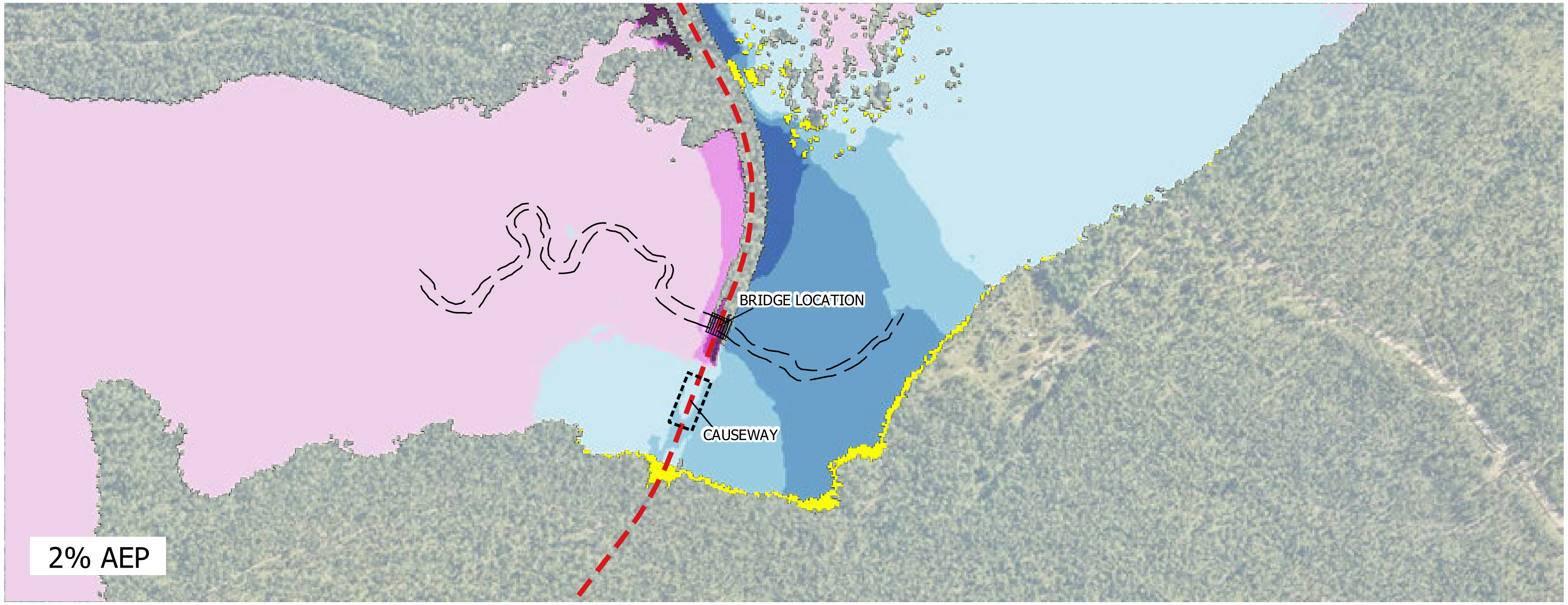

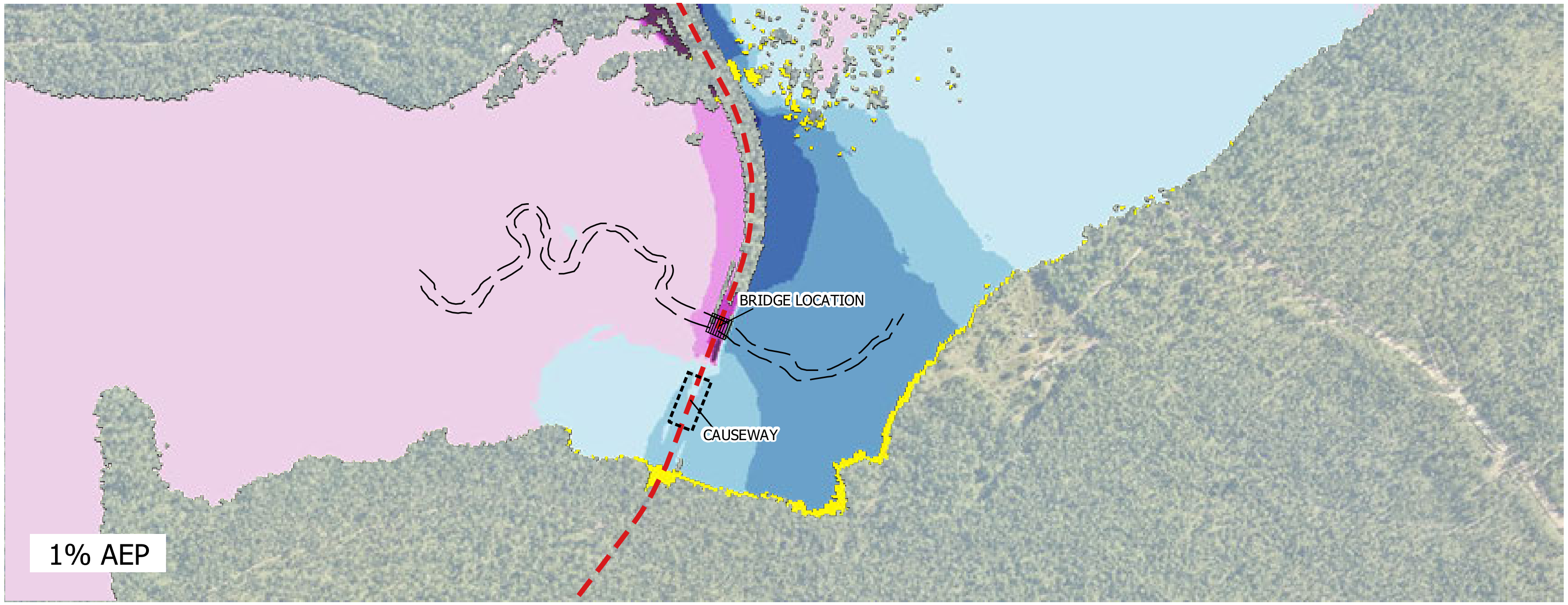

Legend

- Preferred alignment
- Proposed causeway
- River bank

Water level afflux (m)

- <= -0.15
- -0.15 - -0.1
- -0.1 - -0.05
- -0.05- 0
- 0 - 0.15
- 0.15 - 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- > 0.6
- Increase in inundation area

Project	J Quarry Haul Road
Title	Flood Water Level Afflux (2% and 1% AEP) Design Condition - Existing Condition
A4	Figure no. Figure 41
Version	REV - B

Date: 23 June 2020
Datum: GDA94 MGA Zone 53

0 100 200 300 m

Scale 1:9000

N

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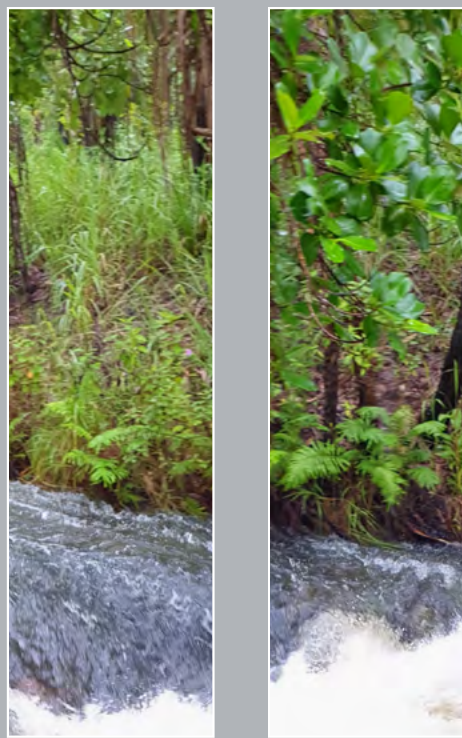
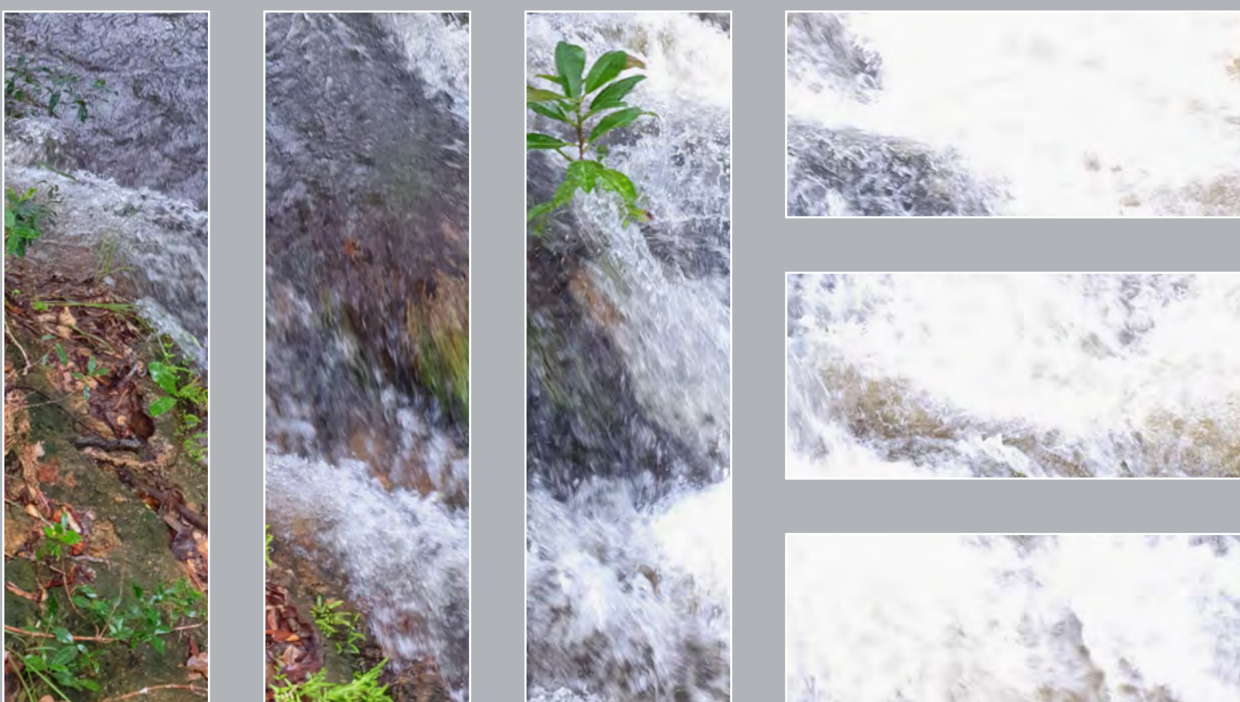
Geomorphic Impact Assessment Report





Geomorphic impact assessment report for the J Quarry Haul Road

Prepared for Hansen Bailey on behalf of Groote Eylandt Mining Company Pty Ltd (GEMCO)

1034-05-B3, 21 August 2020

Prepared by WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Greg Roads
Senior Principal Engineer

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1 Introduction

1.1 PROJECT DESCRIPTION

WRM Water & Environment (WRM) was commissioned by Hansen Bailey on behalf of Groote Eylandt Mining Company Pty Ltd (GEMCO) to complete a geomorphic impact assessment as part of the environmental approval application for the J Quarry Haul Road (the project). The proponent of the project is GEMCO, which has two shareholders - South32 Limited (60%) and Anglo Operations (Australia) Pty Ltd (40%).

GEMCO operates an existing manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650 km south-east of Darwin. The mine has been operating since the 1960s in multiple mineral leases known as the Western Leases (Figure 1.1). These tenements were granted in the 1960s, 1970s and 1980s. GEMCO's existing operations in the Western Leases are located on the northern side of the Emerald River. In 2023, mining is scheduled to progress into the southernmost mineral lease (ML961), which contains a future mining area known as J Quarry, located on the southern side of the Emerald River (Figure 1.2). ML961 includes an access corridor connecting the existing mine to J Quarry. However, GEMCO is unable to develop a haul road within the access corridor because of restrictions relating to an Aboriginal sacred site. An alternative alignment for the access corridor is therefore required.

The project involves the development of a haul road within an alternate alignment of the access corridor. The key elements of the project are shown in Figure 1.3 and are limited to project elements and activities that are located beyond the existing tenements. The project involves:

- Construction of a haul road that links the existing mining operations to J Quarry. On the northern side of the Emerald River, within the floodplain of the river, the road will be constructed on an embankment. On the southern side of the river it will be constructed as a causeway on the floodplain. A bridge will be required for crossing the Emerald River. The haul road will also traverse an ephemeral tributary of the Emerald River, known as the Emerald River Southern Tributary (Figure 1.2), via a series of culverts.
- Construction of a construction access track to enable construction equipment to access the area to the south of the Emerald River.
- Realignment of an existing public access track to enable safe public access to the western coast of Groote Eylandt. The realignment includes construction of an underpass of the haul road.

The project site for the purposes of environmental assessment is the area to be disturbed by these project elements (Figure 1.3). The project site is approximately 24 ha. All haul road development activities (and associated mining activities) located within the Western Leases are authorised under existing approvals and are not included in this assessment.

The land within the access corridor is Aboriginal land, designated under the *Aboriginal Land Rights Act (Northern Territory) 1976* (Cth). The project site comprises natural bushland dominated by Eucalyptus and Melaleuca open woodlands, as well as riparian woodlands along the Emerald River and the Emerald River Southern Tributary.

The township of Angurugu is located approximately 10 km to the north of the J Quarry Haul Road, and is the closest residential community (Figure 1.1). The Yedikba outstation is located approximately 450 m to the east of the haul road and is intermittently used by Traditional Owners (Figure 1.2).

1.2 REPORT STRUCTURE

The report is structured as follows:

- Section 2 provides an overview of the existing environment;
- Section 3 describes the flooding and geomorphic characteristics of the Emerald River under existing conditions;
- Section 4 describes the flooding impacts of the project and provides predictions of scour depths and geomorphological impacts;
- Section 5 provides a summary of findings; and
- Section 6 is a list of references.

Figure 1.1 - Location Plan

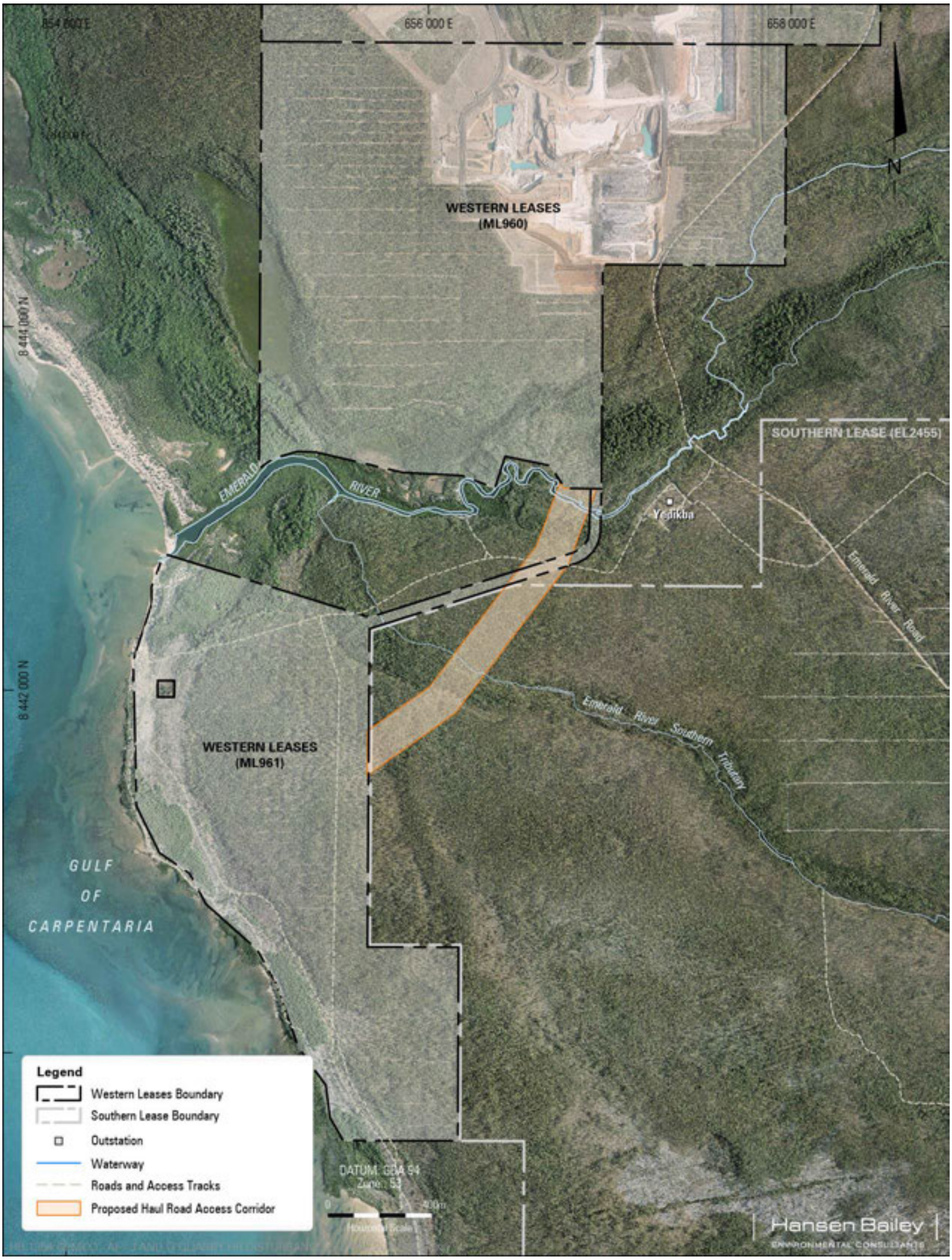


Figure 1.2 - Location of access corridor

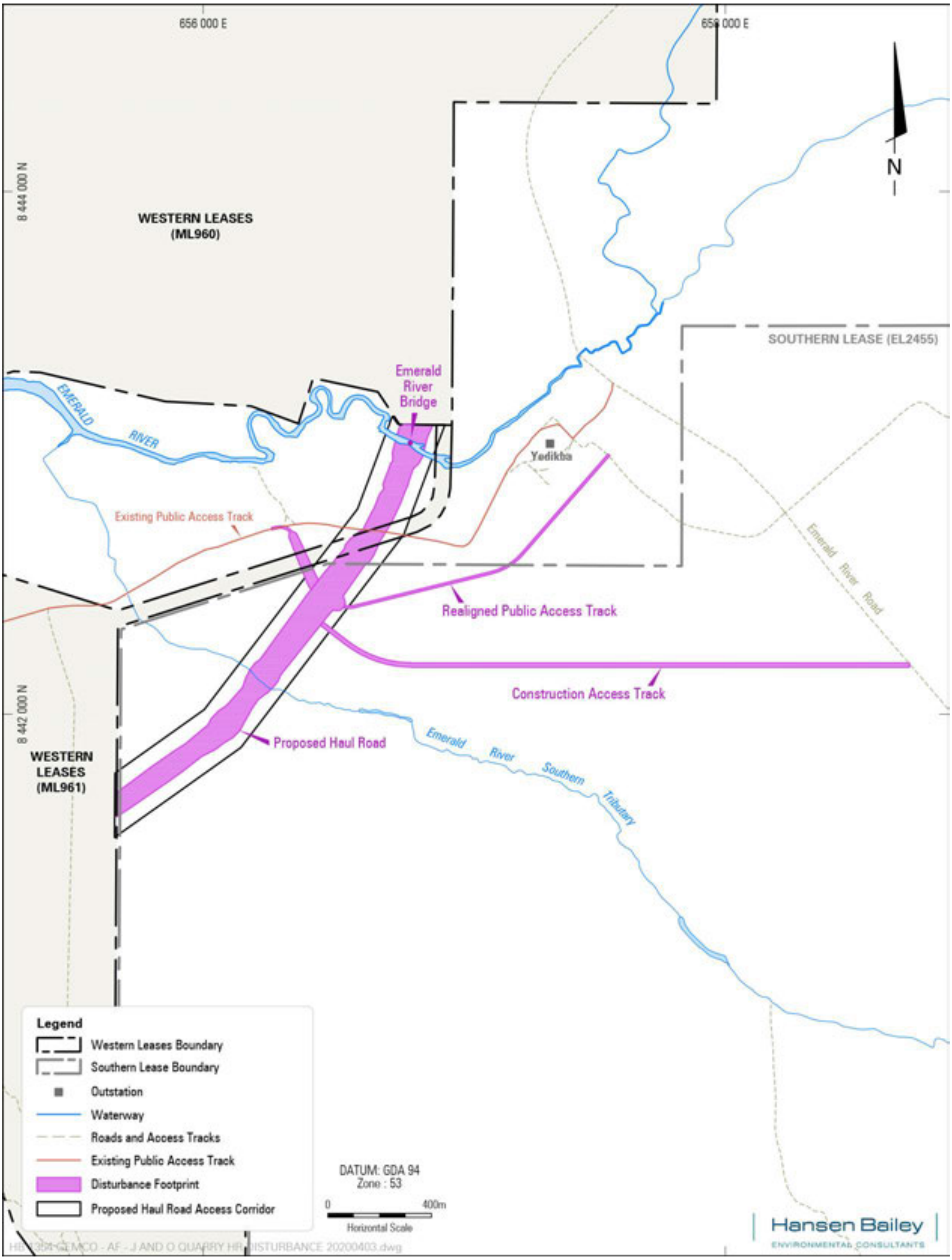


Figure 1.3 - Project layout

2 Existing environment

2.1 CATCHMENT GEOLOGY AND LANDSCAPE DEVELOPMENT

The geology of Groote Eylandt is dominated by horizontally to subhorizontally bedded Proterozoic Dalumbu Sandstone (see Figure 2.1) overlying the Bartalumba Basalt (Nott, 1996). The sandstone forms a resistant plateau about 100 to 140 m above sea level, which is separated from the lowland plains along the western side of the island by an escarpment (see Figure 2.2). Basalt outcrops at the base of the escarpment suggest that this topographic feature has formed from scarp retreat along the contact between the basalt and the overlying sandstone (Nott, 1996).

According to Nott (1996), Cretaceous marine transgression has been the single most important event affecting the long-term landscape evolution on Groote Eylandt. The rise in marine level and sediment-infilling of the two palaeovalley networks effectively liberated the stream systems from their valleys, and enabled them to flow across the upland plateau surface. During the ensuing period of higher sea levels, these streams adopted new courses, and new divides were established.

Coastal barrier dunes have formed along the western coast of the island in the vicinity of the Emerald River mouth. The dunes prevent free drainage of surface runoff from higher ground to the east. Runoff captured behind the dunes forms a series of wetlands on the eastern side of the dunes. The Emerald River mouth cuts through the dunes to discharge westwards to the Gulf of Carpentaria.

2.2 TOPOGRAPHY AND DRAINAGE NETWORK

Streams generally form a radial pattern across the island, flowing from the upland sandstone plateau. The topography of the Emerald River catchment is shown in Figure 2.3. The escarpment that forms the headwaters of the Emerald River has a height of about 50 to 70 m. Ground levels in the lower catchment of the Emerald River in the vicinity of the project are shown in Figure 2.4. Ground levels in the lower Emerald River floodplain are generally below 10 mAHD.

The lower reaches of the Emerald River are joined by two significant tributaries. One tributary (referred to in this report as the “Emerald River Eastern Tributary” or “Eastern Tributary”) joins the Emerald River upstream of the proposed Emerald River bridge. The “Emerald River Southern Tributary” (“Southern Tributary”) joins the Emerald River downstream of the proposed Emerald River bridge and is also traversed by the haul road.

The catchment area of the Emerald River to the J Quarry Haul Road is 70 km^2. The catchment of the Southern Tributary to the haul road is 18 km^2.

Bed levels along the river and two main tributaries are shown in Figure 2.5. The tidal reach of the Emerald River, which extends about 3.7 km upstream from the river mouth, has a bed level below 0 mAHD. The river bed is essentially flat over this reach (note that bed levels below chainage 2,700 m (see Figure 2.5) are inferred rather than surveyed). The proposed Emerald River bridge is located about 3.2 km upstream from the river mouth and is within the tidal reach. A small waterfall with a height of about 2 m is located at the upstream end of the tidal reach (see Figure 2.5). A photograph of the waterfall is shown in

The Emerald River has a bed gradient of about 0.6% over a 1 km length immediately upstream of the tidal reach, before flattening out further upstream.

The Southern Tributary joins the Emerald River about 1300 m upstream from the river mouth and has a bed gradient of about 0.3%. The Eastern Tributary joins the Emerald River about 400 m upstream of the waterfall and has a bed gradient of about 0.2%.

Apart from the bed of the tidal reach, the channel bed, banks and floodplain are heavily vegetated, as shown in Figure 2.7.

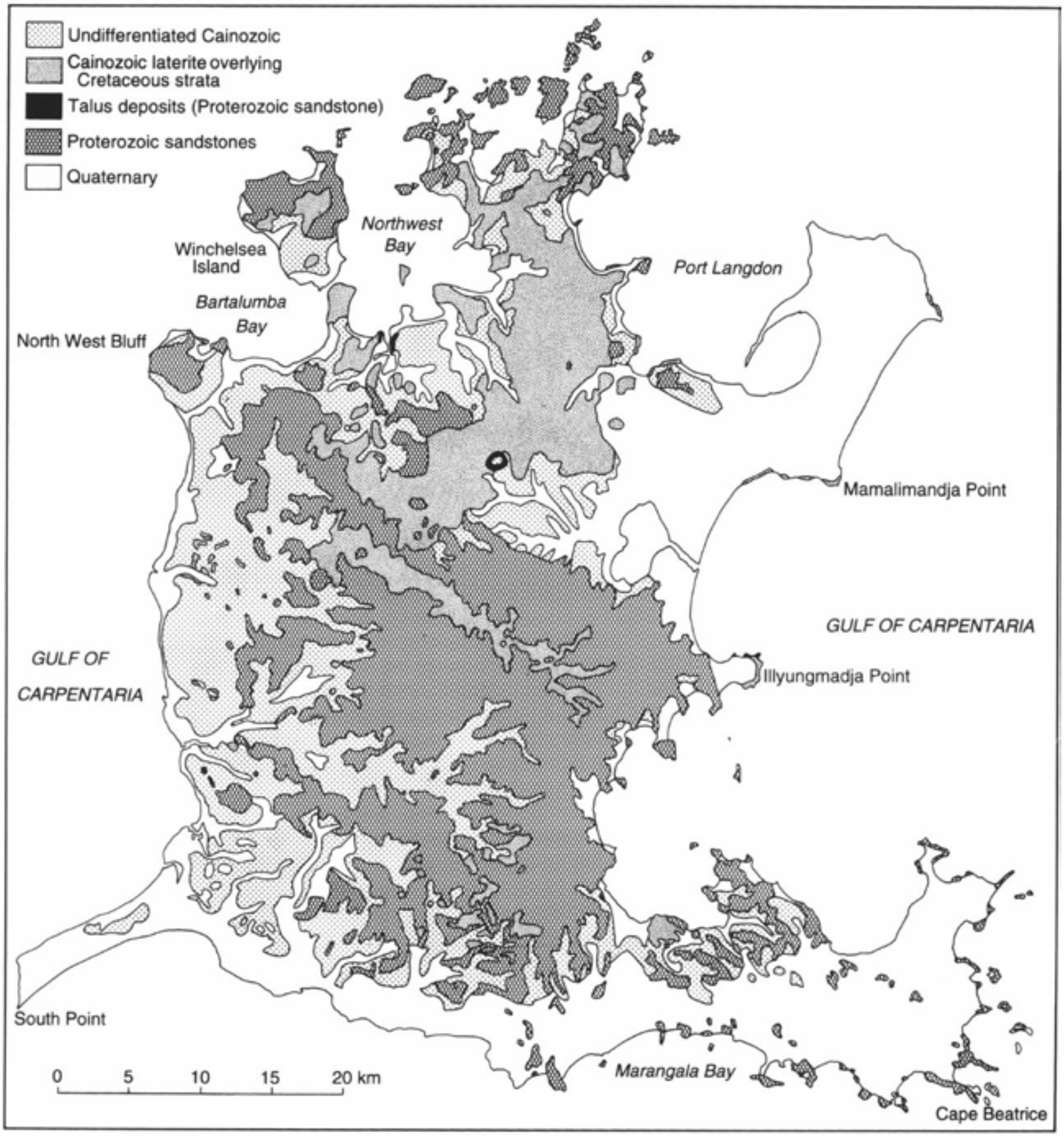


Figure 2.1 - Geological map of Groote Eylandt (source: Nott, 1996)

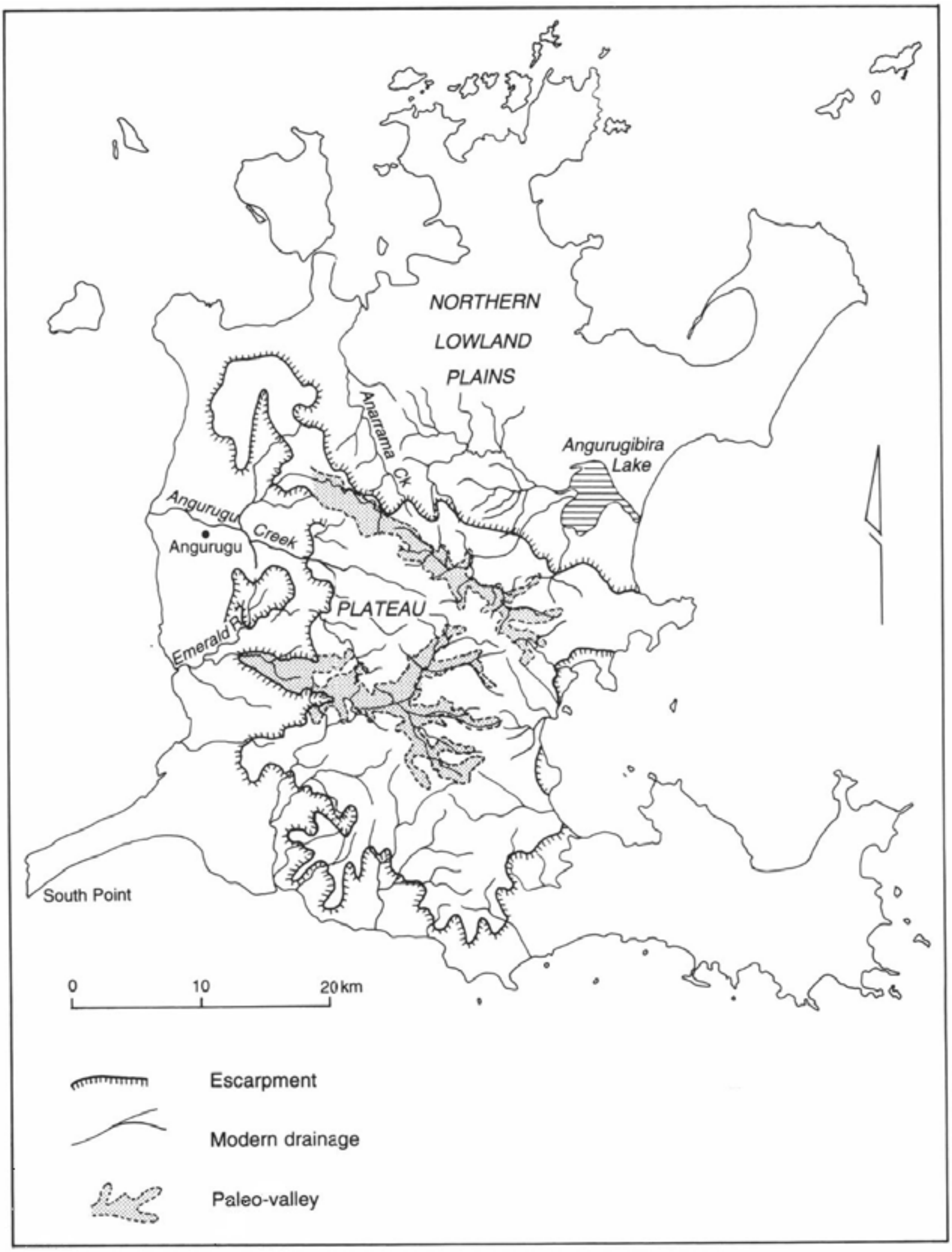


Figure 2.2 - Physiography and drainage of Groote Eylandt (source: Nott, 1996)

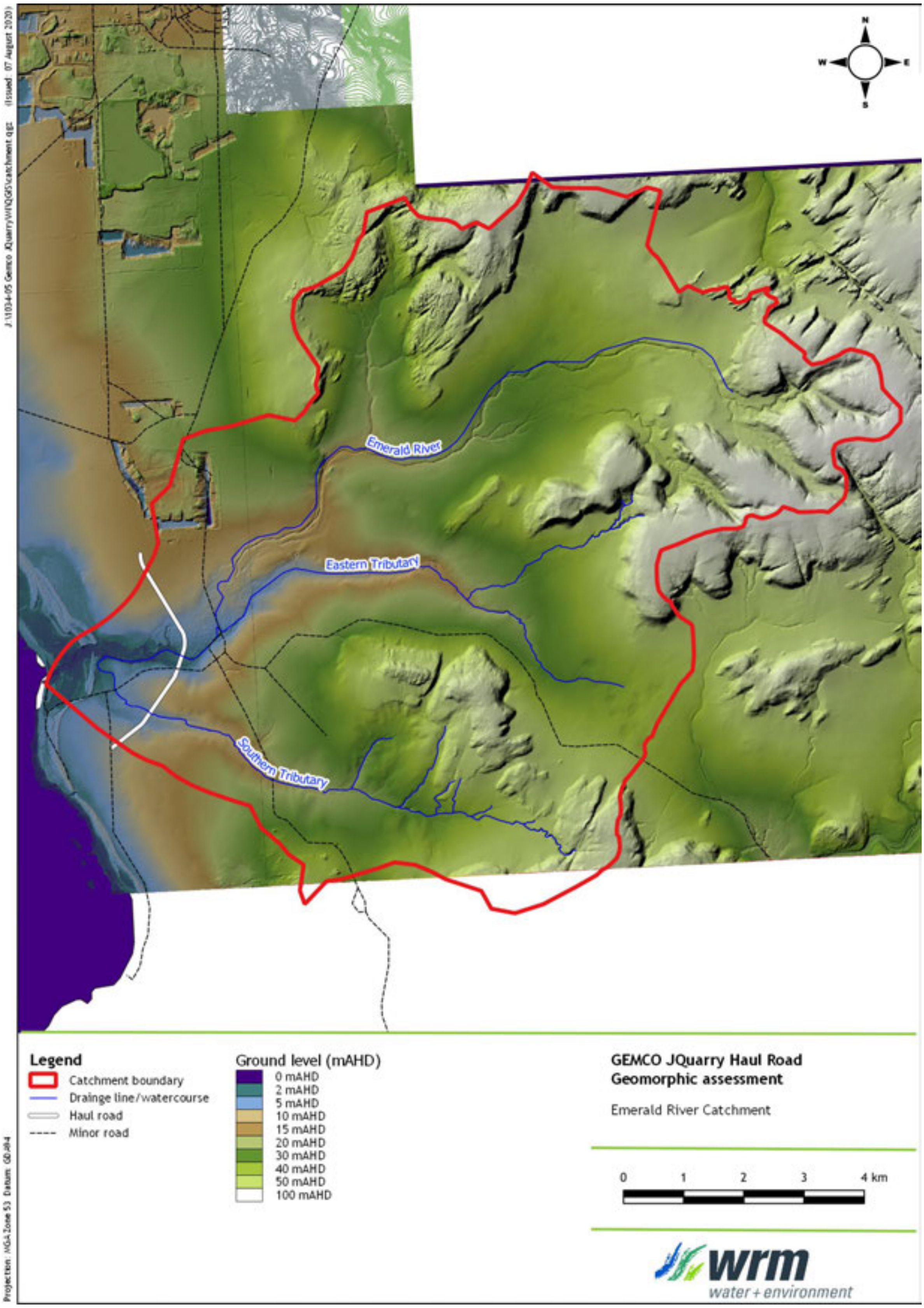


Figure 2.3 -Emerald River catchment topography

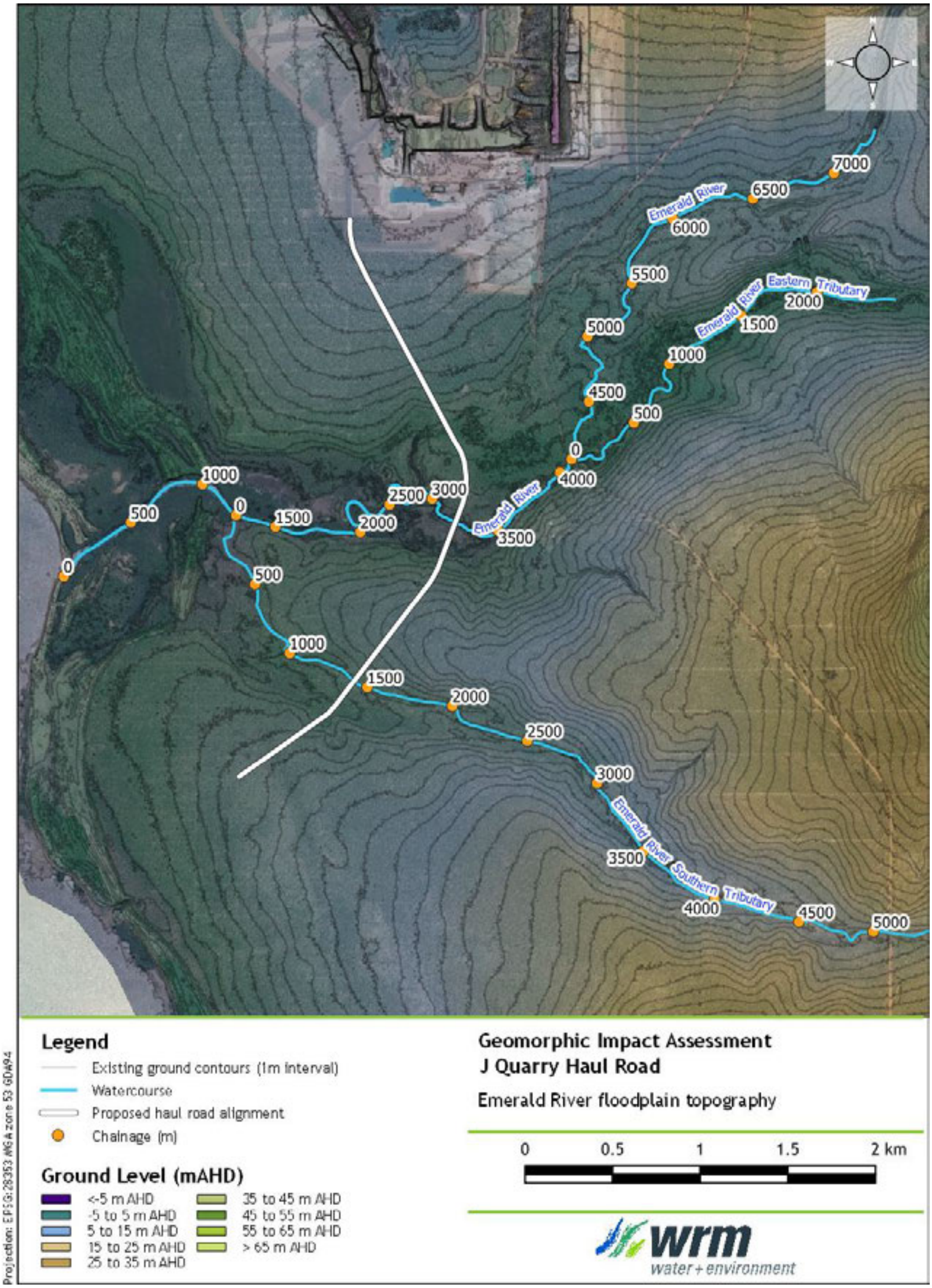


Figure 2.4 - Ground levels across lower Emerald River catchment (from LIDAR data)

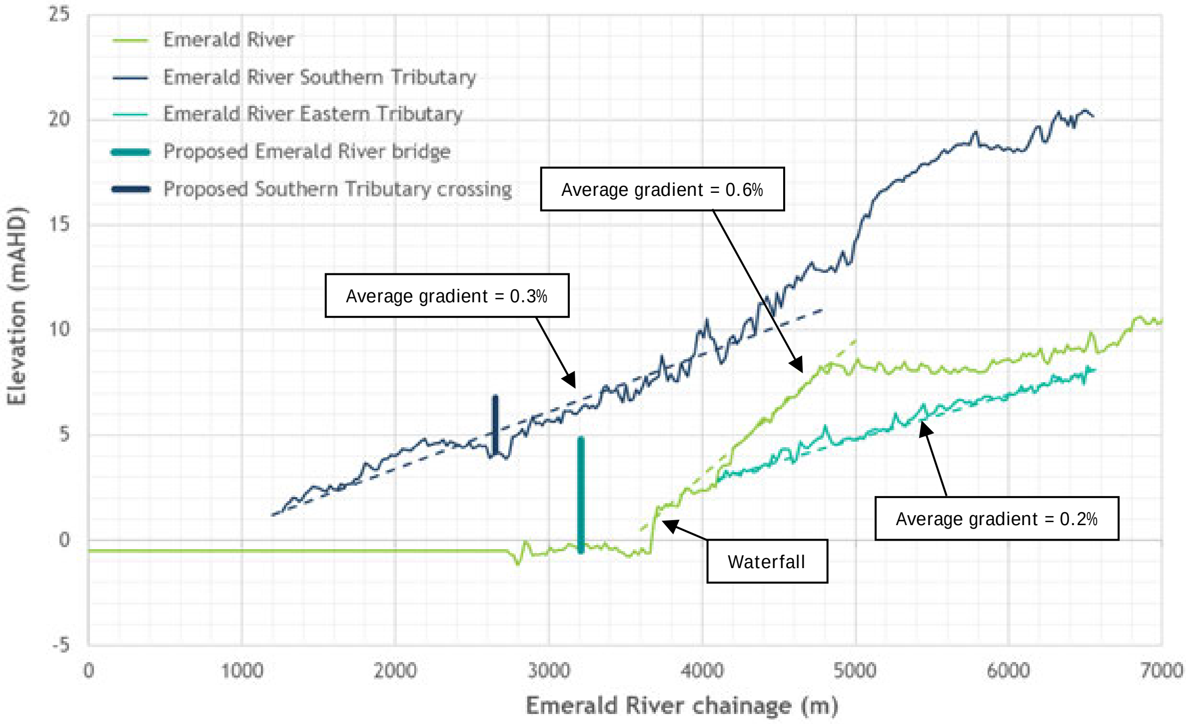


Figure 2.5 - Stream bed levels along lower Emerald River and major tributaries

Figure 2.6 - Photograph of the Emerald River waterfall

Figure 2.8 shows a cross-section of existing ground levels across the Emerald River and Southern Tributary floodplain, as well as design levels along the centreline of the proposed J Quarry Haul Road. At some locations along the Emerald River and its tributaries, the channel is perched, with the bank levels higher than the adjacent floodplain (as shown for the Southern Tributary in Figure 2.8).

Figure 2.7 - Photograph of lower tidal reach of Emerald River near bridge location

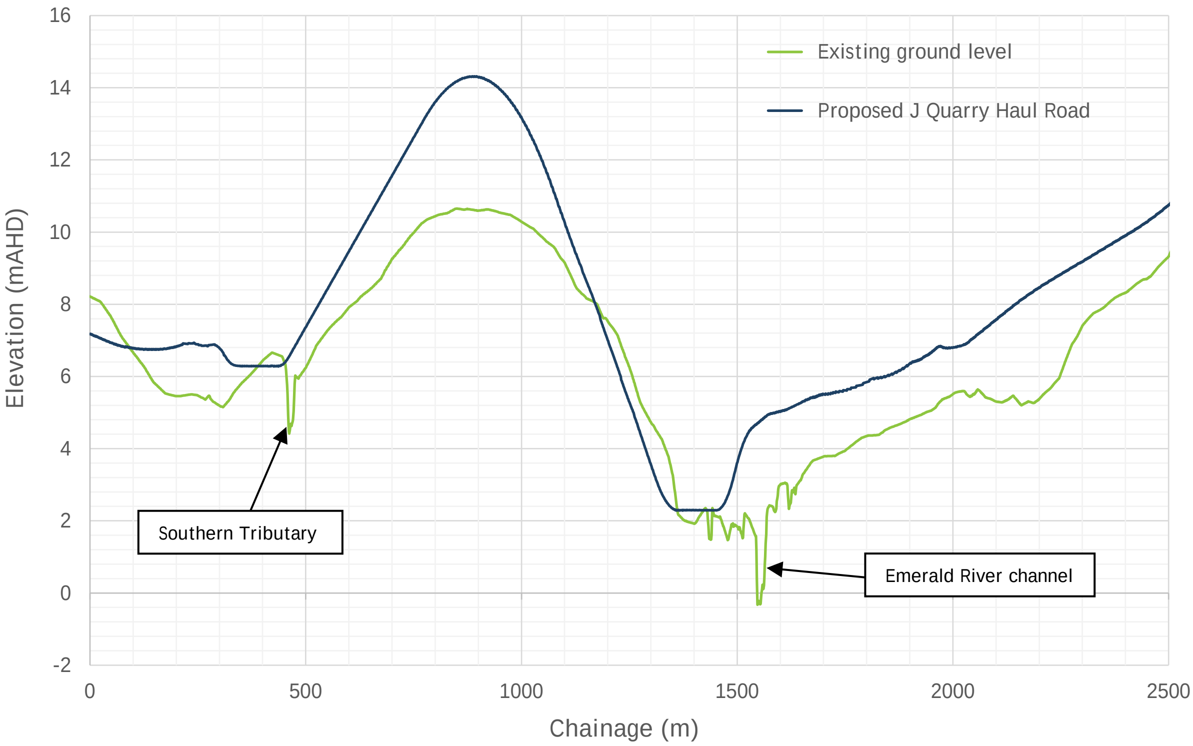


Figure 2.8 - Emerald River floodplain cross-section along Haul Road alignment

2.3 REACH GEOMORPHOLOGY

The alluvial nature of the Emerald River bank material and the tight meander geometry of the channel downstream of the proposed Emerald River bridge suggests that the channel is prone to lateral scour at the outside bends. Evidence of channel migration can be found in the Lidar topographic data, which shows a number of remnant channels on the Emerald River floodplain downstream of the waterfall. This suggests the Emerald River channel has changed locations several times over its history. However, the rate of change within the lower reach (downstream of the waterfall) would appear to be very slow, likely due to the established channel bank and floodplain vegetation (see Figure 2.7). It would appear that the lower reach of the Emerald River has reached a point in its evolution such that it is relatively stable. In comparison, the Emerald River upstream of the waterfall would appear to be actively changing given the very steep topography and perched nature of the channel.

The coastal dune upstream of the Emerald River mouth has formed a large palustrine wetland on its eastern side, which appears to be fed from its local catchment and flood overflows from the Emerald River. It is likely that it was once an estuarine wetland when sea levels were higher.

Given that river bed levels are already below mean sea level and there is little evidence of significant sediment loads, significant or rapid erosion due to channel aggradation or degradation is not expected.

3 Existing conditions assessment

3.1 OVERVIEW

An assessment of the hydraulic and sediment transport characteristics of the Emerald River in the vicinity of the project has been undertaken based on hydrologic and hydraulic modelling completed by Red Earth Engineering (REE, 2020). The modelling has been undertaken using the TUFLOW two-dimensional hydraulic model which simulates hydraulic behaviour within the channels and floodplain of the Emerald River and its tributaries on a 6 m grid. Details of the model configuration and results are provided in the Hydrology and Hydraulics Assessment Report for the project (REE, 2020).

A comparison of model results for the Emerald River under existing conditions and with the haul road has been used to assess the impacts of the project. Note that data upstream of the waterfall has generally not been shown because there is no bathymetric data and this reach is not likely to be impacted by the project.

3.2 FLOW CHARACTERISTICS

3.2.1 Emerald River

The extent and depth of flooding along the Emerald River for the 50%, 20%, 10%, 5%, 2% and 1% annual exceedance probability (AEP) events are shown in the REE (2020) report and have not been repeated here. Figure 3.1 shows longitudinal profiles of existing conditions peak flood levels along the Emerald River from just upstream of the river mouth (chainage = 200) to 4.5 km upstream. Results are shown for the 50%, 10% and 2% AEP events. Average channel flow velocities for existing conditions for the reach below the waterfall are shown in Figure 3.2.

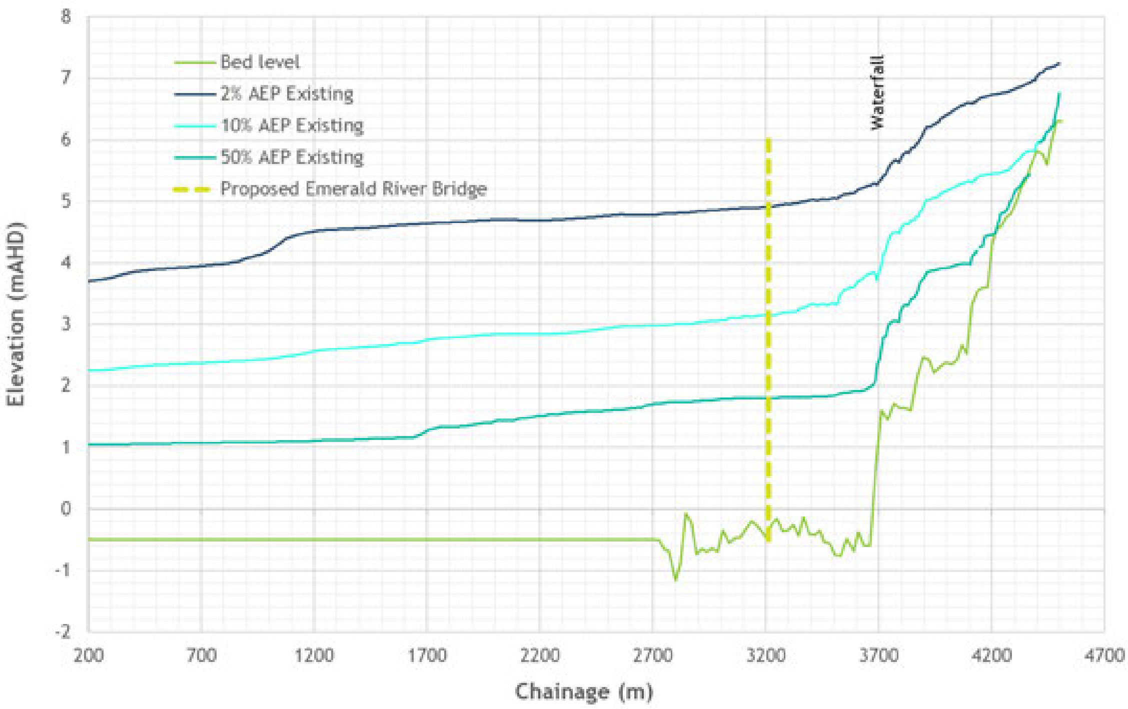


Figure 3.1 - Emerald River water level longitudinal profile, 50%, 10% and 2% AEP events for existing conditions

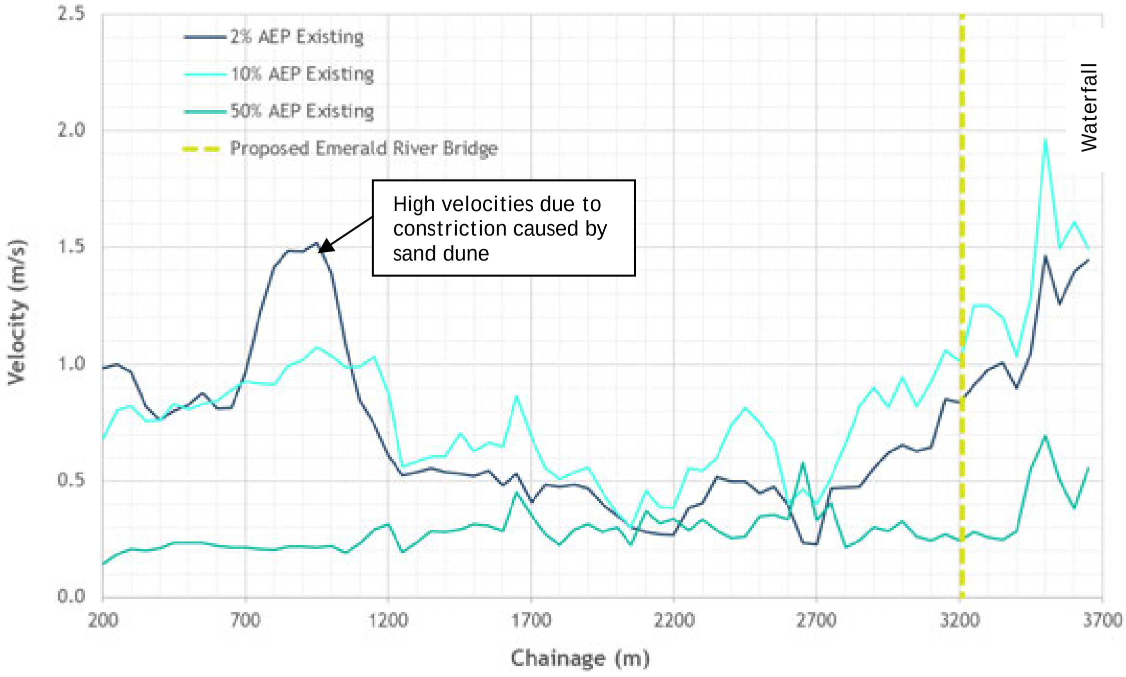


Figure 3.2 - Emerald River velocity longitudinal profile, 50%, 10% and 2% AEP events for existing conditions

The hydraulic model results show:

- Flows for events larger than 50% AEP break out onto the northern floodplain of the Emerald River and drain along a northern flood channel. The northern flood channel drains along several poorly-defined flow paths back to the Emerald River both upstream and downstream of the proposed Emerald River bridge. The model results indicate minor overtopping of the northern river bank for the 50% AEP event, with significant overbank flow occurring for larger events.
- The Emerald River has a gradient of about 0.6% over the 1 km reach upstream of the waterfall. A review of the topographic data and flood modelling results shows that the channel loses definition in this reach, with the 50% AEP event overflowing onto the adjacent floodplain and flowing at shallow depths, likely to compensate for the steeper gradient.
- The Eastern Tributary consists of a small channel and a broad, swampy floodplain in the upper reaches, becoming more confined as it gets closer to the Emerald River confluence. The gradient of the Eastern Tributary is relatively flat at about 0.2%.
- Flow velocities in the tidal reach of the Emerald River downstream of the proposed Emerald River bridge are very low for frequent events as a consequence of the flat bed gradient. As shown in Figure 3.2, velocities along this reach for the 50% AEP event are generally in the range of 0.3 to 0.5 m/s. For larger events, the dune at approximately chainage 1,000 m constricts flow, resulting in higher flow velocities through the constriction (up to about 2.2 m/s) and lower velocities upstream, generally in the range of 0.5 to 1.0 m/s. Velocities in this reach are very similar for the 10% and 2% AEP events. The dune is densely vegetated with mangroves and wet monsoonal vine thicket/rainforest vegetation consists predominantly of sand that and is therefore prone to erosion during overbank flood events as frequent as the 10% AEP event, given the higher hydraulic gradient across the dune as shown by Figure 3.1.

- It would appear that flows in between the proposed Emerald River bridge and the waterfall are in transition from the highly turbulent waterfall flows to the slow estuarine flows. For the 50% AEP event, velocities in this reach are quite low (in the range of 0.3 to 0.7 m/s). For the larger events (10% and 2% AEP) velocities vary from around 1.5 m/s at the waterfall to about 0.5 m/s at chainage 2,800 m, which is located downstream of the proposed bridge.
- A flood channel breaks out onto the southern floodplain of the Emerald River about 200 m upstream of the proposed haul road crossing. Modelling results show a minor break out for the 50% AEP event. The flood channel drains along the southern side of the Emerald River before draining back into the Emerald River about 500 m downstream of the proposed haul road crossing (Figure 2.4). The proposed causeway crosses this southern flood channel.
- In the reach of the proposed Emerald River bridge, the Emerald River channel is relatively straight. The channel then meanders with a very tight geometry for the next 1,000 m before it straightens out again to the river mouth (Figure 2.4).

3.2.2 Southern Tributary

Water level and channel flow velocity profiles along the Southern Tributary are shown in Figure 3.3 and Figure 3.4 respectively. No bathymetric data is available for the Southern Tributary and as such, the bed profile shown in Figure 3.3, is based on the available lidar survey.

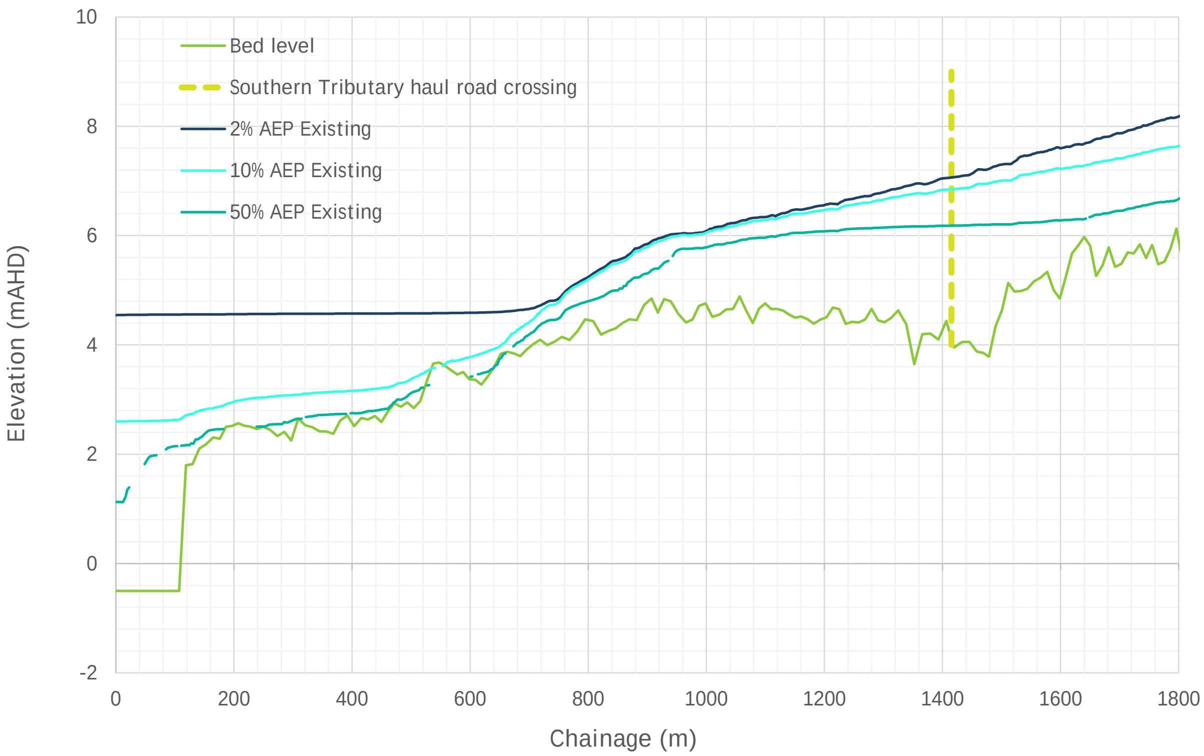


Figure 3.3 - Southern Tributary water level longitudinal profile, 50%, 10% and 2% AEP events for existing conditions

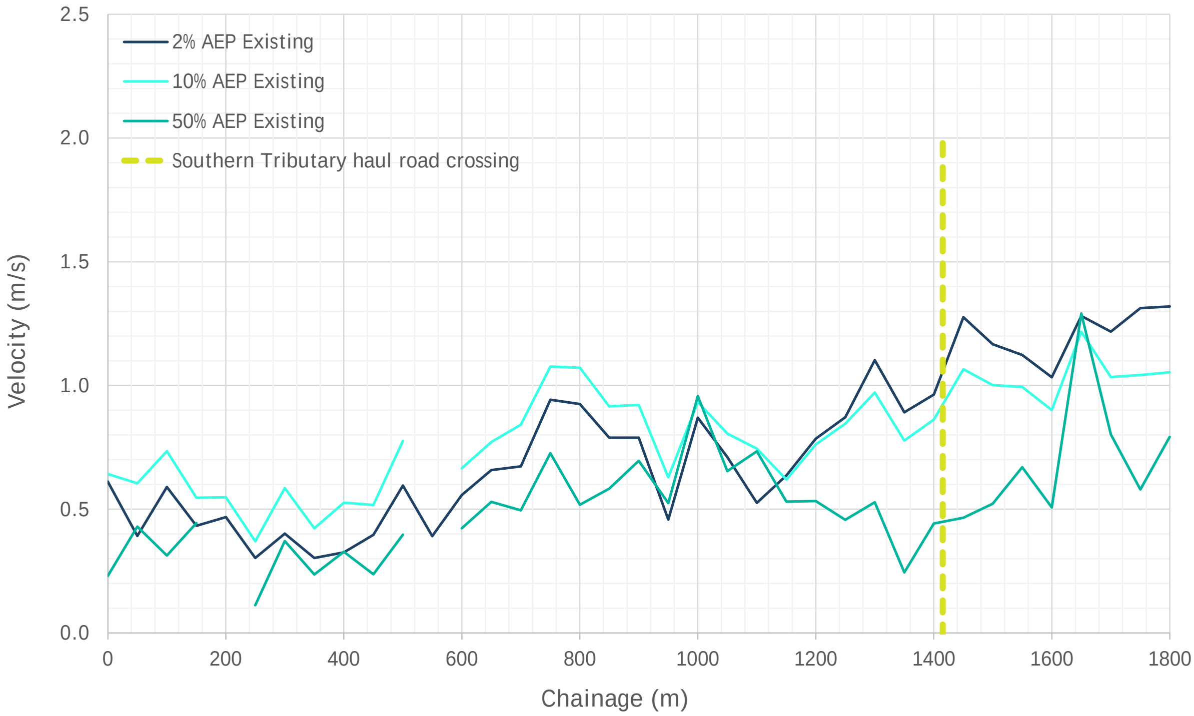


Figure 3.4 - Southern Tributary velocity longitudinal profile, 50%, 10% and 2% AEP events for existing conditions

The hydraulic model results show the following:

- The upper reach of the Southern Tributary (upstream of chainage 1,800 m [see Figure 2.4]) drains along a relatively confined low flow channel and floodplain for all flow events assessed.
- From chainage 1,800 m to chainage 1,000 m, the channel banks are perched above the adjacent floodplain and the floodplain widens significantly. The southern floodplain is the most prominent, carrying much of the flood flows for the larger events.
- At chainage 1,000 m (about 400 m downstream of the proposed haul road crossing), the channel loses definition with most flows draining onto both the southern and northern floodplains. Figure 3.3 shows that the peak 10% and 2% AEP flood levels at chainage 1,000 m are effectively the same. It would appear that the southern floodplain flood levels are still lower than the channel flood levels at this location, which suggests that the southern floodplain is flowing independently of the main channel even for the 2% AEP event.
- Downstream of chainage 1,000 m, flows disperse over much of the broad floodplain until it drains into the Emerald River. Peak flood levels are dominated by Emerald River backwater flooding for the larger events within this reach (see Figure 3.3). Modelling suggests that the Emerald River backwater does not extend up the Southern Tributary to the proposed haul road crossing for events up to the 1% AEP event.
- Peak velocities along the channel vary from an average of about 0.5 m/s for the 50% AEP event to about 0.8 m/s for the 10% and 2% AEP events. Lower velocities occur along the lower reach where backwater flooding from the Emerald River occurs.

3.3 SEDIMENT TRANSPORT

3.3.1 Overview

A review of the available topographic and aerial imagery suggests that the Emerald River downstream of the waterfall and the Southern Tributary carries very low sediment loads. There are no obvious deposits of sediment anywhere within the channels with the exception of the river mouth. The sand at the river mouth would appear to be deposited from coastal processes.

Although the reach upstream of the waterfall has steeper slopes, this does not appear to be contributing significant sediment loads.

3.3.2 Sediment characteristics

REE provided a sample of the bed and bank material at the proposed bridge crossing. The materials report for each sample are given in Appendix A. In summary, the bed material consists of a fine to medium sand with a D_{50} of approximately 0.2 mm. The bank material consists of a grey/mottled orange sandy silt with a D_{50} of also approximately 0.2 mm. The bank material is cohesive with a plastic limit of 19%.

3.3.3 Indicative sediment transport rates

Table 3.1 shows the range of channel bed shear stress and sediment discharge predicted at the peak of each event under existing conditions in the tidal reach of the Emerald River from chainage 200 m to chainage 3,650 m (proposed bridge at chainage 3,200 m) and along the Southern Tributary from chainage 0 m to chainage 1,800 m. Shear stress was calculated as follows:

$$\text{Shear stress} = \rho\ g\ R\ S$$

where ρ = water density, g = gravitational acceleration, R = hydraulic radius, S = hydraulic gradient

Peak sediment discharge was calculated using the Ackers and White (1973) formulae, which is intended to represent total sediment load (bed load and suspended load).

The results suggest that sediment transport rates in the tidal reach of the Emerald River are relatively low. For instance, a total of 36 m^3 per hour of sediment could potentially be transported at the peak of the 10% AEP event. Sediment transport rates for the 2% AEP are not significantly different and in fact bed shear is generally lower due to the impact of the sand dune downstream of the proposed haul road.

The steep channel upstream of the waterfall would suggest much higher sediment transport rates would be delivered to the downstream reach. However, the lack of sediment deposits within the reach in the vicinity of the proposed crossing would suggest that the rate of sediment supply is very low. The small low flow channel and the broad and shallow overland flows in the upstream reach would suggest that any entrained sediment has deposited in the upper reach rather than being transported downstream.

Sediment transport rates in the Southern Tributary are similarly low. Note that there is no bathymetric data for the Southern Tributary and as such, flood depths and therefore bed shear and sediment transport rates may be underestimated. Given the geometry of the waterway and floodplain, the underestimation is not expected to be significant.

Table 3.1 - Peak Bed Shear and sediment discharge rate, existing conditions

Parameter range per event	Emerald River		Southern Tributary	
	Bed Shear Stress (Pa)	Peak sediment discharge (m^3/s)	Bed Shear Stress (Pa)	Peak sediment discharge (m^3/s)
50% AEP event				
25%	0.4	0.000	2.0	0.000
Mean	0.7	0.000	3.9	0.000
75%	0.8	0.000	4.6	0.000
95%	2.3	0.001	8.2	0.002
10% AEP event				
25%	2.2	0.002	3.6	0.000
Mean	4.8	0.010	6.3	0.003
75%	5.9	0.012	8.3	0.004
95%	12.6	0.035	11.5	0.007
2% AEP event				
25%	1.2	0.002	1.9	0.000
Mean	3.5	0.013	5.2	0.004
75%	4.9	0.016	8.3	0.006
95%	11.6	0.056	12.1	0.014

4 Haul road impacts

4.1 OVERVIEW

The haul road design (REE, 2020) includes the following features for flood management:

- The Emerald River crossing will consist of a bridge over the Emerald River and a causeway on the southern floodplain; and
- The Southern Tributary crossing will consist of culverts on the Southern Tributary channel and another set of culverts on the southern floodplain separated by a causeway.

Details of these structures are as follows (REE, 2020):

- Emerald River:
  - a single 36 m span bridge; and
  - a 90 m wide causeway on the southern floodplain.
- Southern Tributary:
  - a 100 m causeway;
  - 7 x 1200 x 1200 mm box culverts (within the main channel of the Southern Tributary); and
  - 6 x 1300 mm diameter pipe culverts excavated below ground level on the southern floodplain together with a 400 m long channel to daylight the culverts.

Outlined below is an assessment of the predicted hydraulic impacts of the proposed haul road and the potential scour depths that could occur at the bridge.

4.2 EMERALD RIVER

4.2.1 Flood levels

Figure 4.1 shows water surface level profiles for existing conditions and with the proposed haul road. The proposed bridge results in maximum afflux of:

- 0.40 m for the 2% AEP event;
- 0.35 m for the 10% AEP event; and
- Less than 0.01 m for the 50% AEP event.

Afflux mapping by REE (2020) shows that flood level impacts are slightly higher on the northern floodplain than in the channel due to the obstruction of overbank flow.

4.2.2 Flood velocities

The impact of the bridge on flow velocities through the bridge waterway section is reported by REE (2020):

- No increase in velocity for the 50% AEP event;
- An increase in velocity from 1.4 to 2.0 m/s for the 10% AEP event; and
- An increase in velocity from 1.4 to 2.2 m/s for the 2% AEP event.

The construction of the haul road would reduce flood velocities upstream and downstream of the bridge, as shown in Figure 4.2 (negative values correspond to a reduction in flood velocity). The bridge would reduce velocities along the river channel by less than 0.5 m/s for the 2% and 10% AEP events. Reductions in velocity extend from about 500 m downstream (chainage 2,700 m) to where the southern floodplain flows re-join the main channel in close proximity to the waterfall, some 500 m upstream (chainage 3,700 m).

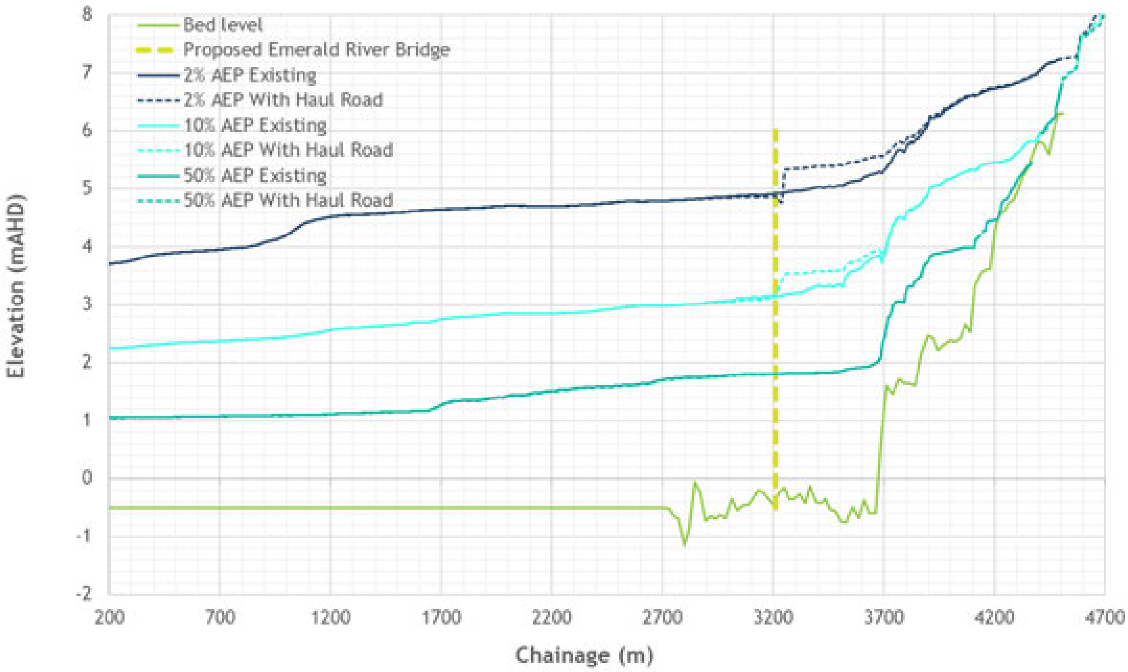


Figure 4.1 - Emerald River water level longitudinal profile, 50%, 10% and 2% AEP events, with and without proposed haul road

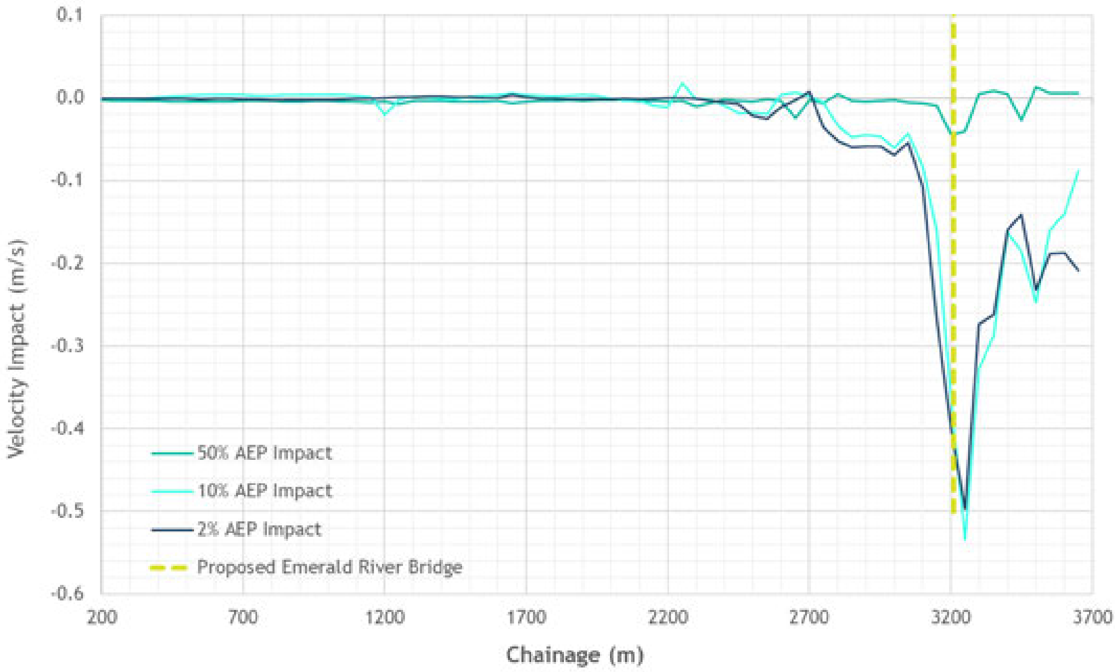


Figure 4.2 - Emerald River velocity impacts due to haul road, 50%, 10% and 2% AEP events

4.2.3 Bed shear stress

Figure 4.3 shows the impact of the project on bed shear stress along the tidal reach of the Emerald River for the 50%, 10% and 2% AEP events.

The project has negligible impact on shear stress for the 50% AEP event along the entire tidal reach. For the 10% and 2% AEP events, shear stress is generally reduced along the reach between the waterfall (chainage 3,700 m) and chainage 2,700 m (excluding the bridge waterway area) due to the distribution of flow onto the southern floodplain. There are no impacts downstream of chainage 2,700 m.

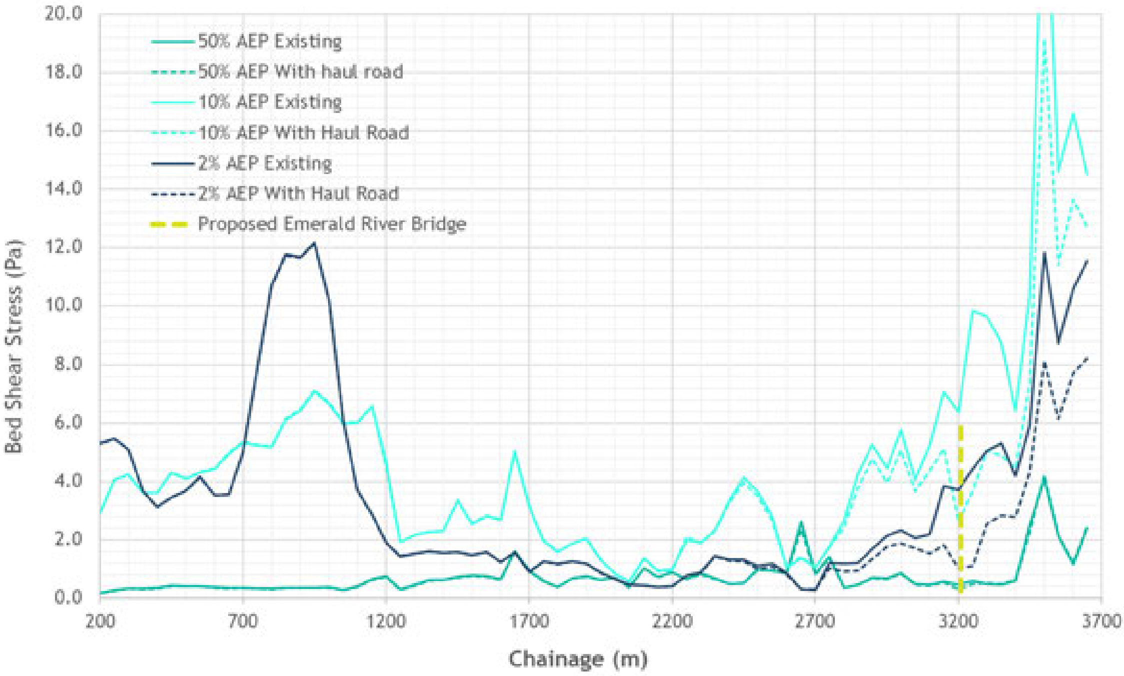


Figure 4.3 - Emerald River shear stress impacts due to haul road, 50%, 10% and 2% AEP events

4.2.4 Emerald River floodplain

The effect of the haul road is to obstruct the northern Emerald River floodplain and divert overbank flows to the causeway on the southern floodplain. This results in:

- elevated flood levels and reduced flow velocities on the northern floodplain; and
- elevated flood levels and increased flow velocities on the southern floodplain.

Peak floodplain flow velocities through the causeway and immediately upstream are up to about 2.5 m/s for the 2% AEP event. Erosion protection is proposed in the high velocity areas across and adjacent to the causeway in order to prevent scouring for this event. The overbank velocity increases along the southern floodplain are generally less than 0.1 m/s, which is negligible.

4.3 SOUTHERN TRIBUTARY

4.3.1 Flood levels

Figure 4.4 shows water surface level profiles for existing conditions and with the proposed haul road. The proposed crossing results in maximum afflux of:

- 0.40 m for the 2% AEP event;
- 0.31 m for the 10% AEP event; and

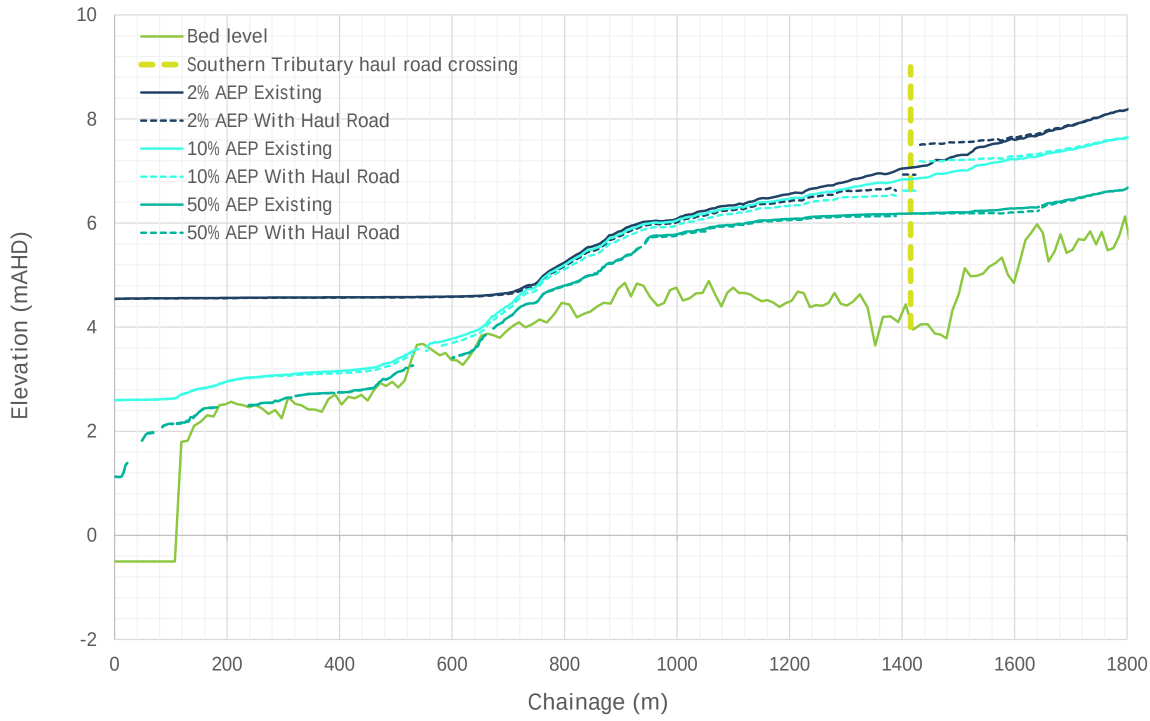


Figure 4.4 - Southern Tributary water level longitudinal profile, 50%, 10% and 2% AEP events, with and without proposed haul road

- About 0.01 m for the 50% AEP event.

Afflux mapping by REE (2020) shows that flood level impacts are slightly higher on the southern floodplain than in the channel due to the obstruction of overbank flow.

4.3.2 Flood velocities

Figure 4.5 shows the impact of the project on flood velocities along the Southern Tributary channel. The impact of the haul road on flow velocities downstream of the Southern Tributary culverts are as follows:

- a reduction in velocity from 0.6 m/s to 0.5 m/s for the 50% AEP event;
- a reduction in velocity from 0.9 m/s to 0.6 m/s for the 10% AEP event; and
- a reduction in velocity from 1.2 m/s to 0.9 m/s for the 2% AEP event.

The haul road would redistribute flows from the Southern Tributary channel onto the adjacent southern floodplain for the 10% and 2% AEP events, thereby reducing channel velocities (and channel flow). The reductions would extend to the Emerald River confluence because the flows diverted to the southern floodplain do not drain back to the Southern Tributary channel.

4.3.3 Bed shear stress

Figure 4.6 shows the impact of the project on bed shear stress along the Southern Tributary for the 50%, 10% and 2% AEP events. The project has negligible impact on shear stress for the 50% AEP event along the entire reach. For the 10% and 2% AEP events, shear stress is generally reduced both upstream and downstream of the haul road due to the distribution of flow onto the southern floodplain.

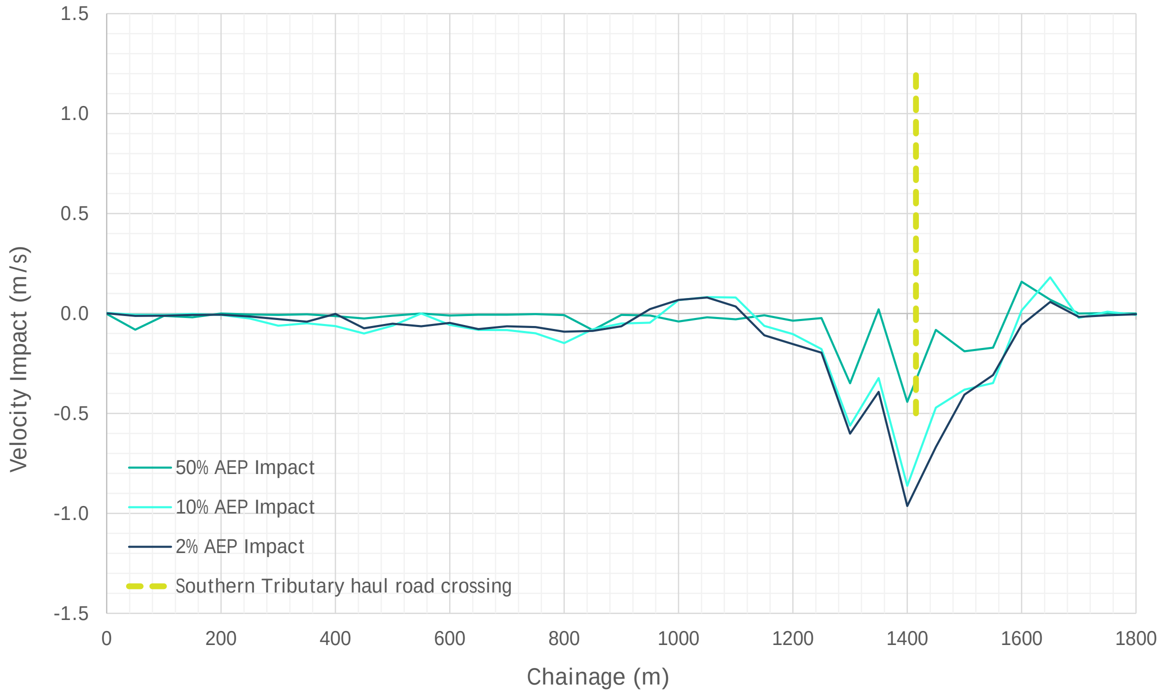


Figure 4.5 - Southern Tributary velocity impacts due to haul road, 50%, 10% and 2% AEP events

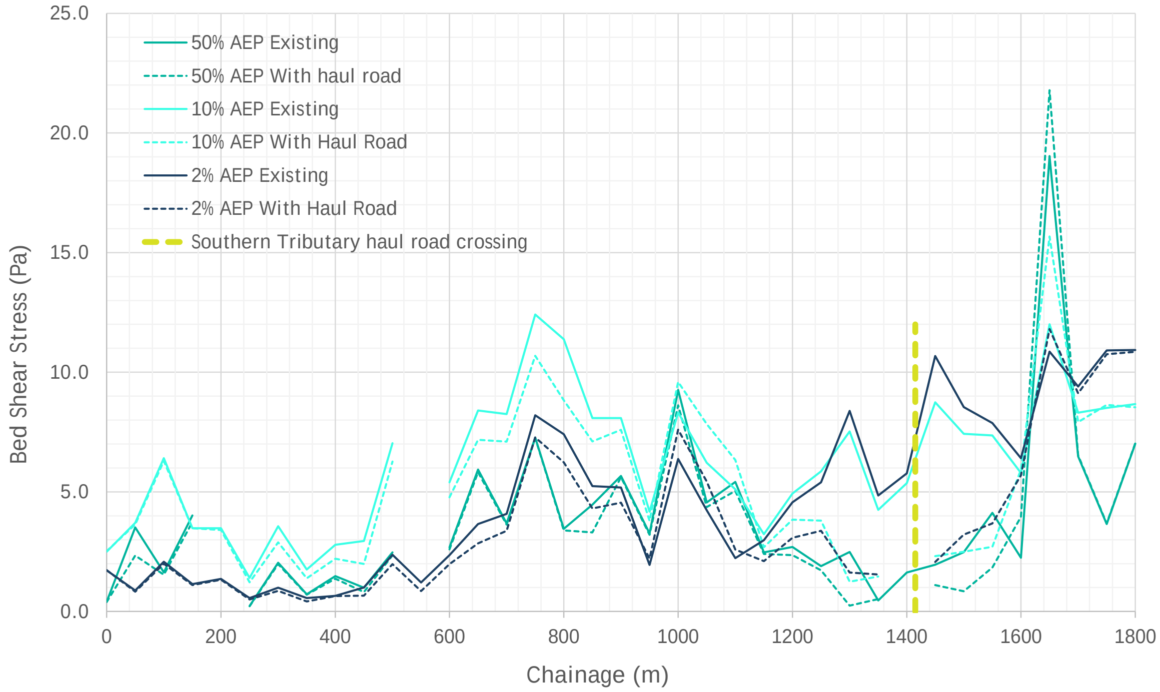


Figure 4.6 - Southern Tributary shear stress impacts due to haul road, 50%, 10% and 2% AEP events

4.3.4 Southern Tributary floodplain

The effect of the haul road is to divert flows from the Southern Tributary channel to the southern floodplain. This results in increased flows and flow velocities along the southern floodplain. Of note, there is a higher potential for floodplain scour along the southern bank of the Southern Tributary for a distance 10 m upstream of the culvert crossing and across the causeway section of the haul road where velocities exceeding 2 m/s are predicted for the 10% and 2% AEP events. Erosion protection is proposed to be installed in the high velocity areas in these locations in order to prevent scouring.

Erosion protection will also be placed in the excavated channel downstream of the southern floodplain culverts to reduce the potential for scour and to maintain the conveyance of the channel. The overbank velocity increases along the southern floodplain are generally less than 0.1 m/s, which is negligible.

4.4 EMERALD RIVER BRIDGE SCOUR DEPTHS

4.4.1 Overview

As discussed in Section 2.3, the Emerald River channel in the reach of the proposed bridge is relatively stable but could be prone to lateral channel migration (albeit over long periods of time).

The contraction caused by the proposed bridge could potentially cause localised scour. No piers are proposed within the waterway opening and therefore local scour would be due to the contraction of the waterway due to the abutments and embankments. The Southern Tributary crossing will consist of culverts and therefore will not result in contraction scour.

Note that TMR (2019) states that "all factors contributing to scour are subject to a significant degree of uncertainty; as such long-term predictions are difficult, as information available on major floods might be limited and the flow conditions may be altered by changes in catchment or climate". For these reasons, the scour estimates are indicative only.

4.4.2 Method of assessment

Local scour estimates have been made using three methodologies:

- the NCHRP (2010) abutment scour equations recommended in the Bridge Scour Manual (TMR, 2019) assuming both live bed scour and clear water scour;
- the pressure flow scour equation recommended in TMR (2019) as pressure flow occurs for all design events investigated; and
- the mean velocity method (Austroads, 2019).

A review of the hydraulic model results provided by REE showed that the constriction caused by the bridge and road embankment significantly altered the distribution of flow towards the causeway to the south of the bridge for the overflowing events. This redistribution significantly reduces channel velocities and peak discharges both upstream and downstream of the bridge for these events. The effect of this was that the NCHRP (2010) abutment scour and pressure flow equations recommended in the Bridge Scour Manual (TMR, 2019) assuming both live bed scour and clear water scour, are not valid. There was a minor contraction for the 50% AEP event and therefore the recommended NCHRP abutment scour and pressure flow scour equations remain valid for this event.

The hydraulic modelling of the proposed bridge, which was modelled as a 1-dimensional structure (in a similar manner to a pipe culvert), showed that peak velocities within the bridge waterway opening would increase above existing conditions and therefore had the potential to cause contraction scour. As a result, an estimate of contraction scour depth was calculated using the mean velocity method in Austroads (2019).

This methodology uses the concept of cross-sectional velocity as a criterion of contraction scour whereby the waterway opening under the bridge will increase in depth to reach a cross sectional area that matches the mean unrestricted (pre-bridge) channel velocity.

4.4.3 Contraction scour

Table 4.1 shows the hydraulic design data and the predicted scour depths determined from the three methodologies for the three design events. The hydraulic design data (channel discharge, depth and velocity) for each design event was determined by sampling the depth and velocity grids (provided by REE) at approximately 3 m increments across the channel at the proposed bridge. Note that the existing channel flow excludes all overbank flows. The following is of note:

- The NCHRP methodology (determined for the 50% AEP event) relates to potential abutment scour whereas the velocity and pressure flow methodologies relate to average channel scour depths. The NCRHP scour depths should be used for the abutments.
- The 2% AEP event produces the largest calculated scour depths peaking at 0.95 m.

Note that the scour depths are based on empirical equations using parameters that have many uncertainties but the results are sufficient to provide an indication of potential scour depths.

Table 4.1 - Emerald River Bridge scour depth calculations

Parameter	Design event (AEP)		
	50%	10%	2%
Existing channel			
Peak discharge (m^3/s)	12	96	168
Peak flow depth (m)	1.6	3.5	5.3
Average peak velocity (m/s)	0.29	1.2	1.2
Bridge section			
Peak discharge (m^3/s)	12	77	83
Average peak velocity (m/s)	0.33	2.1	2.7
Scour calculations			
Velocity methodology (m)	0.05	0.8	0.95
NCHRP methodology (m)	0.42	-	-
Pressure flow methodology (m)	0.03	-	-

5 Summary of findings

5.1 OVERVIEW

The J Quarry Haul Road has been designed to minimise geomorphic impacts on the Emerald River by spanning the river channel without piers or encroaching abutments. This allows minor flood flows to pass beneath the bridge with negligible impact on flood levels, velocities and sediment transport capacity. Low level causeways on the southern floodplain of the Emerald River will allow larger flood flows to overtop the haul road with minimal afflux.

An assessment of the erosion potential of the existing Emerald River channel and the Southern Tributary and an assessment of the impact of the proposed haul road has been undertaken based on hydraulic modelling completed by REE (2020).

5.2 EXISTING CONDITIONS

There has been a history of geomorphological changes to the location of the Emerald River channel across the floodplain where the proposed bridge will be located. The alluvial nature of the bank material and the tight meander geometry suggests that the channel is prone to lateral scour at the outside bends, leading to channel migration. However, the rate of change within the lower reach (downstream of the waterfall) would appear to be very slow due to the established channel bank and floodplain vegetation. Flood velocities in the Emerald River tidal reach downstream of the proposed bridge location are low due to bed levels being below mean sea level and the effect of coastal dunes that constrict the river floodplain.

Given that bed levels are already below mean sea level and there is little evidence of significant sediment loads, erosion due to channel aggradation or degradation is not expected unless a significant channel change event occurs in the upper reach.

5.3 HAUL ROAD IMPACTS

The proposed haul road crossing of the Emerald River consists of an elevated embankment, a bridge over the main channel and a low-level causeway. The haul road crossing for the Southern Tributary will consist of culvert structures in the channel and southern floodplain with a causeway in between.

A review of the model results suggests the following:

- For the 50% AEP event, there would be minimal changes to the flood behaviour with only minor scour occurring at the abutment of the Emerald River bridge and minimal change for the Southern Tributary. The Emerald River causeway would be inundated to a depth of 0.2 m and the Southern Tributary causeway would not be inundated during this event.
- For the 10% and 2% AEP events:
    - the haul road embankment diverts floodwater onto the southern floodplain and across the causeway for both the Emerald River and Southern Tributary crossings, which would reduce peak flood velocities along the channels both upstream and downstream of the bridge (Emerald River) and culvert (Southern Tributary); and
    - peak velocities within the Emerald River bridge waterway opening increase, which could potentially cause contraction scour depths of up to 0.8 m to 0.9 m. The scour is not expected to extend much past the bridge extents because of the reduced velocities upstream and downstream of the bridge.
- Sediment potentially won't fill the scour pool under the bridge during the falling limb of the flood events, as sediment transport rates are relatively low. Filling of

the pool may occur during successive smaller events and potentially from tidal flows.

- Notwithstanding the low sediment transport rates, any scour is likely to occur gradually (except if a large flood occurs in the wet season following construction). Therefore, sediment deposition along the downstream reach is not expected.

Overall, given the relatively low scour depths, the proposed haul road crossing is not expected to have a significant impact on the geomorphology or sediment transport rates of the Emerald River or the Southern Tributary.

6 References

Ackers and White, 1973	Sediment transport: New approach and analysis, *ASCE Journal of the Hydraulics Division, Vol. 99, HY11.*
Austroads, 2019	*Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures, Edition 2.1.* Austroads Ltd, published June 2019.
NCHRP, 2010	*Estimation of Scour Depth at Bridge Abutments, NCHRP Project 24-20, Draft Final Report, Transportation Research Board, National Academy of Science, National Cooperative Highway Research Program, Washington, D.C., U.S.A, (Ettema, R., Nakato, T., and Muste, M.).*
Nott, 1996	Long-term landscape evolution on Groote Eylandt, Northern Territory, *AGSO Journal of Australian Geology & Geophysics*, 16 (3), 303- 307.
REE, 2020	J Quarry Haul Road, Hydrology and Hydraulics Assessment Report, Report ref. J20055-001-R-Rev0, prepared by Red Earth Engineering, 23 July 2020.
TMR, 2019	*Bridge Scour Manual Supplement to Austroads Guide to Bridge Technology Part 8 Chapter 5: Bridge Scour (2018)* The State of Queensland (Department of Transport and Main Roads) 2019.

Appendix A - Sediment characteristics

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74128806735

Address:
QBirt Compound ,
Groote Eylandt Northern Territory

Laboratory: TSF11 Levee Wall Raise Annex
Phone: 07 4728 8023
Fax: 07 4728 8024
Email: peter.gode@constructionsciences.net

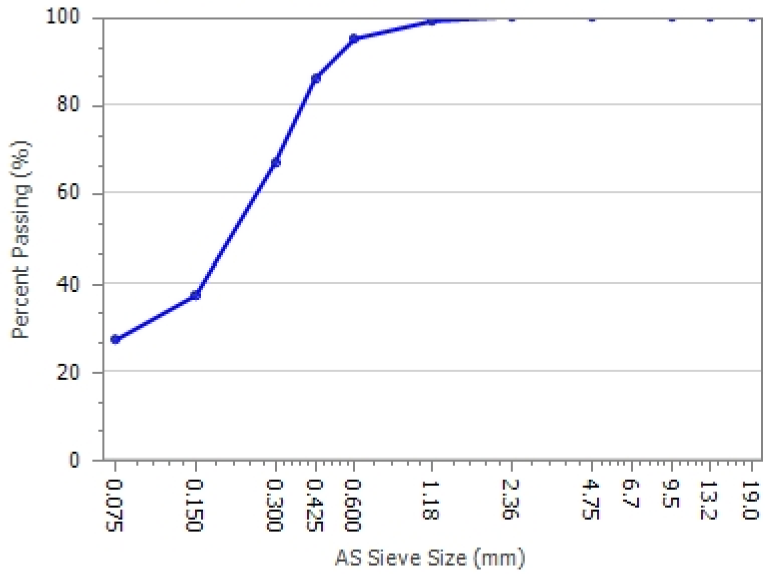
QUALITY OF MATERIALS REPORT

Client:	Q, H & M Birt	Report Number:	25071/R/120-1
Client Address:	Groote Eylandt, Alyangula	Project Number:	25071/P/1
Project:	TSF11 Levee Wall Raise	Lot Number:	TP09
Location:	Groote Eylandt	Internal Test Request:	25071/T/65
Component:	Material Quality	Client Reference/s:	TP09
Area Description:	J-Quarry Alignment	Report Date / Page:	2/12/2019 Page 1 of 3

Test Procedures	AS1289.3.6.1, AS1289.3.1.2			
Sample Number	25071/S/103	E	m	656806.56
Sampling Method	AS1289.1.2.1 Cl 6.5.4	N	m	8443074.01
Date Sampled	29/11/2019	RL	m	Not Provided
Sampled By	Client Sampled			0.4-0.6m
Date Tested	2/12/2019	Material Source	Test Pit	
Att. Drying Method	Air Dried	Material Type	Insitu	
Atterberg Preparation	Dry Sieved	Material Description	Fine-Medium Sand, Grey/Brown	

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
19.0		**100**	
13.2		**100**	
9.5		**100**	
4.75		**100**	
2.36		**100**	
1.18		**99**	
0.600		**95**	
0.425		**86**	
0.300		**67**	
0.150		**37**	
0.075		**27**	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**Not Obtainable**	
Plastic Limit (%)			
Plastic Index (%)			
Linear Shrinkage (%)			
Linear Shrinkage Defects			

Test Result	Specification Minimum	**Result**	Specification Maximum
0.075/0.425 Fines Ratio		**0.31**	
Weighted PI (%)		**-**	
LS x 0.425 Ratio (%)		**-**	
Particle Size Dist. Moisture Content (%)		6.8	

Remarks	Samples were collected near Emerald River as part of the J-Quarry Geotechnical Investigation

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation Number:	1986
Facility Number:	25071
Corporate Site Number:	10599
Base Laboratory Name:	Townsville Laboratory

Riley

Approved Signatory: Trent Riley
Form ID: W85MCRep Rev 1

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74128806735

Address:
QBirt Compound ,
Groote Eylandt Northern Territory

Laboratory: TSF11 Levee Wall Raise Annex
Phone: 07 4728 8023
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QUALITY OF MATERIALS REPORT

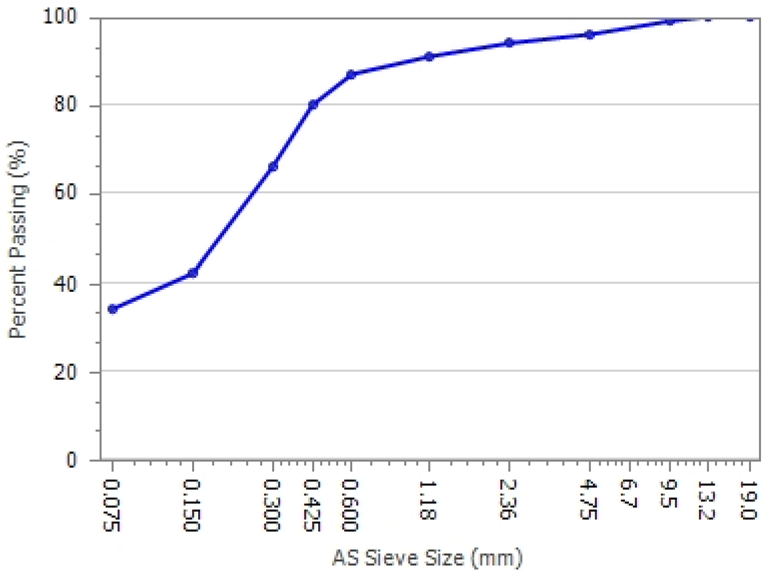
Client:	Q, H & M Birt	Report Number:	25071/R/120-1
Client Address:	Groote Eylandt, Alyangula	Project Number:	25071/P/1
Project:	TSF11 Levee Wall Raise	Lot Number:	TP09
Location:	Groote Eylandt	Internal Test Request:	25071/T/65
Component:	Material Quality	Client Reference/s:	TP09
Area Description:	J-Quarry Alignment	Report Date / Page:	2/12/2019 Page 2 of 3

Test Procedures: AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1

Sample Number	25071/S/104	E	m	656806.56
Sampling Method	AS1289.1.2.1 Cl 6.5.4	N	m	8443074.01
Date Sampled	29/11/2019	RL	m	Not Provided
Sampled By	Client Sampled			1.2-1.4m
Date Tested	2/12/2019	Material Source	Test Pit	
Att. Drying Method	Air Dried	Material Type	Insitu	
Atterberg Preparation	Dry Sieved	Material Description	Grey/mottled orange sandy silt	

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
19.0		**100**	
13.2		**100**	
9.5		**99**	
4.75		**96**	
2.36		**94**	
1.18		**91**	
0.600		**87**	
0.425		**80**	
0.300		**66**	
0.150		**42**	
0.075		**34**	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**28**	
Plastic Limit (%)		**19**	
Plastic Index (%)		**9**	
Linear Shrinkage (%)		**6.0**	
Linear Shrinkage Defects	-		

Test Result	Specification Minimum	**Result**	Specification Maximum
0.075/0.425 Fines Ratio		**0.43**	
Weighted PI (%)		**718.2**	
LS x 0.425 Ratio (%)		**478.8**	
Particle Size Dist. Moisture Content (%)		16.1	

Remarks: Samples were collected near Emerald River as part of the J-Quarry Geotechnical Investigation

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation Number:	1986
Facility Number:	25071
Corporate Site Number:	10599
Base Laboratory Name:	Townsville Laboratory

Riley

Approved Signatory: Trent Riley
Form ID: W85MCRep Rev 1

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74128806735

Address:
QBirt Compound ,
Groote Eylandt Northern Territory

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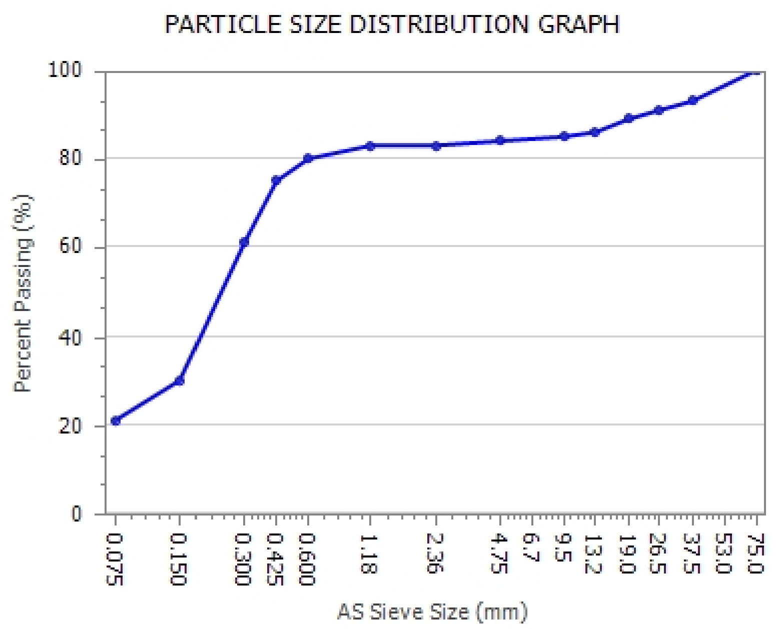
Client:	Q, H & M Birt	Report Number:	25071/R/120-1
Client Address:	Groote Eylandt, Alyangula	Project Number:	25071/P/1
Project:	TSF11 Levee Wall Raise	Lot Number:	TP09
Location:	Groote Eylandt	Internal Test Request:	25071/T/65
Component:	Material Quality	Client Reference/s:	TP09
Area Description:	J-Quarry Alignment	Report Date / Page:	2/12/2019 Page 3 of 3

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1			
Sample Number	25071/S/105	E	m	656806.56
Sampling Method	AS1289.1.2.1 Cl 6.5.4	N	m	8443074.01
Date Sampled	29/11/2019	RL	m	Not Provided
Sampled By	Client Sampled			2.8-3.0m
Date Tested	2/12/2019	Material Source	Test Pit	
Att. Drying Method	Air Dried	Material Type	Insitu	
Atterberg Preparation	Dry Sieved	Material Description	Orange/brown mottled grey clayey sandy silt	

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
75.0		**100**	
37.5		**93**	
26.5		**91**	
19.0		**89**	
13.2		**86**	
9.5		**85**	
4.75		**84**	
2.36		**83**	
1.18		**83**	
0.600		**80**	
0.425		**75**	
0.300		**61**	
0.150		**30**	
0.075		**21**	



Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**24**	
Plastic Limit (%)		**15**	
Plastic Index (%)		**9**	
Linear Shrinkage (%)		**3.0**	
Linear Shrinkage Defects	Cracking		

Test Result	Specification Minimum	**Result**	Specification Maximum
0.075/0.425 Fines Ratio		**0.29**	
Weighted PI (%)		**670.6**	
LS x 0.425 Ratio (%)		**223.5**	
Particle Size Dist. Moisture Content (%)		18.0	

Remarks: Samples were collected near Emerald River as part of the J-Quarry Geotechnical Investigation

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation Number:	1986
Facility Number:	25071
Corporate Site Number:	10599
Base Laboratory Name:	Townsville Laboratory

Approved Signatory: Trent Riley
Form ID: W85MCRep Rev 1

C

Aquatic Ecology Report

C&R CONSULTING
Geochemical & Hydrobiological Solutions Pty Ltd
ABN 72 077 518 784

Underground Coal Gasification / Coal Seam Gas Investigations
Mineralogical, Geological, Petrographic and Soils Services
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GEMCO – J QUARRY HAUL ROAD PROJECT

Aquatic Ecology Assessment

REPORT PREPARED FOR:
Hansen Bailey Pty Ltd on behalf of
Groote Eylandt Mining Company Pty Ltd

Date:
October 2020

IMPORTANT NOTE

Christopher Cuff

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Dr Chris Cuff
Director

2 October 2020
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Date

Cecily Rasmussen

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Dr Cecily Rasmussen
Director

2 October 2020
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Date

IMPORTANT INFORMATION

1. This report is prepared and written in the context of the proposals stated in the introduction to this report and its contents should not be used out of context. Furthermore new information, developing practices and changes in legislation may necessitate revised interpretation of the report after its original submission.
2. Where data have been supplied by the client or other sources, including data from previous site audits or investigations, it has been assumed that the information is correct, but no warranty is given to that effect. While reasonable care and skill has been applied in review of these data, no responsibility can be accepted by C&R Consulting for inaccuracies in the data supplied.
3. This report contains only available factual data obtained for the site/s from the sources described in the text. These data were related to the site/s on the basis of the location information made available to C&R Consulting by the client.
4. The assessment of the site/s is based on information supplied by the client, and on-site inspections by C&R Consulting.
5. The report reflects both the information provided to C&R Consulting in documents made available for review and the results of observations and consultations by C&R Consulting staff.

SUMMARY OF RELEVANT INFORMATION

Project Title	GEMCO – J Quarry Access Corridor
Property Location	Groote Eylandt Western Lease ML961 and Exploration tenement EL2455
Property Description	Manganese mine
Project Purpose	Document the aquatic flora and fauna communities inhabiting the different ecosystems observed and determine potential impacts from the proposed project.
Project Number	18024
Client's Details	
Nominated Representative	Laura Knowles
Title/Position	Principal Environmental Scientist
Company	Hansen Bailey Pty Ltd
Acknowledgements	We would like to thank Mike Chapman, Luke Campbell and Shane Stevens of South32 for their assistance in the field.

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LIST OF ABBREVIATIONS

% Sat	–	Percent Saturation
°C	–	Degrees Celsius
µS/cm	–	Micro-Siemens per centimetre
ALC	–	Anindilyakwa Land Council
ALRA	–	*Aboriginal Land Rights Act (Northern Territory) 1976*
ANZECC	–	Australian and New Zealand Environment and Conservation Council
ARMCANZ	–	Agriculture and Resource Management Council of Australia and New Zealand
AusRivAS	–	Australian Rivers Assessment System
BOM	–	Bureau of Meteorology
C&R	–	C&R Consulting Pty Ltd
CSIRO	–	Commonwealth Scientific and Industrial Research Organisation
DAWE	–	Department Agriculture, Water and the Environment
DENR	–	Department of Environment and Natural Resources (Northern Territory Government)
DO	–	Dissolved oxygen
DPIR	–	Department of Primary Industries and Resources (Northern Territory Government)
DSEWPaC	–	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth Government)
EC	–	Electrical conductivity
EPBC Act	–	*Environment Protection and Biodiversity Conservation Act (1999)*
IPA	–	Indigenous Protected Area
km	–	Kilometre(s)
km^2	–	Kilometres squared
mg/L	–	Milligrams per litre
mm	–	Millimetre(s)
NATA	–	National Association of Testing Authorities
NT	–	Northern Territory
NTU	–	Nephelometric Turbidity Units
PET richness	–	Number of Plecoptera, Ephemeroptera and Trichoptera (PET) families present at a site
SIGNAL	–	Stream Invertebrate Grade Number – Average Level
TPWC Act	–	*Territory Parks and Wildlife Conservation Act 1976*
WONS	–	Weeds of National Significance

1. INTRODUCTION

C&R Consulting Pty Ltd was commissioned by Hansen Bailey on behalf of Groote Eylandt Mining Company Pty Ltd (GEMCO) to complete an aquatic ecology impact assessment report as part of the environmental approval application for the J Quarry Haul Road (the project). The proponent of the project is GEMCO, which has two shareholders - South32 Limited (60%) and Anglo Operations (Australia) Pty Ltd (40%).

GEMCO operates an existing manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650 km south-east of Darwin. The mine has been operating since the 1960s in multiple mineral leases known as the Western Leases (Figure 1). These tenements were granted in the 1960s, 1970s and 1980s. GEMCO's existing operations in the Western Leases are located on the northern side of the Emerald River. In 2023, mining is scheduled to progress into the southernmost mineral lease (ML961), which contains a future mining area known as J Quarry, located on the southern side of the Emerald River (Figure 2). ML961 includes an access corridor connecting the existing mine to J Quarry. However, GEMCO is unable to develop a haul road within the access corridor because of restrictions relating to an Aboriginal sacred site. An alternative alignment for the access corridor is therefore required.

The project involves the development of a haul road within an alternate alignment of the access corridor. The key elements of the project are shown in Figure 3 and are limited to project elements and activities that are located beyond the existing tenements. The project involves:

- Construction of a haul road that links existing mining operations to J Quarry. On the northern side of the Emerald River, within the floodplain of the river, the road will be constructed on an embankment. On the southern side of the river it will be constructed as a causeway on the floodplain. A bridge will be required for crossing the Emerald River. The haul road will also traverse an ephemeral tributary of the Emerald River, known as the Emerald River Southern Tributary (Figure 2), via a series of culverts.
- Construction of a construction access track to enable construction equipment to access the area to the south of the Emerald River.
- Realignment of an existing public access track to enable safe public access to the western coast of Groote Eylandt. The realignment includes construction of an underpass of the haul road.

The project site for the purposes of environmental assessment is the area to be disturbed by these project elements (Figure 3). The project site is approximately 24 ha. All haul road development activities (and associated mining activities) located within the Western Leases are authorised under existing approvals and are not included in this assessment.

The land within the access corridor is Aboriginal land, designated under the *Aboriginal Land Rights Act (Northern Territory) 1976* (Cth). The project site comprises natural bushland dominated by Eucalyptus and Melaleuca open woodlands, as well as riparian woodlands along the Emerald River and the Emerald River Southern Tributary.

The township of Angurugu is located approximately 10 km to the north of the J Quarry Haul Road, and is the closest residential community (Figure 1). The Yedikba outstation is located approximately 450 m to the east of the haul road and is intermittently used by Traditional Owners.

1.1 SCOPE

This aquatic ecology assessment provides a baseline assessment of the Emerald River and a tributary of the Emerald River referred to as the Southern Tributary. The baseline assessment includes the section of the river shown in Figure 4 (termed the "project site" in this report). The report also includes an assessment of the impacts of the project on the aquatic ecology in the Emerald River and the Southern Tributary.

The report includes:

- Section 2 – A detailed description of the regional setting, including the environmental values of the Emerald River catchment.
- Section 3 – A review of relevant Territory and Federal legislation, regulations, policies and guidelines.
- Section 4 – An overview of the methods used to determine the aquatic flora and fauna communities inhabiting the site, including a literature review and detailed field surveys.
- Section 5 – Results of the aquatic ecology study, outlining:
    - The watercourse and habitats present as well as describing their condition;
    - The water and sediment quality observed within the watercourse and associated tributary;
    - The macroinvertebrate communities within the project site;
    - The fish communities present and known to occur throughout the greater catchment;
    - The turtle communities and other vertebrate species documented across the project site;
    - The potential for listed aquatic species to occur within the project site; and
    - Aquatic and riparian flora species.
- Section 6 – An assessment of the likely impacts from the project to the identified aquatic values of the Emerald River system including discussion of mitigation measures;
- Section 7 – A summary of the major findings of the study.

2. REGIONAL SETTING

The project site is located on the western side of Groote Eylandt in the Gulf of Carpentaria, approximately 50km off the east coast of Arnhem Land (Figure 1). Groote Eylandt is the fourth largest island off the Australian mainland covering approximately 2,285km^2. The island is Aboriginal land, scheduled under the *Aboriginal Land Rights Act (Northern Territory) 1976* (ALRA). The Anindilyakwa Land Council (ALC), operating on behalf of the Traditional Owners, is responsible for Groote Eylandt.

Groote Eylandt and the surrounding waters are covered by the Anindilyakwa Indigenous Protected Area (IPA), with rich and unique flora and fauna communities known to inhabit the area.

Mining of manganese on the western side of the island commenced in the early 1960s with GEMCO now operating the mine. Mining is currently undertaken within the Western Leases, with an approval to extend mining into the Eastern Leases (Figure 1). The Southern Lease is an exploration tenement (Figure 1).

2.1 SURFACE WATERS

The project study area encompasses the estuarine and downstream freshwater section of the Emerald River on Groote Eylandt (Figure 4). The J Quarry mineral lease (ML961) includes an approved tenement for an access corridor connecting the existing mine to J Quarry. This tenement traverses the Emerald River near the freshwater/estuarine interface as well as its main tributary (Figure 5).

The Emerald River's headwaters start in the 'White Rock' escarpments, with a total catchment area encompassing ~9,500ha. As the river traverses the landscape towards the gulf, the relatively flat, low-lying topography forms heavily vegetated shallow gradient valleys converging onto coastal plains. This topography promotes the establishment of off-channel wetlands during the wet season when flooding flows expand across the coastal plains.

While many of the drainage lines throughout the region are highly ephemeral, only flowing for short periods (<2 months) after substantial rainfall events, the main arm of the Emerald River is primarily spring fed, maintaining flows all year round (Figure 5).

The entire upstream catchment is relatively untouched by anthropogenic disturbances with only the occasional 4WD track, the public (unpaved) road and an Aboriginal settlement (Yedikba Outstation) present in the area. The most notable watercourse crossing is the Emerald River Bridge which crosses the lower Emerald River approximately 4 kilometres from the mouth of the River. Downstream regional land uses include the existing GEMCO mine which borders the northern bank of the Emerald River, and recreational areas (Figure 5). Mining activities have been approved within the Eastern Leases (ML31219 and ML31220) which are located in the upstream catchment, although works have not commenced.

2.2 ENVIRONMENTAL VALUES

Groote Eylandt (and its surrounding waters) has been declared a Site of Conservation Significance by the Northern Territory (NT) Government Department of Natural Resources, Environment, The Arts and Sport (NRETAS; Appendix 6). This is based on:

(a) the relatively untouched nature of the region;

(b) the limited presence of threatening processes generally associated with the mainland (e.g. feral animals, land clearing, etc.);

(c) the high diversity of flora and fauna communities (approximately 900 plants and 330 vertebrates); and

(d) the presence of 12 known threatened species.

The region also has significant cultural values. Several Aboriginal communities exist on Groote Eylandt, with traditional ecological knowledge passed down through the generations. The island was named by Dutch explorer Abel Tasman in 1644 with the first European settlement (a Christian mission) established in 1921 on the Emerald River with remnants of a wharf still visible (Figure 6).

The NT *Water Act 1992* provides the framework to delineate and protect the environmental values of a system. Under the *Water Act 1992*, identified environmental values can be formalised as beneficial uses through a process of statutory declaration. The beneficial uses declared for the Emerald River catchment include:

- High conservation value of aquatic ecosystems;
- Recreational use, including swimming and aesthetic values;
- Human consumption (i.e. drinking water); and
- Cultural heritage values.

2.3 CLIMATE

The climate of the region is typical of northern tropical Australia, and is dominated by intense rainfall events throughout the summer months of each year (wet season). These rainfall events are often highly variable in their spatial and temporal distribution, with the majority of the rain falling in distinct, spatially separated cells across the landscape. The mean annual rainfall for the region is 1,290.3mm, with approximately 94% of the rain falling between November and April (inclusive) each year (based on 22yrs of data from Bureau of Meteorology (BOM) station 14518; BOM, 2020).

Temperatures range from 13.7ºC (April 2008) to 40.7ºC (December 2018) during the wet season and 7ºC (June and July 2004) to 39.1ºC (October 2011) during the dry season (Figure 7; BOM, 2020). The temperature data show marginal variation throughout the year although temperatures do increase in October and November each year with the 'build-up' to the monsoonal wet season, easing after the seasonal rainfall begins.

The 2017-2018 wet season (after which sampling was undertaken) commenced with November 2017 (248.2mm) recording rainfall totals well above the monthly average (121.3mm; Figure 8). The remainder of the wet season generally recorded below average rainfall, except for January 2018 (Figure 8). Total rainfall in the region over the 12 months prior to sampling (1,056.8mm) was well below the long term average (1,290.3mm). The below average rainfall received toward the end of the 2017-2018 wet season suggests that ephemeral creeks within the region possibly dried earlier in 2018 than in years receiving average rainfall throughout the wet season.

2.4 SURFACE GEOLOGY

The geology of Groote Eylandt has been described by Bolton *et al.* (1990) and Munson *et al.* (2013). A summary of these studies is provided within this section.

Groote Eylandt lies on the eastern margin of the Proterozoic McArthur Basin. The ore deposit is developed within flat lying cretaceous rocks on a basement of Palaeoproterozoic crystalline rocks and Mesoproterozoic quartzite (Groote Eylandt Beds).

Early to Middle Cretaceous sediments of the Mullaman Beds (Walker River Formation) overlie the deeply dissected Groote Eylandt Beds. These sediments occupy two small basins located on the western (northern basin) and the south western (southern basin) of the island. In the northern basin, the oldest Mesozoic strata are unfossiliferous quartz sandstone derived from the underlying Proterozoic quartzite of the Palaeoproterozoic Dalumbu Sandstone. The Cretaceous units are overlain, probably conformably, by a shallow marine glauconite clay stone sequence. The top of this latter lithology contains the primary pisolitic and oolitic manganese ores. These, in turn, are succeeded by secondary ore, concretionary manganese and other weathering products.

In the Emerald River region (containing Deposits D, H and J) the Dalumbu Sandstone outcrops, as do occurrences of pisolitic manganese nodules and sequences of Cenozoic gravel, sand and silt deposits. These outcrops are often intersected by river channel flood plain and swamp sediments as well as coastal zone deposits (cheniers, beach ridges and marine mud). The surficial occurrences of manganese pisolites are underlain by subsurface manganese-rich rocks.

Lateritisation, probably of Cenozoic age, has altered most of the surface sediments to laterite of lateritic conglomerates and breccias. These rocks, up to 25m thick, consist of mainly ferruginous soft and indurated red, brown and yellow mottled clays and sandy clays. There are also occurrences of goethitic and manganiferous pisoliths with occasional pebbles and clasts of manganese oxide and orthoquartzite, where exposed lateritisation has truncated the ore zone to give a wide variety of secondary rock-types including manganiferous spherelites, concretions, dendrites and massive layers of secondary manganese oxides. Sand dunes of Quaternary age cover much of the eastern and southern coastal plains together with a cover of clayey and sandy soils and alluvium.

The base geology exists within the contexts of a series of Land Zone Types within which specific soil types occur. This will influence the sediment composition of waterways.

2.5 SOILS

The soils within the greater catchment area are highly similar and closely related to the present day landform and catchment processes. Within the upper reaches, soil composition is controlled by the geology. Large areas of bare rock form rugged plateaux, steep slopes and narrow gorges. Where soils are present they are observed as a thin veneer of leptic rudosols or tenosols having little pedological organisation. The soils in these areas are generally derived from the underlying geology, are slightly to moderately erosive and are nutrient poor.

Immediately adjacent but down slope of the bare rock plateaux areas are colluvial foot slopes. The soil formation within this zone is more widely spread than the plateaux. These soils still have little pedological organisation and are classified as leptic tenosols. Again, these soils are only slightly erosive and nutrient poor.

Below the colluvial foot slopes lies a complex of alluvial flood plain deposits. The soils within this area are predominantly controlled by the alluvial processes of creeks and rivers with further influence from the underlying geology as well as biological processes. These soils generally have moderate to well pedological organisation. Soils within the alluvial flood plain area include kandosols, chromosols and hydrosols. The erosive and nutrient properties of these soils are varied. The red and yellow kandasols are deep profiles derived from crystalline rock. These soils exhibit thin organic/organic-mineral layers overlying a deep leached sandy loam layer. The organic content of these soils are moderate but they are not susceptible to erosion. The hydrosols of the alluvial plain are associated with wetlands and areas that have impeded drainage. They are often organic rich and exhibit swell and shrink properties similar to vertisols, although these soils are generally not susceptible to erosion.

Below the alluvial flood plain are the marine estuarine units. This includes tidal mudflats, coastal floodplains with channels and the estuary, undulating coastal sandplains with parabolic dunes and beach ridge chenier plains. The soils within these areas are predominantly hydrosols that are prone to various types of inundation. These soils may be relatively high in nutrients due to the accumulation of mangrove debris as well as prone to erosion due to a high sodicity. Additional significant areas of orthic tenosols and arenic rudosols are observed where sandplains and dune fields occur. These areas are generally nutrient poor and prone to erosion via natural Aeolian processes.

3. RELEVANT REGULATORY FRAMEWORK

The legislation, policies and regulations which are considered to be relevant to the management of aquatic ecology in the project area are discussed in the following sections and include:

- The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;
- Ramsar and Nationally Important Wetlands;
- The NT *Territory Parks and Wildlife Conservation Act 1976*;
- The NT *Fisheries Act 1988* and the associated Regulations; and
- The NT *Water Act 1992* and associated Regulations.

3.1 COMMONWEALTH LEGISLATION AND POLICIES

3.1.1 *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999*

The Commonwealth Department of Agriculture, Water and the Environment (DAWE) administers the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action likely to have a significant impact on a Matter of National Environmental Significance (MNES) is subject to assessment under the EPBC Act approval process.

Threatened species listed under the EPBC Act which have the potential to inhabit the project site were considered in this assessment. Database searches identified twenty-two (22) aquatic species of MNES with the potential to occur within a 20km radius of the project site (refer to search results in Appendix 6). Of these, thirteen (13) are listed as threatened, including:

- The Blue Whale (*Balaenoptera musculus*) listed as Endangered;
- the Speartooth Shark (*Glyphis glyphis*) listed as Critically Endangered;
- the Dwarf Sawfish (*Pristis clavata*) listed as Vulnerable;
- the Largetooth Sawfish (*Pristis pristis*) listed as Vulnerable;
- the Green Sawfish (*Pristis zijsron*) listed as Vulnerable;
- the Loggerhead Turtle (*Caretta caretta*) listed as Endangered;
- the Green Turtle (*Chelonia mydas*) listed as Vulnerable;
- the Leatherback Turtle (*Dermochelys coriacea*) listed as Endangered;
- the Hawksbill Turtle (*Eretmochelys imbricate*) listed as Vulnerable;
- the Olive Ridley Turtle (*Lepidochelys olivacea*) listed as Endangered;
- the Flatback Turtle (*Natator depressus*) listed as Vulnerable;
- the Great White Shark (*Carcharodon Carcharias*) listed as Vulnerable;
- the Whale Shark (*Rhincodon typus*) listed as Vulnerable.

A number of these species are also listed as Migratory under the EPBC Act. Further discussion on the likelihood of these species inhabiting the project site based on the field work and literature review undertaken for this study are provided in Sections 5.6.3 and 5.7.

An additional nine MNES aquatic species were also identified within database searches as potentially occurring within a 20km radius of the project site and are listed as a Migratory Marine species under the EPBC Act, but are not threatened (refer to Section 5.8 for further discussion):

- Estuarine Crocodile (*Crocodylus porosus*);

- Dugong (*Dugong dugon*);
- Narrow Sawfish (*Anoxypristis cuspidate*);
- Bryde's Whale (*Balaenoptera edeni*);
- Reef Manta Ray (*Manta alfredi*);
- Giant Manta Ray (*Manta birostris*);
- Australian Snubfin Dolphin (*Orcaella heinsohni*);
- Indo-Pacific Humpback Dolphin (*Sousa chinesis*); and
- Killer Whale (*Orcinus orca*).

Additionally, several species of Pipefish (18 species), Seahorse (4 species), Seasnake (18 species), and dolphin (6 species) with the potential to occur in the area, are listed as Marine and/or Cetacean under the EPBC Act, but are not threatened. However, the project site is not within a Commonwealth Marine Area (the nearest being approximately 20km south of the project site). Therefore, these species are not specifically assessed within this report.

3.1.2 RAMSAR AND NATIONALLY IMPORTANT WETLANDS

Internationally Important Wetlands are identified under the Ramsar Convention, an international cooperative designed to conserve wetlands. Signatories (of which Australia is one) to the Ramsar Convention (also known as The Convention on Wetlands of International Importance) aim to halt the worldwide loss of wetlands and conserve the unique systems that remain. Ramsar wetlands are those that are representative, rare or unique wetlands, or are important for conserving biological diversity. Within Australia, Ramsar wetlands (or Internationally Important Wetlands) are protected under the EPBC Act.

Nationally Important Wetlands are determined via a set of six criteria (generally applied by State and Territory regulatory bodies) of which a wetland must meet at least one to be regarded as a Nationally Important Wetland. Once declared a Nationally Important Wetland the biological, ecological and hydrological information associated with the wetland is documented within the Directory of Important Wetlands. Nationally Important Wetlands are not protected under the EPBC Act, but may be protected under corresponding State or Territory legislation.

The Directory of Important Wetlands, managed by DAWE, is an online database that lists Internationally and Nationally Important Wetlands. The directory provides data and information about important wetlands on which to base management decisions. A search of the Directory of Important Wetlands identified no protected Internationally (Ramsar) or Nationally Important Wetlands occurring on or downstream of the project site.

3.2 NORTHERN TERRITORY LEGISLATION AND GUIDELINES

3.2.1 *TERRITORY PARKS AND WILDLIFE CONSERVATION ACT*

The *Territory Parks and Wildlife Conservation Act 1976* (TPWC Act), administered by the NT Department of Environment and Natural Resources (DENR), provides the framework to ensure the protection and conservation of biodiversity as well as the sustainable use of native flora and fauna populations within the NT. The TPWC Act details:

- The classification and management of wildlife;
- The classification and control of feral animals;
- The permitting requirements to take wildlife and/or enter protected lands; and
- The designation and management of protected lands.

The TPWC Act allocates native flora and fauna species into several categories (aligned with those developed by the International Union for the Conservation of Nature) dependent on the level of management required to ensure their conservation, including:

- Extinct;
- Extinct in the wild;
- Critically endangered;
- Endangered;
- Vulnerable;
- Near threatened;
- Least concern;
- Data deficient; and
- Not evaluated

Species considered 'threatened' and thereby protected under the TPWC Act are classified as either Extinct in the wild, Critically Endangered, Endangered, or Vulnerable. The list of threatened fauna species protected under the TPWC Act includes amphibians, birds, invertebrates, mammals and reptiles. No fish species are currently protected under the TPWC Act, although several species are allocated threatened species status under the Act. Instead, fish species are protected under the *Fisheries Act 1988* (refer to 3.2.2 for further discussion).

Several aquatic wildlife species with the potential to inhabit the project site are listed as threatened (and protected) under the TPWC Act, including the:

- Leatherback Turtle (*Dermochelys coriacea*) listed as Critically Endangered under the TPWC Act;
- Hawksbill Turtle (*Eretmochelys imbricate*) listed as Vulnerable under the TPWC Act;
- Loggerhead Turtle (*Caretta caretta*) listed as Vulnerable under the TPWC Act; and
- Olive Ridley Turtle (*Lepidochelys olivacea*) listed as Vulnerable under the TPWC Act.

Note: these four species are also listed as threatened under the EPBC Act. Further, the Estuarine Crocodile is not listed as threatened under the TPWC Act.

3.2.2 *FISHERIES ACT* AND ASSOCIATED FISHERIES REGULATIONS

The Department of Primary Industry and Resources (DPIR) administers the *Fisheries Act 1988* and associated Fisheries Regulations. These legislative tools protect, conserve and manage fish populations, fish habitat and aquatic life in the NT. The main aim of the *Fisheries Act 1988* is to ensure the sustainability of fisheries and fishery resources via regulation (e.g. permitting and licensing), conservation and management.

Threatened fish species as allocated under the TPWC Act are protected under Part 3, Division 1 of the Fisheries Regulations, which states:

> "*A person shall not take, whether as by-catch or otherwise, fish or aquatic life which is a protected species under the Territory Parks and Wildlife Conservation Act*".

Four fish (elasmobranch[1]) species with the potential to inhabit the project site are currently listed as protected under the TPWC Act, including:

- The Speartooth Shark (*Glyphis glyphis*);
- The Green Sawfish (*Pristis zijsron*);

[1] Elasmobranch – cartilaginous fish that have five to seven lateral to ventral gill openings on each side. The subclass Elasmobranchii (for which elasmobranch is the common name) includes sharks, rays (which includes sawfish), skates and some extinct fishes.

- The Largetooth Sawfish (*Pristis pristis*); and
- The Dwarf Sawfish (*Pristis clavata*).

Note: these four species are also protected under the EPBC Act. No other aquatic wildlife with the potential to inhabit the freshwater reaches of the project site are listed as threatened under the TPWC Act. The potential for the four fish species to utilise the project site is discussed further in Section 5.6.3.

3.2.3 *WATER ACT* AND ASSOCIATED WATER REGULATIONS

The *Water Act 1992*, administered by the DENR, provides for the sustainable management of water resources as well as any other resources with the potential to impact water resources. This is achieved through a range of processes including the investigation, allocation, use, control, protection, management and administration of water resources.

Previously, water licensing provisions under the *Water Act 1992* did not apply to mining activities. However, recent amendments to the *Water Act 1992* apply to 'water use' by mining activities. 'Water use' by mining activities includes:

- Interfering with a waterway (e.g. diversions, dams, weirs, etc.);
- Taking groundwater or water from a waterway for other than stock and/or domestic purposes;
- Undertaking bore work (e.g. drilling, decommissioning, etc. water bores); and
- Recharging an aquifer.

'Water use' will now require a range of licences and permits for the following activities:

- Water bore work for a mining activity must be undertaken by, or under the supervision of, a driller granted the relevant licence under the *Water Act 1992*;
- Water bore work undertaken for a mining activity in a Water Control District will require a permit granted under the *Water Act 1992*; and
- Taking water from a waterway or bore (including for dewatering) by a mining activity (other than for stock and/or domestic use) requires a licence granted under the *Water Act 1992*.

The *Water Act 1992* also provides the framework to delineate and protect environmental values. Under the *Water Act 1992*, identified environmental values can be formalised as beneficial uses through a process of statutory declaration. However, no beneficial uses have been declared for the watercourses targeted within this study. Instead, the potential environmental values relevant to the project site are discussed further in Section 2.2.

4. METHODS

4.1 DESKTOP STUDY

4.1.1 LITERATURE REVIEW

A literature review was conducted of all available studies that have previously assessed aquatic ecology and surface water ecosystems within the region. Each component targeted in the field surveys (e.g. aquatic habitat, water and sediment quality, aquatic flora and aquatic fauna) was reviewed. This background information provided valuable insight when preparing field surveys and assisted in the ability to target specific areas/habitats within each watercourse.

Reports reviewed included:

- Webb, G. (1992). Flora and Fauna Surveys on the Western Side of Groote Eylandt, N.T. (1991-92). Report prepared for BHP Manganese-GEMCO, by G. Webb Pty Ltd.
- Thornburn, D. (2010). Monitoring of Metals in Molluscs and Fishes of the Angurugu and Emerald Rivers, Groote Eylandt, Northern Territory, July 2010. Report prepared for BHP Billiton – Groote Eylandt Mining Company Pty Ltd, by Indo-Pacific Environmental Pty Ltd.
- URS (2012). Flora and Fauna Surveys of Western Groote Eylandt. Report prepared for BHP Billiton GEMCO, by URS Australia Pty Ltd.
- Cumberland Ecology (2015). Eastern Leases Project: Aquatic Ecology Assessment Report. Report prepared for Hansen Bailey on behalf of South 32 Pty Ltd, by Cumberland Ecology Pty Ltd.

Information collected during the literature review on each component of the study is discussed in a regional and ecological context. This aided in determining the background (existing) aquatic ecological processes occurring across the project site as well as in upstream and downstream areas. This is an essential part of the study as the determination of these processes and the potential connectivity of the project site to other areas must be determined in order to assess the implications of any proposed activities on the regional aquatic environments.

4.1.2 DATABASE SEARCHES

Database searches for this study targeted listed aquatic flora, fauna and communities previously documented in the area, as well as known wetlands. Database searches included the EPBC Protected Matters Tool (2020), which targets EPBC Act species and communities, and InfoNet (2018) which targets TPWC Act protected species and identifies potential pests. Internationally and Nationally Important Wetlands relevant to the project site were searched via the Directory of Important Wetlands in Australia, using the DAWE website. The list of Important Wetlands was also searched using the NT Government website (https://nt.gov.au/environment/soil-land-vegetation/important-wetlands).

The fully compiled database search reports including the areas searched are provided in Appendix 6.

4.1.3 Aerial Photography Review

Historic and recent (September 2017) high resolution aerial photography and lidar imagery, provided by GEMCO, was reviewed to identify habitats present across the project site that would be targeted as part of field surveys. Further, drone flights of each of the targeted watercourses were conducted onsite by GEMCO staff in the month prior to the field survey. The resultant still images and video were also reviewed to provide additional insight into access constraints and safety concerns.

4.2 Field Surveys

All field surveys were undertaken with the written permission of the ALC. Appropriate permits from the NT Government (and Queensland Government for Animal Ethics Approval) were also obtained to conduct research on the targeted fauna, including:

- A Permit to Interfere with Unprotected Wildlife for Commercial Purposes (Permit Number: 63013);
- A Permit to Interfere with Protected Wildlife (Permit Number: 63014);
- A Licence to use Premises for Teaching or Research Involving Animals (Licence Number: 080);
- A Section 17 Special Permit under the *Fisheries Act 1988* (Permit Number: 2016-2017 / S17/3446); and
- Animal Ethics Approval (Reference Number: CA2016/02/942).

4.2.1 Key Personnel

Two C&R personnel undertook the aquatic ecology surveys of the Emerald River:

1. Matthew Knott (BSc(Hons); MEIANZ) – Senior Scientist/Project Manager

   Matt has over 15 years post graduate experience undertaking aquatic ecology surveys throughout Queensland, the Northern Territory and New South Wales, with particular focus on Cape York Peninsula and the Gulf of Carpentaria. In a previous role, with the Australian Centre for Tropical Freshwater Research (ACTFR now referred to as TropWATER), Matt assisted with freshwater fish surveys throughout the Cape York Peninsula and the Gulf of Carpentaria as part of the Northern Australia Freshwater Fish Atlas Project (NAFF Project). Matt is also a committee member for the North Queensland Division of the Environmental Institute of Australia and New Zealand (EIANZ).

2. Benjamin Cuff (BSc) – Senior Scientist

   Ben has been involved in environmental sampling and analysis (water, soil, rock, terrestrial and aquatic fauna and flora) for over 15 years. He has extensive field experience in a variety of regions ranging from the South East Asian wet tropics (e.g. the Philippines) to the dry environments of western Queensland (e.g. Cloncurry, Mt Isa and/or Southwest Queensland). Ben's specialty lies in botany and soils with many of his projects involving the chemical and physical relationships of soils and rocks to vegetation zonation and hydrology. Ben's knowledge of physical and natural systems has given him a unique opportunity to relate these environmental factors to environmental compliance, environmental monitoring, planning and approval frameworks and potential engineering limitations.

4.2.2 Timing

The aquatic ecology field survey of the Emerald River was undertaken toward the beginning of the 2018 dry season (17th – 20th July 2018). Survey timing was heavily influenced by access constraints and safety concerns for samplers as well as the requirements for surveying protected aquatic fauna.

Timing of the survey was compliant with the requirements stipulated within the Survey guidelines for Australia's threatened fish (DSEWPaC, 2011) and the NT AusRivAS Sampling and Processing Manual (Lloyd & Cook, 2002).

4.2.3 Site Selection

Aquatic ecology sampling sites were located based on different habitat types present within a watercourse (e.g. wetland, pool, riffle and/or run), proposed project layout (i.e. proposed location for a road crossing of the Emerald River) and accessibility for sampling. Potential sampling sites were determined through an assessment of aerial photographs, available drone imagery and site boundaries. Detailed review of the aerial photographs and drone imagery resulted in the identification of key habitat types within each watercourse that were then assessed (ground truthed) during the field assessment.

A total of six sampling sites were assessed for aquatic ecology values across the project site (refer to Figure 9 and Table 1), including:

- A downstream estuarine site in close proximity to the mouth of the Emerald River (ERMP-AQ-01). This site was selected as it is located immediately adjacent with the south-western boundary of the existing mine (ML960);
- A mid-reach Emerald River site, located halfway between the mouth and the proposed crossing location (ERMP-AQ-02);
- A site located within the upstream tidal reaches of the Emerald River (ERMP-AQ-03), slightly downstream (~150m) of the previous documented horizontal waterfall (URS, 2012). The site is located within the current J Quarry boundary, immediately upstream of the proposed Emerald River haul road crossing.
- An upstream freshwater reference site (ERMP-AQ-04), located above the current Emerald River Road crossing with no tidal influence noted;
- A site located on the Southern Tributary of the Emerald River entering from the southeast upstream of ERMP-AQ-01 (ERMP-AQ-05). This site is located downstream of the proposed haul road alignment; and
- An ephemeral wetland in the vicinity of the proposed J Quarry haul road alignment (ERMP-AQ-06).

Some sites were dry at the time of sampling and so not all sites could be sampled for every parameter. Table 1 displays the site coordinates and the parameters targeted at each site.

Table 1: Sites targeted and parameters assessed

Site	Easting (GDA94; Zone 53L)	Northing (GDA94; Zone 53L)	Parameters sampled							
			Habitat Condition	Drone survey/GT	Macroinvertebrates	Fish & Large Macroinvertebrates	Sediment Quality	Water Quality	Turtles	Aquatic and/or Riparian Flora
ERMP-AQ-01	655206	8443243	X	X	X	X	X	X	X	X
ERMP-AQ-02	656211	8443146	X	X	X	X	X	X	X	X
ERMP-AQ-03	656925	8442969	X	X	X	X	X	X	X	X
ERMP-AQ-04	657560	8443423	X	X	X	X	X	X	X	X

Site	Easting (GDA94; Zone 53L)	Northing (GDA94; Zone 53L)	Parameters sampled							
			Habitat Condition	Drone survey/GT	Macroinvertebrates	Fish & Large Macroinvertebrates	Sediment Quality	Water Quality	Turtles	Aquatic and/or Riparian Flora
ERMP-AQ-05	655741	8442392		X			X			
ERMP-AQ-06	656912	8442860		X						

GT – Ground-truthed via walking in.

4.2.4 Aquatic Habitat

Habitat Characteristics and Condition

Habitat condition was assessed at each sampling site in accordance with the methods outlined within the NT AusRivAS Sampling and Processing Manual (Lloyd & Cook, 2002). While this is not generally adopted at marine sites it was used to standardise the description of habitats between sites. In accordance with this manual, the following nine key physical habitat characteristics were assessed:

- Bottom substrate/available cover;
- Embeddedness;
- Velocity/depth cover;
- Channel alteration;
- Bottom scouring and deposition;
- Pool/riffle, run/bend ratio;
- Bank stability;
- Bank vegetative stability; and
- Streamside cover.

Habitat characteristics are given a rating based on their condition, with the overall habitat bioassessment score for a site (the sum of all the possible ratings) then allocated to one of four categories signifying habitat condition present at the site (Table 2).

Table 2: Rating system used to determine Habitat Bioassessment

Number	Habitat Variable	Habitat condition rating ranges			
		Poor (≤38)	Fair (39 – 74)	Good (75 – 110)	Excellent (>110)
1.	Bottom substrate / available cover	0 – 5	6 – 10	11 – 15	16 – 20
2.	Embeddedness	0 – 5	6 – 10	11 – 15	16 – 20
3.	Velocity / depth category	0 – 5	6 – 10	11 – 15	16 – 20
4.	Channel alteration	0 – 3	4 – 7	8 – 11	12 – 15
5.	Bottom scouring and deposition	0 – 3	4 – 7	8 – 11	12 – 15
6.	Pool / riffle, run / bend ratio	0 – 3	4 – 7	8 – 11	12 – 15

Number	Habitat Variable	Habitat condition rating ranges			
		Poor (≤38)	Fair (39 – 74)	Good (75 – 110)	Excellent (>110)
7.	Bank stability	0 – 2	3 – 5	6 – 8	9 & 10
8.	Bank vegetative stability	0 – 2	3 – 5	6 – 8	9 & 10
9.	Streamside cover	0 – 2	3 – 5	6 – 8	9 & 10
-	Total Habitat Bioassessment Score	0 – 38	39 – 74	75 – 110	111 – 135

Photos were taken to document habitat variability at each site. As well as providing a detailed overview of existing habitat condition at each sampling site, this habitat assessment also provides a baseline for each site against which future change can be monitored.

Drone surveys were also taken at key sites (i.e. the main channel crossing location) to detail benthic substrates, channel morphology and habitat types present throughout each entire reach. The images reviewed are provided in Appendix 1 to provide further context to the project site setting.

4.2.5 WATER QUALITY

Basic water quality analysis was undertaken at each site to assist in the interpretation of the biological data. Water quality at each site was tested using a Eureka Manta Sub-2 in-situ field meter. The following in-situ parameters were measured:

- Water temperature (°C);
- Electrical conductivity (µS/cm);
- pH (Units); and
- Dissolved oxygen (mg/L and %sat).

Grab water samples were also collected from each site. All grab samples were analysed at a National Association of Testing Authorities (NATA) accredited laboratory for standard analytes known to influence aquatic community structure, including:

- Suspended Solids (mg/L);
- Hardness (mg/L);
- Alkalinity (mg/L);
- Major anions and cations (mg/L);
- Various dissolved and total metals/metalloids (including Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, Se, V, Zn, U, Fe, Hg and Cr_{VI}; mg/L).
- Ammonia (mg/L);
- Nitrite (mg/L);
- Nitrate (mg/L);
- Nitrite + Nitrate (mg/L);
- Total Kjeldahl Nitrogen (mg/L);
- Total Nitrogen (mg/L);
- Total Phosphorus (mg/L); and
- Reactive Phosphorus (mg/L).

Data Analysis

Water quality data were analysed, tabulated and compared to the ANZECC & ARMCANZ Water Quality Guidelines for Aquatic Ecosystems (2000). Any analytes above the guideline values are discussed further and potential changes in water quality throughout each targeted watercourses are also documented.

4.2.6 Sediment Quality

Sediment quality provides an assessment of the accumulation of quality characteristics (specifically, metals and metalloids) within aquatic systems over an extended period of time (e.g. years). Sediment quality analyses also provide an indication of the level of quality characteristics naturally available to organisms occurring within the substrate and/or ingesting fine sediments.

Sediment sampling was undertaken in accordance with the best practice methods outlined in the Australian Standard AS5667.1 (*Guidance on Sampling of Bottom Sediments*) and the CSIRO published *Handbook for Sediment Quality Assessment* (Simpson *et al.* 2005).

Approximately two kilograms of sediment was collected from each targeted sample site by placing nine randomly selected (across the stream channel) subsamples into a bucket, mixing the subsamples within the bucket, and taking the required sample. Samples were collected using a plastic trowel, with samplers wearing powder free latex gloves.

Samples were sent to a NATA accredited laboratory for testing. At the laboratory, samples were sieved with particle size distribution analysed. The whole sample was then tested for the following total quality characteristics:

- Aluminium (Al)
- Arsenic (As)
- Boron (B)
- Cadmium (Cd)
- Chromium (Cr)
- Cobalt (Co)
- Copper (Cu)
- Iron (Fe)
- Lead (Pb)
- Mercury (Hg)
- Manganese (Mn)
- Nickel (Ni)
- Selenium (Se)
- Silver (Ag)
- Uranium (U)
- Vanadium (V)
- Zinc (Zn)

Note: After the initial results were received from the laboratory further assessment of the fine fraction was required for a selection of sites. These samples were then wet sieved to remove the <63µm fraction that was again tested for the full suite of metals outlined above.

Data analysis

Sediment quality data were analysed, tabulated and compared to the ANZECC and ARMCANZ Interim Sediment Water Quality Guidelines for Aquatic Ecosystems (2000) which were reviewed in Simpson *et al.* (2013). Any analytes above the guideline values are discussed further.

4.2.7 Macroinvertebrate Communities

Macroinvertebrates are invertebrate fauna that can be seen by the naked eye. It includes such organisms as arthopods (insects, mites and crayfish), molluscs (snails, mussels, limpets and clams), annelids (segmented worms), nematodes (roundworms) and platyhelminthes (flatworms).

4.2.7.1 *Freshwater*

Only one freshwater site (ERMP-AQ-04) maintained water for macroinvertebrate sampling during the study. At this site, only the undercut edge habitats was targeted for macroinvertebrates as the other habitats present did not comply with the relevant NT sampling protocols (Lloyd & Cook, 2002).

Sampling methods followed the procedures set out in the NT AusRivAS Sampling and Processing Manual (Lloyd & Cook, 2002). This involves the use of a standard triangular mouthed frame fitted with a 250µm mesh size net as well as a long-handled cultivator fork to collect the sample. The edge habitat was sampled by selecting the appropriate section (e.g. backwater with leaf litter and/or undercut bank and some trailing vegetation/exposed roots, if available) and vigorously disturbing the edge to a depth of ~30cm with the cultivator fork while the second sampler sweeps through the disturbed and suspended material. A maximum distance of 10m was sampled.

Samples taken were filtered through a 10mm mesh sieve to remove the larger organic material. Any material collected in the sieve was picked through prior to being discarded. The remainder of the sample was emptied into a bucket so that it could be further agitated before being decanted back into the 250µm mesh net, with care taken not to collect excessive amounts of sediment. The remaining sediment was washed and decanted several times while in the bucket to ensure all organisms were removed prior to emptying into a sorting tray where it was picked through and then also discarded. The remaining sample in the 250µm mesh net was emptied into zip-lock plastic bags with 70% ethanol and sent to the C&R laboratory for detailed family identification. Within the laboratory the samples were picked, with organisms enumerated and identified to the lowest practical taxonomic level (in most instances family) to comply with AusRivAS standards. Macroinvertebrate samples for this project were initially identified by a suitably qualified Aquatic Ecologist, with 10% (or greater) of samples randomly chosen for verification by a Senior Aquatic Ecologist to ensure Quality Assurance and Quality Control (QA/QC).

Data Analysis

Analysis of macroinvertebrate data was undertaken in accordance with current best practice methods using a range of indices to describe the macroinvertebrate communities inhabiting the project site, including:

- **Taxonomic richness** – This represents the total number of different macroinvertebrate taxa collected at each site. This is to determine the diversity of the macroinvertebrate community present at each site. Healthier sites will have a greater diversity.
- **PET Taxa richness –** Indicates the number of families collected from three specific orders; Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies). These macroinvertebrate orders are considered sensitive to changes within their environment. Therefore, a low number of families collected from these orders (compared to the guidelines values) may suggest habitat degradation.
- **SIGNAL 2 index –** The SIGNAL index (Stream Invertebrate Grade Number – Average Level) was developed by Chessman (1995) to assist in the bioassessment of water quality in Australia. Chessman (1995) determined sensitivity grade numbers (between 1 and 10) for most freshwater macroinvertebrate families in Australia based on how sensitive each was to various pollutants and other physical and chemical factors. These physical and chemical factors may include water temperature, turbidity, electrical conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorous. In 2003 Chessman devised a weighted system for analysing SIGNAL indices to provide an overall SIGNAL 2 score for the site. This weighted system of analysis takes into consideration relative family abundance and therefore community composition. The overall SIGNAL 2 score is calculated using the following steps:
  - Determine SIGNAL grade for each different taxa present;
  - Determine weighting of each taxa present based on the number of individuals collected using the categories outlined in Chessman (2003);
  - Multiply the weight value by the SIGNAL grade for each taxa; and,
  - Divide the total weight determined for a site (add up all the weights) by the total SIGNAL grade x weight determined (add up all the values determined in the previous step) to provide an overall SIGNAL 2 score for the site.

SIGNAL 2 scores are interpreted using bi-plots and compared against the number of families recorded at each site. The bi-plots can then be divided into quadrants with each separate quadrant identifying the particular conditions relevant to a site (Figure 10). The boundaries determining the quadrants are generally based on regional guidelines (where available). However, stream specific boundaries can be identified if sufficient reliable data are available. Alternatively, Chessman (2003) designates interim boundaries for each quadrant based on a whole-of-Australia assessment undertaken. Use of the interim boundaries is considered an accepted approach.

- **AusRivAS modelling –** Further assessment of the data was also undertaken using the AusRivAS modelling programme to compare collected data against reference sites within the region and provide a level of macroinvertebrate community condition for each site. Data were analysed using the AusRivAS NT-Early Season Edge model. For a full description of how this model functions please refer to the *AusRivAS Predictive Modelling Software Version 3.1 UsersManual (2004)* and the *AusRivAS Macroinvertebrate Bioassessment Predictive Modelling Manual (2000).* However, the results of the model showed that no reference sites were available for comparison for the type of edge habitat sampled on the project site. The reference sites within the AusRivAS model generally occur in the north-west of the NT in different systems to those encountered on Groote Eylandt. Therefore, no AusRivAS modelling results are discussed within Section 5.5. Instead, a Shannon-Wiener Diversity Index assessment was used to provide a further indication of the condition of macroinvertebrate communities inhabiting the project site.
- **Shannon-Wiener Diversity Index –** The Shannon-Wiener Diversity Index is a quantitative measure that reflects how many different species there are in a dataset / community, and simultaneously takes into account how evenly individuals are distributed among those species. This index provides an assessment of biodiversity of a community assemblage sampled at a site based on the diversity of the assemblage and the abundance of each family present. The index is calculated using the equation:

$$H' = -\Sigma p_i \ln p_i$$

Where p_i is the proportion of individuals found in family i, or $p_i = n_i/N$; where n_i is the number of individuals in species i and N is the total number of individuals within the sample. Evenness of the sample is then calculated by the equation:

$$\text{Evenness} = H'/\ln(N)$$

The Shannon-Wiener Diversity Index increases as both the richness and evenness of a community increase, although values are rarely recorded greater than 4. The higher the number, the greater the biodiversity value of a site. Evenness is a measure of dominance of families within a community. The lower the evenness value the greater the propensity for a monoculture.

4.2.7.2 *Estuarine*

Assessing the macroinvertebrate communities inhabiting the estuarine reaches of a watercourse requires a different method to freshwater macroinvertebrate sampling for various reasons. In northern Australia the main reason is safety due to the presence Estuarine Crocodiles.

For the current study benthic macroinvertebrate communities were sampled using a petite ponar grab sampler to collect a relatively standardise sample (~2.5-3kg, wet weight) over a known area (15cm x 15cm). Three replicate samples were collected from each site. Each sample was sieved in a 1mm sieve within the field before being preserved in >70% ethanol for transportation back to the laboratory. Samples were sent to a third party laboratory where a taxonomist identified each organism to the family levels and enumerated the sample. A standard error of 10% was applied to laboratory identification processes for QA/QC.

Data Analysis

Similar to the freshwater samples, analysis of macroinvertebrate data was undertaken in accordance with current best practice methods using a range of indices to describe the macroinvertebrate communities inhabiting the project site, including:

- **Taxonomic richness** – This represents the total number of different macroinvertebrate taxa collected at each site. This is to determine the diversity of the macroinvertebrate community present at each site. Healthier sites will have a greater diversity.
- **PET Taxa richness –** Indicates the number of families collected from three specific orders; Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies). These macroinvertebrate orders are considered sensitive to changes within their environment. Therefore, a low number of families collected from these orders (compared to the guidelines values) may suggest habitat degradation.
- **Shannon-Wiener Diversity Index –** This index provides an assessment of biodiversity of a community assemblage sampled at a site based on the diversity of the assemblage and the abundance of each family present. The index is calculated using the equation:

  $$H' = -\Sigma p_i \ln p_i$$

  Where p_i is the proportion of individuals found in family i, or $p_i = n_i/N$; where n_i is the number of individuals in species i and N is the total number of individuals within the sample. Evenness of the sample is then calculated by the equation:

  $$\text{Evenness} = H'/\ln(N)$$

  The Shannon-Wiener Diversity Index increases as both the richness and evenness of a community increase, although values are rarely recorded greater than 4. The higher the number, the greater the biodiversity value of a site. Evenness is a measure of dominance of families within a community. The lower the evenness value the greater the propensity for a monoculture.

However, more rigorous statistical analysis of the estuarine benthic macroinvertebrate data was also undertaken using the PRIMER v6 statistical package. Replicate macroinvertebrate data collected at each site was transformed and analysed via resemblance matrices using an array of techniques including:

- Non-metric multi-dimensional scaling (MDS) plots – This technique constructs a "map" of the samples, that have been analysed via a similarity (or dissimilarity) matrix, in a specified number of dimensions (in this case two) where samples that display greater similarity will appear closer together (Clarke & Warwick 2001).
- Cluster analysis (dendogram) – This analysis "groups" samples together that are more similar (based on the results of a similarity matrix, as above) to each other (Clarke & Warwick 2001). The output of such an analysis provides a dendogram which displays at what percentage replicates are considered similar. These results can also be displayed on the MDS plot via rings which distinguish percent similarity between groups.
- Species contributions analysis (Similarity percentages - SIMPER) – Calculates percentage contribution of macroinvertebrate families (in this case) to the similarity between replicates within a site as well as the percent contribution of macroinvertebrate families to the dissimilarities between sites (Clarke & Warwick 2001). This analysis allows for the determination of potential indicator species. The presence and/or abundance of these species may then be used to identify impacted sites from non-impacted sites.
- Analysis of similarities (ANOSIM) – This technique performs a 1-way or 2-way ANOVA (in this case 1-way) on the chosen similarity matrix (macroinvertebrate assemblages at each site) (Clarke & Warwick 2001). When performing this analysis, the null hypothesis that there are no differences between macroinvertebrate assemblages at each site is being tested. The output provides an R value and p value for each paired site. The closer the R value is to one the greater the dissimilarities are between sites (Clarke & Warwick 2001). The p value provides the significance value of the relationship (i.e.

p<0.01 is highly significant). If two sites are found to display strongly, significantly different macroinvertebrate assemblages the results will display an R value of close to one and p<0.01, thereby rejecting the null hypothesis.

- Linking community analyses to environmental variables (BEST / BIO-ENV) – This multivariate analysis determines if any environmental variables (in this case physico-chemical water quality, habitat score and sediment metals concentrations) are significantly influencing macroinvertebrate community structure (Clarke & Warwick 2001). The technique can determine if one or a combination of, environment variables best 'explain' the biotic pattern (Clarke & Warwick 2001). The result is a correlation statistic, or Rho. The closer Rho is to 1 the greater the correlation between the variable(s) and the biotic pattern (Clarke & Warwick 2001).

4.2.8 Fish and Large Macroinvertebrate Communities

4.2.8.1 *Freshwater*

Freshwater fish communities were surveyed using a combination of backpack electrofishing, a set fyke net and baited traps (Table 3). Backpack electrofishing (using a Smith-Root LR-24) was the preferred sampling technique. Baited traps were employed to target both fish and crustaceans. This included replicate samples of collapsible box traps (2mm mesh) and opera house traps (1.5" mesh). The fyke net was also deployed where flows allowed. Table 3 outlines the fishing techniques utilised.

Fish collected were enumerated, identified, measured (to determine life history stage) and photographed. A general assessment of fish health was also noted. Any specimens unable to be identified within the field were euthanised or photographed and sent to the NT Museum and Art Gallery for identification by a qualified taxonomist.

Freshwater fish surveys were conducted in accordance with the methods developed for the Northern Australian Freshwater Fish Atlas Project (NAFF, 2007, a collaboration between the National Centre for Tropical Wetland Research and Griffith University), the Survey guidelines for Australia's threatened fish (Department of Sustainability, Environmental, Water, Populations and Communities (DSEWPaC), 2011; where appropriate) and in accordance with the *Australian Code of Electrofishing Practice 1997*, under the animal ethics approval CA2016/02/942.

Data Analysis

The following fish and large macroinvertebrate parameters were analysed for each of the sites sampled: i) Species richness, ii) total abundance, iii) abundance of listed aquatic species, iv) abundance of exotic species, v) abundance of each life history stage present (e.g. juvenile, intermediate or adult) and vi) mean fork length. Note; fork length is a measurement of fish length taken from the tip of the snout of the head to the deepest point in the notch of the tail fin.

4.2.8.2 *Estuarine*

Estuarine fish communities were surveyed using gill nets (of various mesh size), cast nets and visual surveys dependent on the habitat targeted (e.g. deep pool, shallow run, etc.). Large macroinvertebrate species were targeted using baited crab traps. Table 3 outlines the fishing techniques utilised at each site during the field assessment.

Fish collected were enumerated, identified, measured (to determine life history stage) and photographed. A general assessment of fish health was also noted for each surveyed site. Any specimens unable to be identified within the field were euthanised or photographed and sent to the NT Museum and Art Gallery for identification by a qualified taxonomist.

Fish surveys were conducted in accordance with the methods developed for the Survey guidelines for Australia's threatened fish (DSEWPaC, 2011; where appropriate) under the animal ethics approval CA2016/02/942.

Data Analysis

Captured estuarine fish species were analysed for i) species richness, ii) total abundance, iii) abundance of listed aquatic species, iv) abundance of exotic species, v) abundance of each life history stage present (e.g. juvenile, intermediate or adult) and vi) mean fork length.

4.2.9 TURTLE COMMUNITIES

Turtle surveys were conducted to identify any turtle species that may be present within the project site. Turtle communities at each targeted site were assessed via visual surveys as site conditions and species targeted were not appropriate for the deployment of baited cathedral traps. Snorkelling was not conducted because of unconducive habitat conditions (e.g. shallow or tannin waters) and safety concerns. Therefore, walk through visual surveys (while electrofishing) or boat based visual surveys were employed to target all species of turtles potentially inhabiting the area.

Turtles are regularly seen (if present) during electrofishing surveys for fish communities. If noticed, the electrofisher is shut down to prevent injury to the animal. Similarly, turtles are often observed when netting estuarine reaches. Samplers spent 5-6 hours at each site undertaking visual surveys. If turtles were observed photographs would be taken to aid in the identification process.

All turtle surveys were conducted under Animal Ethics Approval No.: CA 2016/02/942. There are no specific national guidelines detailing survey methods for listed marine turtles. However, visual (air or land based) population surveys are generally undertaken at nesting locations, while habitat utilisation surveys are generally conducted via visual boat or air based surveys as conducted for this project.

Data Analysis

Freshwater turtles were analysed for i) species richness, ii) total abundance, iii) abundance of listed aquatic species, iv) abundance of exotic species, and v) abundance of each life history stage present (e.g. juvenile, intermediate or adult).

4.2.10 OTHER AQUATIC VERTEBRATES

The potential presence of other aquatic vertebrates in the region was assessed through the completion of a literature review and database searches, specifically the Commonwealth's *Protected Matters Search Tool* and the NT Government's *InfoNet* database. The database searches indicated that the Estuarine Crocodile (listed as Marine Migratory under EPBC Act) occurred within the greater catchment area. No other aquatic vertebrates with statutory protection (other than marine turtles and the elasmobranchs that are discussed in Section 3.1.1) were revealed from database searches.

A literature review, together with a habitat assessment, was undertaken to determine the potential for estuarine crocodiles to be present. It concluded that the species utilises the area. However, due to health and safety concerns for personnel and animals a detailed, targeted field survey for estuarine crocodiles was not warranted. Refer Section 5.8 for further detail.

Table 3: Fishing settings and effort employed at each site

Site	Date	Habitat sampled	Average Depth	Method	Fishing Settings			Total Effort
ERMP-AQ-01	19/07/2018	Deep estuarine habitat at mouth with muddy bed	>2m	Baited crab traps	3 deployed	35mm mesh		16.5 hrs
				Gill net	2 deployed	75mm mesh	25m x 2m	11 hrs
				Gill net	1 deployed	150mm mesh	25m x 2m	5.5 hrs
ERMP-AQ-02	18/07/2018	Shallow sandy bed with deeper undercut banks on bends	~1m	Baited crab traps	2 deployed	35mm mesh		10 hrs
				Gill net	1 deployed	75mm mesh	25m x 2m	5 hrs
				Gill net	1 deployed	150mm mesh	25m x 2m	5 hrs
ERMP-AQ-03	18/07/2018	Shallow sandy run with deeper undercut banks and trailing veg	~1.2m	Baited crab traps	2 deployed	35mm mesh		10 hrs
				Gill net	1 deployed	75mm mesh	25m x 2m	5 hrs
				Gill net	1 deployed	150mm mesh	25m x 2m	5 hrs
ERMP-AQ-04	17/07/2018	Heavily vegetated, narrow channel with moderate flows ~1.5m/s	1m	Baited box traps	3 deployed	2mm mesh		54 hrs
				Baited opera traps	3 deployed	1” mesh		54 hrs
				Fyke net	1 deployed	¾” mesh		18 hrs
				Backpack Electrofisher	780V	60Hz	25% Duty	170 secs

Note: ERMP-AQ-05 and ERMP-AQ-06 were not sampled for fish as insufficient water was present at the time of sampling.

4.2.11 AQUATIC AND RIPARIAN FLORA

Aquatic flora can have many different forms, including:

- Submerged macrophytes: Predominantly growth is beneath the water surface although flowers and or leaves of some species protrude the surface of the water;
- Floating macrophytes: Can be either attached or free floating (Sainty & Jacobs, 2003). For example, the introduced water hyacinth floats freely around waterways being moved across the surface by wind or currents, while the waterlilies are rooted to the substrate but the mature leaves float on the surface;
- Emergent macrophytes: Generally grow in the shallower waters and are rooted to the substrate with the majority of the plant (stems, flowers and leaves) protruding above the surface of the water (Sainty & Jacobs, 2003); and,
- Algae: Generally need to be fully submerged to survive.

Aquatic flora surveys were conducted at each site along a 100m reach (i.e. 50m upstream and 50m downstream of each sampling location). This assessment detailed the presence/absence of all native and exotic aquatic flora and their form (from the four categories listed above) as well as the percent cover of each species at each site. Transects could not be effectively surveyed in high tannin waters and/or deep habitats, therefore transects generally targeted shallower waters.

Riparian vegetation was assessed by evaluating the stand structure, growth form and the floristic assemblage present. At each site the vegetation type was recorded noting the dominant species within the tallest, middle, and lowest stratums. An estimate of the projective foliage cover was conducted at each site as well as an estimate of the vegetative groundcover. These estimations of cover combined with the dominant species data was used to assign a vegetation classification (e.g. sedgeland, woodland, forest, etc.) at each of the monitoring sites. This was a site specific assessment undertaken of a maximum reach of 100m at each monitoring location and not a broad scale determination of vegetation communities for the area. To identify the broad scale vegetation communities within the project site, please refer to mapping prepared by DENR and/or any available site specific vegetation mapping.

Photographs of different macrophyte and riparian species present at each site were taken. Specimens of any species that could not be identified in the field were photographed for identification purposes within the C&R laboratory or sent to a taxonomic specialist within the NT Government for further assessment.

The data collected provides the administering authority with an understanding of the existing condition of aquatic macrophyte and riparian communities present within the section of the Emerald River assessed.

5. RESULTS

This section presents the results of the field survey and desktop study. Within each major sub-section of these results, the background condition as noted from the desktop study is compared against the findings of the field survey to provide a detailed overview of the current aquatic ecology condition found within the project site. The major sub-sections include:

- Sections 5.1 provides the description of the characteristics associated with each of the watercourses and wetlands surveyed across the project site;
- Section 5.2 outlines the condition of the habitats present at each sampling site as determined through the habitat condition bioassessment;
- Section 5.3 discusses the water quality recorded at each site;
- Section 5.4 discusses the sediment quality recorded at each site
- Section 5.5 describes the macroinvertebrate communities inhabiting the project site;
- Section 5.6 describes the fish communities utilising the project site and connected watercourses;
- Sections 5.7 and 5.8 outlines the occurrence of turtles and other aquatic vertebrates (except fish) within the project site; and
- Section 5.9 outlines the aquatic and riparian flora known within the region and observed across the project site.

5.1 EMERALD RIVER

The Emerald River is a large, perennial river system located on the western side of Groote Eylandt, stretching ~20km from its source to the Gulf of Carpentaria and with a catchment size of ~9,310ha. Its headwaters are located within the 'White Rock' escarpment, with large freshwater pool sections known to occur upstream of the project site. The project site is associated with the freshwater/saline interface of the watercourse.

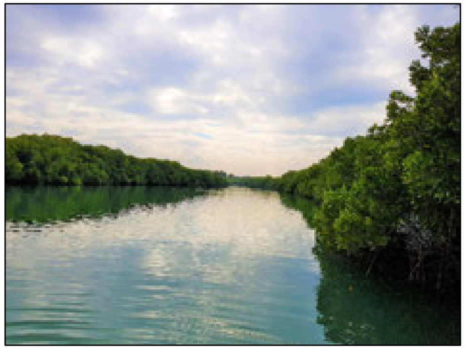
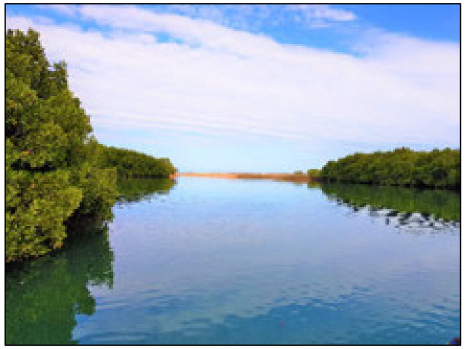
Natural rock bars, located >400m upstream of the proposed Emerald River haul road crossing, form a horizontal waterfall effectively limiting the encroachment of estuarine waters any further upstream. Large marine wetland areas associated with the downstream reaches of the watercourse are located behind the coastal dune systems.

The downstream, estuarine reaches are wide (typically ~20m wide) with well-defined high banks (up to 5m high), while the lower freshwater reaches were characterised by a narrow channel (generally <5m wide) with limited high banks (typically 2m) and the potential for several overflow channels (refer to site descriptions in Table 4). Based on the stream morphology observed (refer to Appendix 1 for a detailed overview), it is expected that during the wet season the lower freshwater reaches typically flood across the landscape into a series of overflow channels and ephemeral wetlands/marsh lands while the estuarine system would remain largely contained (although there were some areas that probably flood).

While the Emerald River is known to be perennial (with a flow rate of >1.5m/s during field surveys), a large, ephemeral tributary enters the main arm of the river from the south, intersecting the project site (refer to Figure 5). While it is understood that this tributary can maintain water in its upper reaches (<1km upstream of the project site) for several months following the end of the wet season (*pers. comm*. M. Chapman), the reach associated with the project site is ephemeral.

The bed habitat throughout the Emerald River catchment is dominated by fine sand with sections of bedrock and marine mud also observed (Table 4). Undercut/eroded banks were present throughout most reaches, with riparian vegetation covering almost 100% of the banks a common occurrence (refer to Section 5.9 for further discussion).

Table 4: Site descriptions, sampling limitations and site pictures

Site	Upstream view	Downstream view	Description
ERMP-AQ-01			The site was slightly upstream of the mouth on the Emerald River, downstream of a major tributary confluence. The site did not show any potential influence from mining related activities. This is the widest point on the river averaging ~50m, with the widest point being 85m across. The water was turbid with visibility <2m. The depth towards the centre of the channel was between 2.5-3m. The substrate was dominated by marine mud, with no seagrass noted in petite ponar samples. The banks were heavily vegetated by one species of mangrove (refer to Section 5.9) with depositional banks exposed at low tide. Some woody debris within the channel provided additional structurally complex habitat. The entrance to the river is very shallow (<1m) and was effectively cut-off from the marine coastal areas during low tide (water depth ~0.3m). This will limit some fauna's ingress and egress to the system. ***Limitations* –** The increased turbidity impaired vision through the water column.
ERMP-AQ-02			This site consisted of a shallow, sandy, relatively straight section of the river with tight, deep bends located at either end. It is situated ~1km upstream of the confluence with the main tributary. The tight bends had eroded banks where large woody debris has fallen into the deeper sections and accumulated over time. Various species of mangroves line the banks at this site with some exposed areas (i.e. lacking vegetation) on the southern bank (Appendix 1). Water clarity was slightly turbid. However, as the majority of the reach was shallow (~1m) the bottom was easily inspected throughout. The substrate was dominated by fine sand with no submerged aquatic vegetation noted. ***Limitations* –** The shallow depth of the water throughout the site made it difficult for fishing nets with drops of 2m.

Site	Upstream view	Downstream view	Description
ERMP-AQ-03			This site is located on the freshwater/estuarine interface, immediately upstream of the proposed Emerald River haul road crossing. There are several small, ephemeral drainage channels that enter the main arm immediately upstream and downstream of this point, increasing the channel width (the main channel is ~25m wide; Appendix 1). Depth averaged ~1.5m, although there was a shallow section ~1m. The water at this site was clear with samplers able to visually identify fish species easily from the boat. A downstream flow was always present at this site even on an incoming tide as freshwater pushed downstream over the top of the intruding marine waters. The riparian zone displayed a mixture of freshwater and marine plants. Submerged aquatic vegetation was not present. The substrate was dominated by fine sand with some rock bars also observed. There was also a high level of leaf litter present. ***Limitations –*** The nets have a drop of 2m and the shallow depth of the water throughout the site (i.e. <2m) made the nets bunch up. This meant that they were more easily seen by fish and so were avoided, meaning that the fishing was less effective.
ERMP-AQ-04			ERMP-AQ-04 is located upstream of any anthropogenic impacts within the freshwater reaches of the Emerald River. The site was narrow (<3m wide), fast flowing (>1.5m/s) shallow creek with several bottleneck points and deeper, undercut banks on the bends. The water clarity at the site was very clear. The riparian zone was comprised of various rainforest species, while the aquatic flora was dominated by sedges (refer to Section 5.9). Erosion was noted on the bends. The substrate was dominated by fine sand although it was heavily vegetated with a large amount of woody debris also found. ***Limitations –*** The moderate flow rate limited electrofishing efficiency with affected fish regularly

Site	Upstream view	Downstream view	Description
			being washed downstream out of the field of influence and escaping.
ERMP-AQ-05			Located along the existing access corridor within the main tributary of Emerald River and downstream of the proposed haul road alignment this site was characterised by a dry Melaleuca wetland with a sedge dominant understory. No water was present during the field surveys with the tributary known to be ephemeral. The substrate was dominated by sand and clay, with a large amount of leaf litter and mats of dried algae present. There was no defined channel instead the wetland spread across a wide area within the flood plain. ***Limitations –*** Only sediment samples were able to be collected from this site after ground-truthing.
			
ERMP-AQ-06			The site was a small Melaleuca and Pandanus wetland located on the southern bank of the Emerald River adjacent to ERMP-AQ-03. The site held little water during sampling with only a couple of large, shallow puddles observed with some fringing ferns. The substrate was dominated by sand and clay, with a large amount of leaf litter and mats of dried algae present. There was a limited defined channel suggesting the wetland would remain relatively confined in the wet season before overtopping and draining into the Emerald River (refer to images in Appendix 1 for site overview). ***Limitations –*** This site was only ground-truthed and no samples were taken.

5.2 HABITAT CONDITION

Prior to the field surveys, high resolution aerial photography, Lidar imagery as well as drone footage were assessed to determine any potential unique aquatic habitats (e.g. in-channel wetlands, riffle zones and/or deep pools) within the project site. All identified “potentially unique” habitats were ground truthed during the field visit and then, if deemed necessary, targeted as a survey site.

The AusRivAS habitat condition assessment was determined for each sample site and the results are presented in Figure 11. It should be noted that this assessment is not usually conducted on estuarine reaches. However, it has been performed on this occasion as it provides an insight into the physical properties of the site and allows comparison of values with the freshwater site.

The results indicate the majority of sites are in a similar condition (good), with ERMP-AQ-04 observed on the border of good to excellent condition (Figure 11). This is a direct result of the untouched nature of the watercourses and the strong riparian values noted at each site (Table 4). The high score at ERMP-AQ-04 is reflective of the diverse range of habitats and increased structural complexity (e.g. large amount of woody debris, substantial macrophyte beds and deep undercut banks on the bends) noted at the site (Table 4).

These results are not unexpected for the region with few anthropogenic disturbances noted. The only reason the sites did not score excellent was the lack of riffle zones and/or larger grainsized substrate. The systems containing flows during the survey were largely comprised of substrates dominated by fine sand. While bedrock was observed at ERMP-AQ-03, it was not dominant, and flows were insufficient to create riffles.

ERMP-AQ-02 recorded the lowest condition score of any site. This is directly related to the increased sedimentation associated with the sand bar noted at the site (Figure 11 and Table 4). Sedimentation can smother macroinvertebrate communities inhabiting a site and may reduce primary production (Gleason *et al*., 2003; Gray & Ward 1982; Wood & Armitage 1997).

Note: This type of habitat condition assessment has not previously been performed within the region. Therefore, there are no historic data available for comparison.

5.3 SURFACE WATER QUALITY

In-situ water quality monitoring was undertaken at each monitoring site for pH, EC, Temperature and Dissolved Oxygen (DO), with stratified sampling undertaken at the deeper, tidally influenced sites (Table 5). The data show that the water at ERMP-AQ-04 was extremely fresh (<50µS/cm; pH = 5.5; Table 5) with the sites increasing in salinity with increasing distance downstream (Table 5).

The stratified sampling indicates the freshwater was sitting on top of the saline waters creating a saltwater wedge that pushes upstream with the incoming tide, underneath the freshwaters flowing downstream (Table 5). This saltwater wedge was still strong at ERMP-AQ-03 (immediately upstream of the proposed Emerald River haul road crossing where surface waters were fresh (EC = 725µS/cm) and at 1m depth waters were almost marine in composition (EC = 46,810µS/cm). The characteristics of this freshwater/estuarine interface must be considered within the design of any proposed crossing to ensure hydrological processes are maintained.

The alkalinity, cation and anion results support the in-field findings that the waters at ERMP-AQ-04 are highly fresh prior to the increasing influence of the saline wedge with increasing distance downstream (Table 6). The freshwater sections of the systems sampled for aquatic ecology are highly fresh, comparable in quality to rainwater, slightly acidic (i.e. low pH) and low in alkalinity (i.e. buffering capacity; Table 5 and Table 6). These results support historic findings of similar conditions within the upstream reaches of the Emerald River (Cumberland, 2015).

The levels of suspended solids at all sites provide further evidence of the low energy environment of the watercourse sections assessed (at time of sampling), with limited erosion noted (refer to Table 4) and naturally low sediment loads (Table 6).

Levels of metals and metalloids were compliant with ANZECC & ARMCANZ (2000) guideline values at all sites, although levels of some metals were higher in estuarine sites compared to the freshwater site. This is probably caused by natural variation in the differences in ionic strength and hence variable solubilities between the water types. There was no evidence of any influence from mining activities.

The low DO levels recorded at all estuarine sites may be influencing the structure of aquatic communities present. The lowest DO levels were recorded at ERMP-AQ-02 (Table 5). As well as being outside the ANZECC & ARMCANZ (2000) guideline values, the DO levels at ERMP-AQ-02 were only slightly above the chronic limit (~68%) of extended exposure for native, tropical freshwater fish (Burrows *et al.*, 2007). It is likely that the vast array of pelagic marine fish observed within the system (refer to Section 5.6) are also sensitive to these lower levels of oxygen.

Nutrient levels recorded were generally below the limit of reporting at all sites, although elevated total nitrogen levels were recorded in the downstream estuarine reaches (Table 6). Lower nutrient levels within the freshwater environment are expected, as the upstream catchment soils are relatively devoid of nutrients with limited erosive potential (refer to Section 2.5). Further, the Emerald River freshwater reach was in constant flow, with few areas available for pooling and the capture of large amounts of leaf litter and/or detrital material. Low nutrient levels within the Emerald River freshwater reaches has been previously reported (Cumberland, 2015).

The high total nitrogen levels in the downstream estuarine reaches are likely from natural processes associated with microbial activity on decaying organic matter and within marine/mangrove mud. The banks of the watercourse within these downstream reaches were heavily lined with mangroves (a source of detrital material) and, while freshwaters flow overtop and slowly mix, the system is not prone to large flushes for prolonged periods (likely only during floods in the wet season) with the entrance from the coastal waters relatively narrow and shallow. The breakdown of the detrital mangrove material is known to produce nitrogen at increasing levels until the material is broken down (Rice & Tenore, 1981). Therefore, the slow flushing of the marine component within the watercourse is likely to be insufficient to reduce the natural nitrogen levels created from the decaying mangrove material until flooding freshwater flows within the wet season are received. This is likely to be the natural process observed within the Emerald River estuarine reaches each year.

Full analytical results (i.e. Certificate of Analysis) are provided in Appendix 2.

Table 5: In-situ water quality parameters at each site

Site	Units	LOR	ERMP-AQ-01				ERMP-AQ-02		ERMP-AQ-03			ERMP-AQ-04	ANZECC & ARMCANZ (2000) Freshwater	ANZECC & ARMCANZ (2000) Estuarine
Depth	m	0.1	0.2	1	2	2.5	0.2	1.2	0.2	1	2	-	-	-
Temperature	°C	0.01	23.00	24.93	24.80	24.18	23.83	25.02	25.92	27.70	27.30	26.12	NA	NA
pH	pH units	0.01	7.27	7.91	8.08	8.07	7.24	7.80	6.51	7.60	7.60	5.52	6.0 - 8.0	7.0 – 8.5
EC	µS/cm	0.1	31900	47500	48400	48410	2580	47900	725	46810	46980	38.7	20 – 220	NA
DO	%sat	0.1	75.2	71.7	83.1	84.8	70.8	72.3	93.5	85.0	75.0	88.8	85 - 120	80 – 120

NA – None available.

Indicates a non-compliance of a guideline value.

Table 6: Water quality of grab samples collected from each site and tested in a NATA accredited laboratory

Quality Characteristic	Units	LOR	ERMP-AQ-01 19/07/2018	ERMP-AQ-02 18/07/2018	ERMP-AQ-03 18/07/2018	ERMP-AQ-04 17/07/2018	ANZECC & ARMCANZ (2000) Freshwater 95% SPL	ANZECC & ARMCANZ (2000) Freshwater 99% SPL	ANZECC & ARMCANZ (2000) Marine 95% SPL	ANZECC & ARMCANZ (2000) Marine 99% SPL
Suspended Solids (SS)	mg/L	5	7	<5	<5	<5	NA		NA	
Turbidity	NTU	0.1	0.8	0.5	0.4	0.9	2 - 15.0		1 - 20.0	
Total Hardness as CaCO3	mg/L	1	3620	3740	1900	<1	NA		NA	
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	NA		NA	
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	NA		NA	
Bicarbonate Alkalinity as CaCO3	mg/L	1	70	75	47	4	NA		NA	
Total Alkalinity as CaCO3	mg/L	1	70	75	47	4	NA		NA	
Sulfate as SO4 - Turbidimetric	mg/L	1	1670	1660	801	2	NA		NA	
Chloride	mg/L	1	10800	11100	6210	10	NA		NA	
Calcium	mg/L	1	185	190	118	<1	NA		NA	
Magnesium	mg/L	1	766	794	390	<1	NA		NA	
Sodium	mg/L	1	6460	6650	3240	9	NA		NA	

Quality Characteristic	Units	LOR	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	ANZECC & ARMCANZ (2000) Freshwater		ANZECC & ARMCANZ (2000) Marine	
			19/07/2018	18/07/2018	18/07/2018	17/07/2018	95% SPL	99% SPL	95% SPL	99% SPL
Potassium	mg/L	1	226	238	119	<1	NA		NA	
Dissolved metals										
Aluminium	mg/L	0.01	<0.05	<0.05	<0.01	0.03	0.055	0.027	0.0005*	NA
Arsenic	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.013	0.0008	0.0023*	NA
Beryllium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.00013*	NA	NA	NA
Barium	mg/L	0.001	0.01	0.011	0.009	0.008	NA	NA	NA	NA
Cadmium	mg/L	0.0001	<0.0005	<0.0005	<0.0001	<0.0001	0.0002	0.00006	0.0055	0.0007
Chromium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.001	0.0001	0.0274	0.0077
Hexavalent Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.0001	0.0044	0.00014
Cobalt	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.0028*	NA	0.001	0.000005
Copper	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.0014	0.001	0.0013	0.0003
Lead	mg/L	0.001	<0.005	<0.005	0.002	<0.001	0.0034	0.001	0.0044	0.0022
Manganese	mg/L	0.001	0.035	0.056	0.064	0.04	1.9	1.2	0.08*	NA
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	0.00006	0.0004	0.0001
Nickel	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.011	0.008	0.07	0.007
Selenium	mg/L	0.01	<0.05	<0.05	<0.01	<0.01	0.011	0.005	0.003*	NA
Uranium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	0.0005*	NA	NA	NA
Vanadium	mg/L	0.01	<0.05	<0.05	<0.01	<0.01	0.006*	NA	0.1	0.05
Zinc	mg/L	0.005	<0.025	<0.025	<0.005	<0.005	0.008	0.0024	0.015	0.007
Boron	mg/L	0.05	2.99	3.17	0.48	<0.05	0.37	0.09	5.1*	NA
Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	0.300*	NA	NA	NA
Total metals										
Aluminium	mg/L	0.01	<0.05	<0.05	0.04	0.08	NA	NA	NA	NA
Arsenic	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Beryllium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Barium	mg/L	0.001	0.011	0.01	0.009	0.009	NA	NA	NA	NA
Cadmium	mg/L	0.0001	<0.0005	<0.0005	<0.0001	<0.0001	NA	NA	NA	NA

Quality Characteristic	Units	LOR	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	ANZECC & ARMCANZ (2000) Freshwater		ANZECC & ARMCANZ (2000) Marine	
			19/07/2018	18/07/2018	18/07/2018	17/07/2018	95% SPL	99% SPL	95% SPL	99% SPL
Chromium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Hexavalent Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	NA	NA	NA	NA
Cobalt	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Copper	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Lead	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Manganese	mg/L	0.001	0.034	0.05	0.064	0.084	NA	NA	NA	NA
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	NA	NA	NA	NA
Nickel	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Selenium	mg/L	0.01	<0.05	<0.05	<0.01	<0.01	NA	NA	NA	NA
Uranium	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	NA	NA	NA	NA
Vanadium	mg/L	0.01	<0.05	<0.05	<0.01	<0.01	NA	NA	NA	NA
Zinc	mg/L	0.005	<0.026	<0.026	<0.005	<0.005	NA	NA	NA	NA
Boron	mg/L	0.05	2.91	2.84	0.39	<0.05	NA	NA	NA	NA
Iron	mg/L	0.05	<0.05	<0.05	0.07	0.16	NA	NA	NA	NA
Nutrients										
Ammonia as N	mg/L	0.01	0.03	0.03	0.02	<0.01	0.9	0.32	0.91	0.5
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	NA	NA	NA	NA
Nitrate as N	mg/L	0.01	0.01	<0.01	0.03	<0.01	0.7	0.017	NA	NA
Nitrite + Nitrate as N	mg/L	0.01	0.01	<0.01	0.03	<0.01	NA	NA	NA	NA
Total Kjeldahl Nitrogen as N	mg/L	0.1	2.2	0.6	<0.1	<0.1	NA	NA	NA	NA
Total Nitrogen as N	mg/L	0.1	2.2	0.6	<0.1	<0.1	0.2-0.3		0.25	
Total Phosphorus as P	mg/L	0.01	<0.05	<0.05	<0.01	<0.01	0.01		0.02	
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.004		0.005	

SPL – Species Protection Level.
NA – None available.
*Indicates a guideline value of low reliability.
Indicates a non-compliance of a guideline value.

5.4 Sediment Quality

5.4.1 Particle Size Distribution

Particle size distribution results for each site quantify the in-field observations (discussed in Table 4) with the majority of sites dominated by sand. The exceptions are ERMP-AQ-01 and ERMP-AQ-5 where large components of clay and silt were noted (Figure 12). Sand comprised ≥87% of sediment collected from ERMP-AQ-02, ERMP-AQ-03 and ERMP-AQ-04, while it accounted for <37% at ERMP-AQ-01 and ERMP-AQ-05 (Figure 12). This is directly related to the types of habitats targeted, with ERMP-AQ-01 (within the estuary) comprised almost entirely of marine mud, and ERMP-AQ-05 (a shallow wetland habitat within an ephemeral tributary) where soil present is similar to that within the adjacent floodplain (refer Section 2.5).

No cobble or greater grain size were recorded at any sites. ERMP-AQ-03 displayed the highest results for gravel composition (8%; refer Figure 12). Large grainsize composition suggests a more structurally complex bed habitat and thereby the potential to maintain a greater diversity of macroinvertebrate fauna. The substrates throughout the project site are dominated by small grain size sediments suggesting that macroinvertebrate bed habitat communities will be relatively depauperate in taxonomic richness.

Particle size distribution results confirmed that sediments within the region's watercourses were directly influenced by geological characteristics and upstream soil properties (i.e. low erosivity and low nutrients). The influence of the geology is confirmed by the sediment chemistry results.

5.4.2 Metal/Metalloid Chemistry

Sediment quality analysis was originally performed on the whole sample collected from each site. However, based on the levels of metals observed within the initial results, additional analyses were performed on a standardised <63µm grain sized fraction of each sample (Table 7).

Metal and/or metalloid concentrations recorded at all monitoring sites indicated a wide/varied range of levels between sites. All, however, were compliant with best practice sediment quality guideline values (Table 7). The majority of the samples collected recorded levels of manganese above those typically observed within tropical mainland systems through the Gulf of Carpentaria, although this is not unexpected given the local geology (Table 7). Thorburn (2010) noted similar levels of manganese within the Emerald River in similar reaches to those assessed within the current study, suggesting they are natural in origin.

While aluminium and iron concentrations appear high compared to other metals tested at most sites, these levels are relatively standard for sediments throughout tropical northern Australia (Table 7). Manganese, iron, aluminium, silicon and titanium are relatively immobile elements during tropical weathering processes and tend to be residual (i.e. they are relatively enriched) in all tropical soils and weathering profiles.

ERMP-AQ-05 generally recorded the highest levels of metals of any site, potentially a result of the hydrological nature of the site (being a shallow vegetated wetland) increasing deposition of sediments eroded from metal rich rock formations in the upper catchment area (Table 7). Metal levels generally reduced when the <63µm data were reviewed. This is unexpected as the greater surface area of the particles compared to weight generally increases the concentration (mg/kg) of metals present as observed for every other sample (Table 7). Further, smaller sediment particles generally display a greater ability to react with metals or metalloids in colloidal form again increasing levels.

Aluminium at ERMP-AQ-05 was the only element to show an increase in the <63µm sample compared to the whole sample, (21,400mg/kg to 27,700mg/kg; i.e. approximately 30%). This increase in aluminium probably represents increased levels of gibbsite type ($Al(OH)_3$) and kaolinite type ($Al_2Si_2O_5(OH)_4$) minerals. These minerals are very common in most tropical weathering profiles and generally have much lower adsorption capacities than the manganese oxy-hydroxide and iron oxy-hydroxide minerals present in the profile. Thus overall adsorbed aluminium levels will be lower.

The high concentrations of some metals recorded at each site are probably associated with the surrounding surface geology with the headwaters beginning in White Rock. The surficial geology is known to be enriched in metals and depleted of minerals (Munson *et al.*, 2013). These geological characteristics of the local catchment areas surrounding and upstream of each individual site influence the metal and metalloid concentrations. The elevated levels of metals observed in small sections of each watercourse are not expected to greatly influence downstream results under natural conditions. The low erosivity attributes of the soils within the catchment, and the general lack of fine (silts and clays) particle sizes mobilised from upstream waters, suggest that large sediment plumes/slugs do not actively migrate downstream within the system. Thus, alterations to the hydrological processes across the project site have the potential to influence the metal and metalloid concentrations throughout each catchment.

Geochemically, thorium to uranium ratios in highly weathered (bauxite) rocks are high, typically ranging from 1.5:1 to 30:1. This ratio reflects the generally highly immobile nature of thorium in weathering profiles and the relatively mobile nature of uranium.

The thorium/uranium ratios in the <63µm fraction were 1.23, 0.589, 0.976, 0.60 and 1.05 in sequence moving upstream. These are all well below the usual range and in three of the samples the ratio is <1 signifying uranium concentrations are greater than thorium concentrations, implying enrichment of uranium in the sediments. The most likely mechanism for this is through uranium chloride solution complexes being captured by the surfaces of small particles, with the chloride component a normal constituent of saline water of marine origin. Once adsorbed, the energetics of these uranium complexes will be high. Consequently, they will be residual and lead to relatively high levels of uranium (compared to thorium) within the fine fraction. This relative enrichment of uranium is a natural process, indicating the role of chloride in the chemical transport processes occurring between the estuarine and freshwater systems.

Full analytical results (i.e. Certificate of Analysis) are provided in Appendix 3.

Table 7: Sediment chemistry recorded at each site compared to best practice guidelines

Quality characteristic	Units	LOR	ERMP-AQ-01		ERMP-AQ-02		ERMP-AQ-03		ERMP-AQ-04		ERMP-AQ-05		ANZECC & ARMCANZ (2013)	
			Whole	<63µm	Whole	<63µm	Whole	<63µm	Whole	<63µm	Whole	<63µm	Value	SQG-High
Aluminium	mg/kg	50	16700	19800	380	13000	1170	13000	500	10300	21400	27700	NA	NA
Boron	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NA	NA
Iron	mg/kg	50	42200	50900	1430	52600	9470	63000	410	10300	106000	71900	NA	NA
Arsenic	mg/kg	1	16.6	16.1	<1.00	20.2	2.37	16.7	<1.00	1.08	12.6	6.87	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	10
Chromium	mg/kg	1	39.9	44.8	1.2	31.8	8.2	31.6	1.1	15.4	37.9	44	80	370
Copper	mg/kg	1	10.5	16.2	<1.0	64.9	1.9	44.1	<1.0	27.7	11.3	18.1	65	270
Cobalt	mg/kg	0.5	7.9	7.7	<0.5	5.6	0.9	12.9	<0.5	10.4	21.3	16.4	NA	NA
Lead	mg/kg	1	15.9	16.1	<1.0	15.5	1.9	20.2	<1.0	10.6	24.8	25.1	50	220
Manganese	mg/kg	10	417	424	<10	194	73	946	72	2280	2020	1090	NA	NA
Nickel	mg/kg	1	11.2	12.1	<1.0	8.6	<1.0	8.7	<1.0	7.3	9.3	11.5	21	52
Selenium	mg/kg	0.1	0.8	0.6	<0.1	1	0.2	1.3	<0.1	1.3	1.6	1.1	NA	NA
Silver	mg/kg	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	4
Vanadium	mg/kg	2	96.2	88.6	4.3	137	36.4	150	2.5	58.3	181	205	NA	NA
Zinc	mg/kg	1	23.7	24.8	<1.0	49.6	2.5	28.1	<1.0	15.6	6	7.9	200	410
Thorium	mg/kg	0.1	-	3.7	-	3.3	-	4	-	0.9	-	4.1	NA	NA
Molybdenum	mg/kg	0.1	1.4	1	0.8	10.1	1.5	11.6	<0.1	0.4	1.2	1	NA	NA
Uranium	mg/kg	0.1	3	3	0.2	5.6	0.9	4.1	<0.1	1.5	3.2	3.9	NA	NA
Mercury	mg/kg	0.01	0.02	0.02	<0.01	0.03	<0.01	0.06	<0.01	0.04	0.04	0.05	0.15	1
Total organic carbon	%	0.02	-	2.58	-	6.09	-	5.69	-	3.76	-	6.28	NA	NA

5.5 MACROINVERTEBRATE COMMUNITIES

5.5.1 FRESHWATER

5.5.1.1 *Taxonomic Richness*

Macroinvertebrate sampling methods for the NT states that two habitats should be targeted for analysis using the AusRivAS modelling programme; (1) sandy bed habitat and (2) edge habitat (Lloyd & Cook, 2002). However, ERMP-AQ-04 did not contain a sandy bed habitat conducive to the AusRivAS sampling methods. Therefore, only an edge sample was collected.

Twenty seven (27) different macroinvertebrate taxa were collected from the edge habitat at ERMP-AQ-04. The site was dominated (in abundance) by the family Chironomidae (true flies) which is known to be tolerant to environmental change. However, various sensitive taxa were also recorded.

Historic assessments have noted a wide range of taxonomic richness within the watercourses of Groote Eylandt. Cumberland Ecology (2015) noted a similar overall diversity of macroinvertebrate taxa to the current study, while URS (2012) documented a far greater taxonomic richness throughout the region. Cumberland Ecology (2015) recorded a total of 24 taxa, with an average site taxonomic richness of 7 within the upper reaches of the Emerald River. While the overall taxonomic richness was similar to that recorded at ERMP-AQ-04, the average site richness recorded by Cumberland (2015) was far lower than that noted from the one site assessed within the current study.

URS (2012) reported a total of 117 taxa within the Emerald River and Angurugu River. However, this study identified taxa to a lower level then required by the AusRivAS methods (i.e. down to Genus and in some instances Species level instead of simply Family level). The consequence of this falsely inflated the results compared to the approved standards (URS, 2012). On closer inspection of the URS (2012) raw data, a total of 41 different Families/Sub-families (Orders for Acarina) were recorded, with 27 – 36 recorded at each site (based on composite samples) within the Emerald River. These numbers are similar to that recorded in the current study.

All three studies found similar macroinvertebrate assemblages within the region's watercourses (URS, 2012; Cumberland Ecology, 2015). This is probably a response to the highly mobile terrestrial adult stage displayed by the majority of organisms. Interestingly, similar to the current study, none of the previous assessments recorded any molluscs (e.g. freshwater snails, etc.) within the community assemblages at any sites (URS, 2012; Cumberland Ecology, 2015). This is unexpected given the large amount of aquatic vegetation and algae noted in the freshwater reaches. However, the highly fresh waters sampled may be too fresh to allow molluscs to inhabit the region (i.e. too low in essential ions like calcium).

The complete raw data results of the number of individuals of each macroinvertebrate family collected at each site across the project site are provided in Appendix 4.

5.5.1.2 *PET Richness*

PET richness is calculated by the sum of the number of Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) families present at a site. PET taxa are generally sensitive to environmental change and anthropogenic disturbances. Therefore, the number of PET taxa inhabiting a site can be a measure of site condition, or provide an indication of an un-impacted site's potential to be influenced by anthropogenic activities. PET richness levels between 2 and 5 are considered relatively standard in tropical north Australian systems (QWQG, 2009), with edge habitats and/or riffle zones generally recording PET taxa values at the higher end of this range or above.

ERMP-AQ-04 recorded PET richness at 8, suggesting the system is in excellent condition with a variety of sensitive organisms inhabiting the area. Total site data found PET richness accounted for ~30% of taxa present at any site. Cumberland (2015) found similar levels of PET richness, recording a total of 6 families (compared to the current study's 8) and an overall percent composition of 20% for the project site.

The current study recorded two Ephemeroptera families, six Trichoptera families and no Plecoptera families on site. Plecoptera families are rarely recorded in tropical northern Australia systems, generally preferring more temperate habitats. The most sensitive taxa recorded was from the family Philopotamidae (Trichoptera) which has a SIGNAL grade of 8 suggesting they are highly sensitive to environmental change.

The PET results suggest that the aquatic ecology values of the system will be sensitive to change, with macroinvertebrate communities able to act as bio indicators to determine potential impacts from any proposed developments.

5.5.1.3 *SIGNAL 2 Analysis*

SIGNAL2 scores provide further indication on the condition of macroinvertebrate communities inhabiting a site. Generally, a SIGNAL2 score of less than four suggests the site is in poor condition and potentially influenced by anthropogenic disturbances (Chessman, 2003). However, SIGNAL2 scores are often recorded between three and four within tropical ephemeral systems influenced by drying processes at the end of the wet season.

SIGNAL2 bi-plot quadrant boundaries are not available for the region. Chessman (2001) states that interim bi-plot boundaries for edge habitats of 15.5 taxonomic richness and 4 SIGNAL2 score can be adopted for most of Australia. However, it is also stated that it is best to develop site specific boundaries based on background data for each individual system (Chessman, 2001). Cumberland (2015) developed site specific boundaries for the region as 3 taxonomic richness and 5 SIGNAL2 scores, despite all sampled sites scoring below 5 in SIGNAL2 scores. The reasoning behind Cumberland (2015) boundary delineation is not well understood. However, the taxonomic richness level appears low while the SIGNAL2 score value appears high.

ERMP-AQ-04 scored a SIGNAL2 value of 4.70 with taxonomic richness of 27 within the edge habitat. If the Chessman (2001) interim boundaries are adopted this site would occur in quadrant 1, suggesting that it is in good condition and healthy (Figure 10). Adopting the Cumberland Ecology (2015) boundaries would place this site in quadrant 2, suggesting the site assemblages are influenced by elevated nutrient or salinity levels (Figure 10). However, water quality values for these parameters were both compliant with guideline levels and not of concern, suggesting the Cumberland Ecology (2015) boundaries are inappropriate (Table 6). Instead, it is recommended that the Chessman (2001) interim boundaries be utilised for any future macroinvertebrate assessments until sufficient, suitable local data exists to develop site-specific boundaries.

5.5.1.4 *Shannon-Wiener Diversity Index*

Values for the Shannon-Wiener Diversity Index generally score between 1.5 and 3, with the higher values signifying greater biodiversity. ERMP-AQ-04 scored 2.05 (Figure 13). This result is considered relatively average, suggesting the system displays good biodiversity values within macroinvertebrate assemblages.

Evenness values occur between 0 and 1. The higher the value the more even the spread of organisms across all families recorded, with a result of 1 suggesting all families present have an equal abundance. The lower the evenness value the more the community is represented as a monoculture. ERMP-AQ-04 scored an evenness value of 0.27 suggesting a greater dominance of one or two particular species (Figure 13). Review of the raw data shows that the dominant family is the tolerant Chironomidae.

It is not uncommon in natural systems to observe skewed abundance data. URS (2012) recorded higher Shannon-Wiener Diversity Index levels than this current study (ranging 2.8 – 3.7). However, the URS (2012) analysis was based on macroinvertebrate data identified to a lower level, automatically increasing the diversity compared to the current assessment. Hence, their higher biodiversity index results are expected (URS, 2012). No evenness values were provided within the URS (2012) report to allow comparison during this current evaluation.

5.5.2 ESTUARINE

5.5.2.1 *Taxonomic Richness*

Thirty-five (35) families of marine macroinvertebrates were identified inhabiting the estuarine reaches of the project site, averaging seventeen (17) families per site. Interestingly, taxonomic richness and abundance appeared to decrease with increasing distance upstream (Figure 14 and Figure 15). This is expected to be a result of the dynamic environment experienced upstream, immediately below the rock bar/horizontal waterfall (refer to Section 5.1 and Table 5).

Water chemistry in the upper reaches of the estuary will experience large shifts in various parameters throughout the year as freshwater inputs increase and subside with the commencement and cessation of the wet season, respectively. The faunal assemblage inhabiting these reaches will in turn shift throughout the year dependent on water quality. Such systems are well known to increase in taxonomic richness and Shannon-Wiener Diversity Index with increasing distance downstream of this dynamic zone (Laio *et al.*, 2016). This is a natural process associated with the wet season in tropical rivers, although the effects of this can be exacerbated through upstream anthropogenic disturbances.

Note: No other publicly available studies have surveyed benthic macroinvertebrate communities within Groote Eylandt estuaries to enable comparison.

5.5.2.2 *Shannon-Wiener Diversity Index*

As stated in Section 5.5.1.4, values for the Shannon-Wiener Diversity Index generally score between 1.5 and 3, with the higher values signifying greater biodiversity. All sites scored diversity index values of greater than 1.5, with no sites scoring above 2.2 (Figure 13). These results are considered relatively average, suggesting the watercourses across the project site display good biodiversity within macroinvertebrate assemblages.

Evenness values fall between 0 and 1. The higher the value the more even the spread of organisms across all families recorded, with a result of 1 suggesting all families present have an equal abundance. The lower the evenness value the more the community is represented as a monoculture. Interestingly, ERMP-AQ-02 scored the highest Shannon-Wiener Diversity Index values and the greatest evenness results despite the site recording the lowest habitat condition score because of recent sand bar migration and ERMP-AQ-01 displaying the greatest taxonomic richness (Figure 13 and Table 4).

Review of the raw data shows that families from the class Gastropoda are the most abundant at all sites. All sites display a skewed abundance by particular families (generally from the class Gastropoda) to some degree (Figure 13). However, this is not uncommon in natural systems.

5.5.2.3 *Detailed Statistics*

Multi-dimensional scaling (MDS) and cluster analysis of estuarine benthic samples showed a degree of separation between all sites, although ERMP-AQ-02 and ERMP-AQ-03 displayed minor overlap (30 – 40%; Figure 16). An analysis of similarities (ANOSIM) found that the overlap between the two sites was weak, with a strong significant difference between all sites noted (Global R=0.959, p<0.01).

An assessment of the pairwise comparisons for individual sites found that all sites were inhabited by macroinvertebrate assemblages that were strongly different to each other (R ranged from 0.926 to 1). However, the low number of replicates (i.e. 3 from each site) impacted the ability to determine if these pairwise relationships were significant (all pairwise tests recorded p=0.1).

A SIMPER analysis found the main contributors to the difference between sites was the greater abundance of Cirratulidae at ERMP-AQ-01 compared to the two other sites (accounting for ~16 – 20% of the dissimilarity) and the greater abundance of Naticidae and Spionidae at ERMP-AQ-02 compared to ERMP-AQ-03 (accounting for ~30% of the dissimilarity).

Cirratulidae are marine polychaete worms that generally inhabit marine muds although some species live in rock crevices (Chambers, 2000). Hence, the occurrence of the family at ERMP-AQ-01 and not at the other two estuarine sites is likely associated with the change in substrate. ERMP-AQ-01 was the only site found to have high levels of silt and clay, while ERMP-AQ-02 and ERMP-AQ-03 were almost entirely comprised of sand (refer to Section 5.4.1).

Naticidae are predatory marine gastropods known to inhabit sandy substrates in tropical to temperate systems (Huelsken *et al.*, 2008), while Spionidae are another family marine polychaete worms potentially more versatile than Cirratulidae as they inhabit several different substrate types (Dix *et al.*, 2005). The difference in abundance of these families between ERMP-AQ-02 and ERMP-AQ-03 is not immediately understood. However, the assessment of the macroinvertebrate data against the environmental variables available for the site (i.e. habitat condition, water and sediment quality data) found that EC levels at the surface (i.e. 0.2m depth) best correlate with the patterns observed in the macroinvertebrate community assemblages (Rho=0.708, p=0.01). Other environmental variables also correlated well, although these were strongly associated with EC.

Based on this assessment it is suggested that the freshwater influence from natural downstream flows is structuring macroinvertebrate communities within the upper estuarine sections of the Emerald River. It is suggested that the extent (downstream) of this influence will vary dependent on season, with increased freshwater outputs during the wet season likely shifting the macroinvertebrate assemblage inhabiting ERMP-AQ-03 toward a freshwater species dominated community. Further, by the end of the dry season it is likely that more estuarine families will recruit to the area with the potential to encounter Naticidae and Spionidae at ERMP-AQ-03 later in the year as the freshwater influence diminishes.

5.5.3 BAITED TRAPS

Three larger decapod species were identified within the project site during the field surveys. These included one species of freshwater prawn and two species of marine crabs (Table 8). Table 8 indicates the sites from which these invertebrates were recorded and their abundance.

As expected the freshwater prawn species was caught at ERMP-AQ-04 while the crabs were observed in the upper estuarine reaches (Table 8). Mud crabs are widespread across northern Australia, maintaining a major commercial fishery in the NT and Queensland (Jones & Morgan, 2002). Note; there are two species of mud crabs in Australia, both occurring in the Northern Territory, *Scylla serrata* (Green Mud Crab) and *Scylla olivacea* (Brown Mud Crab). *Scylla serrata* is the larger of the two and generally brown/dark green in colour (Jones & Morgan, 2002). This species is known to inhabit shallower waters within estuaries, generally burrowing in mud associated with mangroves (Jones & Morgan, 2002).

Mud crabs caught were generally adult to sub-adult *Scylla serrata,* with an average carapace width of 100mm (adults can reach over 250mm in carapace width).

There are at least 16 species of fiddler crab known to occur in northern Australia. The species observed in the Emerald River is probably *Uca signata*, although it was not confirmed within the field. Discussions of the ecological traits of all the larger decopoda species identified in the area are provided in Appendix 4.

Table 8: Invertebrate species caught in baited traps

Site	*Uca sp.** (Fiddler crab)	*Scylla serrata* (Mud crab)	*Macrobrachium australiense* (Freshwater prawn)
ERMP-AQ-01			
ERMP-AQ-02	2		
ERMP-AQ-03		2	
ERMP-AQ-04			4

* Likely *Uca signata* as known to occur within the Gulf of Carpentaria. However, a specimen was not able to be caught for identification.

5.6 Fish Communities

5.6.1 Freshwater

5.6.1.1 *Species Richness*

Five freshwater fish species were recorded across the project site, including:

- *Glossamia aprion* (Mouth almighty);
- *Melanotaenia nigrans* (Blackbanded rainbowfish);
- *Melanotaenia splendida inornata* (Chequered rainbowfish);
- *Mogurnda mogurnda* (Northern trout gudgeon); and
- *Neosilirus ater* (Black eel-tailed catfish).

No species listed under the EPBC Act or the TPWC Act were found during the field surveys. Further, no introduced species were observed during the field surveys. All five species are obligate freshwater fish (i.e. they are restricted to freshwater and don't persist in estuarine or marine waters for any stages of their lifecycle).

Previous studies have identified wide-ranging species richness of freshwater fish assemblages within both the Amagula River and neighbouring watercourses. Cumberland Ecology (2015) recorded a total of five species occurring within the upstream freshwater reaches of the Amagula and Emerald Rivers while URS (2012) recorded fifteen species and Webb (1992) recorded twelve species within the Angurugu and Emerald Rivers (refer to Table A5.1 in Appendix 5).

A full description of the major ecological traits of each species caught within the current study along with pictures of each species is provided in Appendix 5.

5.6.1.2 *Life History Stages*

Fork length data was collected from captured fish prior to release to provide insight into life history stages present. In general, adults and sub-adults of each species were caught with average fork lengths displayed in Figure 17. It is likely that wetlands within the region are utilised as nursery/breeding grounds for many species of freshwater fish known to occur in the region (Pusey *et al.* 2004). Once the fish are at the sub-adult stage they will access the main channel of watercourses to traverse greater distances upstream and downstream dependent on season and life history phase (Pusey *et al.* 2004).

5.6.2 ESTUARINE

5.6.2.1 *Species Richness*

Twenty-six fish species were recorded within the estuarine reaches of the project site. Table A5.3 (in Appendix 5) shows the abundance of each fish species recorded at each sampling site. No species listed under the EPBC Act or the TPWC Act were found during the field surveys. Further, no introduced species were observed during the field surveys.

Previous studies have identified wide-ranging species richness of estuarine fish assemblages within the Emerald River and the Angurugu River. URS (2012) recorded fifty-eight species of fish, forty-one species in the Emerald River and forty-seven species in the Angurugu River. Webb (1992) and Taylor (1964) recorded forty-two species and thirty-nine species, respectively, within the Angurugu and Emerald Rivers (combined) (refer to Table A5.4 in Appendix 5).

The current study identified an additional (common on the mainland) two estuarine species not previously recorded on Groote Eylandt; the Lesser Salmon Catfish (*Neoarius graeffei*) and the Blackspotted Rockcod (*Epinephelus malabaricus*; Table A5.4). Several estuarine species observed in previous studies were not recorded in the current assessment (Table A5.4). Many of these were smaller bodied fish species. The current study employed larger mesh sized gill nets to target protected elasmobranch species as previous studies had sufficiently catalogued the estuarine fish assemblages and more targeted surveys were required. To date a total of ninety-eight species of estuarine fish have been recorded within the Emerald River and the Angurugu River, combined (Taylor, 1964; Webb, 1992; URS, 2012).

5.6.2.2 *Abundance*

Fish abundance results did not correspond with species richness results at each site (Figure 18). All sites recorded similar species richness despite the abundance of fish at ERMP-AQ-03 recording a level almost three times higher than both other sites (Figure 18). This is a result of the schooling nature of the species observed, increasing the number of individuals disproportionately to the number of species. These results will also be strongly influenced by the same sampling deficiencies (e.g. large mesh net size) discussed in relation to the richness data above.

5.6.2.3 *Life History Stages*

Fork length data was collected from captured fish prior to release to provide insight into life history stages present. All specimens of each species caught were adults with average fork lengths displayed in Figure 19. The lack of juvenile (and smaller) fish is due to the large mesh size of the gill nets employed. As discussed in Section 5.6.2.1, the current study employed larger mesh sized gill nets to target protected elasmobranch species as previous studies had sufficiently catalogued the estuarine fish assemblages and more targeted surveys were required.

Note: A large number of juvenile and larval fish were observed during the field surveys although these could not be identified from simple visual observations.

5.6.3 PROTECTED ELASMOBRANCH SPECIES

Several listed elasmobranchs were identified as potentially occurring within a 20km radius of the project site in database searches (refer to Sections 3.1.1 and 3.2.2) including:

- the Speartooth Shark (Critically Endangered under the EPBC Act and Vulnerable under the TPWC Act);
- the Dwarf Sawfish (Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act)
- the Largetooth Sawfish (Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act);
- the Green Sawfish (Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act);
- the Narrow Sawfish (Migratory Marine under the EPBC Act);
- the Great White Shark (Vulnerable and Migratory Marine under the EPBC Act); and
- the Whale Shark (Vulnerable and Migratory Marine under the EPBC Act).

No protected elasmobranch species were encountered during the field surveys. Using historic professional fishing records, Field *et al.* (2008) identified three species of sawfish (Narrow, Green and Dwarf) within the coastal waters north of Groote Eylandt. No Speartooth Sharks have been recorded in the area, although they are known to occur on the eastern side of the Gulf of Carpentaria (Field *et al.*, 2008). Despite several different studies and considerable fishing effort on various major watercourses across Groote Eylandt, no sawfish or Speartooth Sharks have been recorded (Webb, 1992; Thornburn, 2010; URS, 2012; Cumberland Ecology, 2015).

Sawfishes and Speartooth Sharks are known to inhabit coastal waters, estuaries and rivers, preferring tidally influenced zones that display high turbidity and deeper (>1m) waters with mud/sand substrates (Field *et al.*, 2008; Kyne & Pillans, 2014). Speartooth Sharks appear to migrate during the tidal cycle, travelling up to 25km in a particular direction over one cycle (Pillans *et al.*, 2005). While the movements of sawfish are not well understood, the Largetooth Sawfish has been known to travel up to 400km inland during flood events, with specimens recorded from isolated permanent pools in the dry season (SPRAT Profile; DAWE, 2020).

Speartooth Sharks are generally bottom feeders, actively predating on benthic species of fish and crustaceans, while likely to also be opportunistic carrion feeders as they are known to be susceptible to baited hook fishing (Peverell *et al.*, 2006; Kyne & Pillans, 2014). Similarly, sawfishes are bottom dwellers, actively predating on slow-moving shoaling fish, crustaceans and molluscs, while also susceptible to baited hook fishing (SPRAT Profile; DAWE, 2020; Kyne & Pillans, 2014).

Based on the discussed ecology of the protected elasmobranch species known to inhabit the greater Gulf of Carpentaria region, and the identified fish and macroinvertebrate communities as well as available habitats on the project, it is considered highly unlikely that Speartooth Sharks and the majority of the sawfish species would inhabit any of the freshwater reaches on the project site (refer to Table A7.1 in Appendix 7 for further discussion). However, as large permanent pools are known to be present upstream of the project site on the Emerald River, there is a low potential for juvenile Largetooth Sawfish to utilise the project site as a pathway to access (or leave) these upstream pools during flood events (Table A7.1).

There are no large permanent pools or off-channel wetlands/lagoons in the upper reaches of the Southern Tributary. The system is largely ephemeral with only one small (<10m wide and <30m long) pool known to persist throughout much of the year. Based on this, any use of this system by Largetooth Sawfish would be limited to periods of flow in the wet season primarily for foraging with no appropriate upstream refugia available during the dry season.

While there is the potential for the protected sawfish and Speartooth Shark species to inhabit the Emerald River estuarine system, it is a reasonably small system (the estuarine section is ~3.8km long and generally ~20m wide) compared to neighbouring systems, with access to upstream freshwater systems restricted for much of the year by a series of rock bars forming a horizontal waterfall. Therefore, while there is conducive habitat for sawfish and Speartooth Shark to exploit within the estuary section of the Emerald River, individuals would not use the system for extended periods of time due to its short length and narrow width.

The Great White Shark and the Whale Shark do not inhabit small tidal river systems and are not of concern to this project (refer to Table A7.1). A full assessment of the likelihood of all the protected elasmobranch species to utilise the project site is provided in Table A7.1 in Appendix 7.

5.7 Turtle Communities

5.7.1 Freshwater

No freshwater turtles were observed during the field surveys. However, there is anecdotal evidence that the Northern Snake-necked Turtle (*Chelodina oblonga*) inhabits the central freshwater lakes on Groote Eylandt (pers. comm. Traditional Owners). These turtles are common throughout northern Australia and are known to occur within wetlands throughout the Gulf of Carpentaria and Papua New Guinea (Limpus *et al.* 2006). The species is not listed under either the EPBC Act or the TPWC Act.

No substantial freshwater wetlands containing sufficient water occurred on the project site. Hence, targeted surveys for the Northern Snake-necked Turtle within their preferred habitat could not be undertaken. It is unlikely that this species inhabits the project site as its preferred habitats (i.e. permanent/large lagoons/wetlands) are not present within the area.

5.7.2 Estuarine

Six species of protected marine turtles were identified as potentially present across the project site through database search results (refer to Section 3.1.1 and Appendix 6). No marine turtles were observed utilising the area during field surveys.

Chatto & Baker (2008) noted four species of protected turtles (Flatback turtle, Green turtle, Hawksbill turtle and Olive Ridley turtle) nesting on Groote Eylandt beaches during the dry season, suggesting the timing of the current field surveys was appropriate. However, all species nest along the southern and eastern sides of the island, with none reported as nesting on the western side (Chatto & Baker, 2008). Further, Leatherback turtles and Loggerhead turtles are not known to nest on Groote Eylandt at all (Chatto & Baker, 2008). A full assessment of the likelihood of these protected vertebrates utilising the project site is provided in Table A7.1 in Appendix 7.

Based on this assessment it is suggested that most species of protected turtles will forage along the western side of the island as they migrate north or south through the Gulf of Carpentaria to preferred habitat. Therefore, any use of the Emerald River by marine turtles will likely be minimal and on an opportunistic basis (refer to Table A5.5). It should be noted that no seagrass beds (the preferred food of most marine turtles) were observed at any of the monitoring locations during the field surveys.

5.8 Other Aquatic Vertebrates

Several marine vertebrates (other than the protected elasmobranchs and turtles discussed in Sections 5.6.3 and 5.7.2) were listed and identified as potentially occurring (in EPBC Act search results) within a 20km radius of the Emerald River (refer to Section 3.1.1). Of these only two species; the Estuarine Crocodile (*Crocodylus porosus*) and the Olive Seasnake (*Aipysurus laevis*) were observed utilising the project site. The EPBC Act lists these species as Marine Migratory and Marine, respectively, while neither species is listed under the TPWC Act.

Evidence of Estuarine Crocodiles was noted at all sites within the estuary, with a 2.5m specimen observed basking on the bank ~50m upstream of ERMP-AQ-03. Two Olive Seasnakes were sighted at ERMP-AQ-01. A full assessment of the likelihood of all the protected marine vertebrates, identified in database searches, to utilise the project site is provided in Table A7.1 in Appendix 7.

5.9 Aquatic and Riparian Flora

5.9.1 Aquatic Flora

Seven species of aquatic flora were found at ERMP-AQ-04, including:

- *Blyxa sp.*;
- *Colocasia esculenta var. aquatilis*;
- *Cyperus sp*.;
- *Eleocharis spiralis*;
- *Eriocaulon wildenovianum*;
- *Lomandra longifolia*; and
- *Vallisneria nana*.

No floating (free or attached) aquatic plant forms were noted at the site. The lack of these types of aquatic flora is probably a factor of the habitats present and the strong flows recorded. The results are similar to the Cumberland Ecology (2015) study which found the upstream Emerald and Amagula Rivers to be dominated by sedges.

No submerged aquatic vegetation was observed at any of the estuarine sites (e.g. seagrass). Instead, the aquatic vegetation associated with the estuarine sites was comprised almost entirely of mangrove species within the riparian/intertidal zone. Therefore, aquatic vegetation associated with the estuarine sites is discussed in Section (5.9.2).

No aquatic Weeds of National Significance (WONS) were sighted during field surveys. None of the aquatic flora species identified within the project site are listed under the EPBC Act.

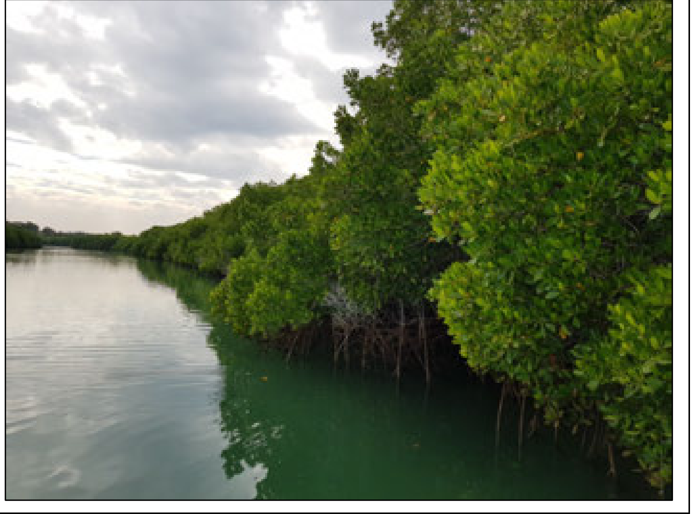
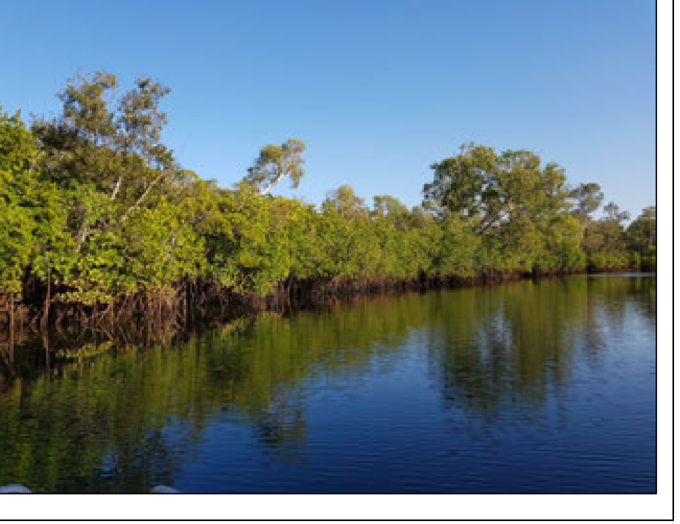
5.9.2 Riparian Flora

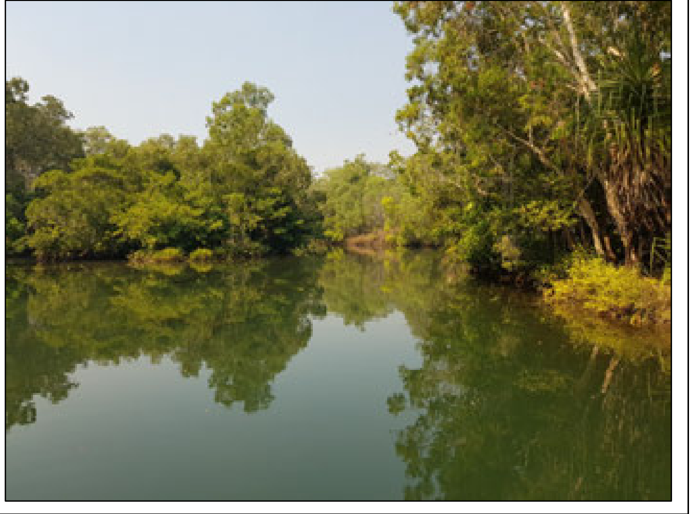
The most upstream monitoring point assessed for this study (ERMP-AQ-04) is located in the lower freshwater reaches of the Emerald River. The riparian vegetation within this section of river is characterised as Melaleuca woodland/Monsoon vine forest dominated by *Melaleuca leucadendra* with a sparse sedge understory. These vegetation communities are reflective of the hydrodynamics of the river. There is little to no indication that there is any estuarine influence within the upper reaches of the project site. The riparian zone in this freshwater reach extends from the bank over 50m onto the adjacent flood plain.

Approximately 400m downstream of ERMP-AQ-04 the river cascades over a horizontal water fall. This is the approximate limit of tidal influence and is reflected in the riparian community observed. From this point, traversing downstream, the riparian zone slowly grades through a zonation sequence from a Melaleuca woodland/Monsoon vine forest to a Melaleuca woodland/low mangrove forest to a mangrove forest. This zonation is influenced by the tidal waters coming up the river and the perennial freshwater flows coming down the river. The width of the riparian vegetation is highly variable ranging from 50m in the Melaleuca woodland/Monsoon vine forest areas to over 500m in the mangrove forest (Table 9).

A detailed description of the riparian communities inhabiting each monitoring site is provided in Table 9. Note; these results are based on a site specific assessment conducted over a maximum reach of 100m at each monitoring location and are not a broad scale determination of vegetation communities for the area. To identify the broad scale vegetation communities within the project site, please refer to mapping prepared by DENR and/or any available site specific vegetation mapping.

Table 9: Description of the riparian community at each monitoring site

Site	Description	Photos of associated riparian zones
ERMP-AQ-01	The riparian vegetation at ERMP-AQ-01 is comprised of a low Mangrove forest. The tallest stratum is dominated by two mangrove species; *Rhizophora stylosa* and *Avicennia marina.* Other species inhabiting the site include *Lumnitzera racemose, Bruguiera gymnorrhiza* and *Ceriops australis*. No mid or lower stratum was observed at the site. The width of the riparian zone at this point is in excess of 500m from the bank as adjacent to the banks are a complex of small drainage features and off channel wetlands.	
ERMP-AQ-02	The riparian assemblage at ERMP-AQ-02 is comprised of a combination of low Mangrove forest and Melaleuca woodland. On the northern side, the riparian zone is defined by a thin zone of mangroves aligning the bank. The mangroves within this zone are dominated by *Rhizophora stylosa* and *Avicennia marina*. The bank of the river on this northern side is on the outer side (higher energy zone) of a bend, because of this, the bank rises sharply and on top of the bank the vegetation is dominated by *Melaleuca leucadendra* and *Melaleuca viradiflora*. No understory is observed in the mangrove forest. Within the Melalecua woodland the understory is dominated by a mixture of sedge species including *Leptocarpus spathaceus*, *Leptocarpus elatior* and *Eleocharis spiralis.* The southern bank is on the inward side (low energy zone) of the bend. The bank is not steep at this point and the combination of this and the high sinuosity of the river at this location has led to the formation of an extensive mangrove zone. The tallest stratum is dominated by several mangrove species including *Rhizophora stylosa, Avicennia marina* and *Bruguiera gymnorrhiza.*	

Site	Description	Photos of associated riparian zones
ERMP-AQ-03	The vegetation community associated with the ERMP-AQ-03 site is a Melaleuca woodland. The tallest stratum is dominated by *Melaleuca leucadendra* at a maximum height of 15m. The species assemblage at this site was considerably more complex as the site is influenced by both fresh and saltwater process. Within the mid story mangrove species such as *Rhizophora stylosa* and *Bruguiera gymnorrhiza* were observed. Non-estuarine species include *Canarium australianum* and *Pandanus spiralis.* Immediately adjacent to the watercourse the understory was dominated by the fern species *Acrostichum speciosum.*	
ERMP-AQ-04	The riparian vegetation at ERMP-AQ-04 is a Melaleuca woodland/monsoon vine forest dominated by *Melaleuca leucadendra* with a sparse sedge understory. The tallest stratum is dominated by *Melaleuca leucadendra* at a maximum height of 15m. Other common species within the tallest stratum make up the vine forest component and include *Syzygium angophoroides* and *Canarium australianum.* The mid stratum is dominated by *Pandanus spiralis.* Monsoon forest species within the mid stratum include *Dillenia alata*, *Pouteria sericea* and *Diospyros maritima.* The lower stratum is quite sparse with a thick layer of leaf litter. Species that are found adjacent to the channel include ferns such as *Lygodium microphyllum* and herbs such as *Philydrum lanuginosum* and *Typhonium flagelliforme.* The riparian zones on both sides of the watercourse are confined to 10m.	

Site	Description	Photos of associated riparian zones
ERMP-AQ-05	ERMP-AQ-05 is within a Melaleuca woodland dominated by *Melaleuca leucadendra* and *Melaleuca cajuputi* at a maximum height of 15m. The mid stratum is dominated by *Pandanus spiralis*, *Acacia alacocarpa*, *Acacia difficilis* and *Acacia leptocarpa*. The understory is dominated by a mixture of sedge and herb species including *Leptocarpus spathaceus*, *Leptocarpus elatior, Eleocharis spiralis* and *Philydrum lanuginosum*. At the time of observation the channel was completely dry. The groundcover within the channel was a thick layer of decomposing leaf litter. No live grass or sedge species were found within this area. The riparian zones on the eastern side of the watercourse is confined to within 10m of the bank. The riparian zone on the western side extends out over 150m from the site. During the wet season it is likely that this whole area is inundated.	
ERMP-AQ-06	ERMP-AQ-06 riparian vegetation is characterized by a Melaleuca woodland with a fern dominated understory. The tallest stratum is dominated by *Melaleuca leucadendra* at a maximum height of 15m. The mid story is dominated by *Pandanus spiralis* and the understory is dominated by several fern species including *Blechnum indicum* and *Lygodium microphyllum.* The riparian zones on both sides of the watercourse are extensive as the site is close to the main branch of the Emerald River.	

6. IMPACT ASSESSMENT

6.1 INTRODUCTION

This section provides an assessment of the potential impacts of the project on the aquatic environment. It includes consideration of the potential impacts arising from the construction and operation of the haul road and associated access roads. This assessment draws on specialist studies undertaken for the project including flood modelling of the Emerald River floodplain (Hydrology and Hydraulics Assessment Report (REE, 2020)) and a geomorphic assessment of the watercourses to be impacted by the project (Geomorphic Impact Assessment Report (WRM, 2020)).

The project has been designed to minimise potential impacts on aquatic ecology values. This included an iterative process whereby the haul road was initially designed as an embankment across a large part of the Emerald River floodplain. This initial design would have provided optimum road flood immunity and haulage efficiency. However, hydraulic modelling and scour modelling of this initial design identified there was significant potential for scour in the bed of the Emerald River. The potential scour impacts were deemed to be unacceptable and alternative lower impact haul road designs were subsequently investigated.

The preferred haul road design is described in Section 6.2 and includes an embankment on the northern side of the Emerald River and a bridge over the Emerald River. To the south of the river, the haul road is designed with a low level causeway on the floodplain. The haul road crossing of the Southern Tributary has been designed as a series of culverts in the channel and southern floodplain, and a low level causeway in between. Section 6.2 describes the design features of the project which were developed to minimise impacts on the identified aquatic ecology values.

The potential impacts of the project on the aquatic ecology values of the Emerald River and the Southern Tributary are described in Sections 6.3 and 6.4, respectively. Potential impacts on threatened and migratory species are described in 6.5. The potential for cumulative impacts are also assessed and discussed in Section 6.6.

6.2 DESIGN FEATURES OF THE PROJECT

6.2.1 ROADS

The haul road will be a dual lane, unsealed road, designed for use by mine vehicles only. Similar to haul roads at the existing mine, the haul road will be constructed with a compacted pavement of laterite and middlings. The haul road will generally be constructed at grade, although some localised cuts or areas of fill are required (i.e. for the embankment and to provide adequate cover for drainage infrastructure). Earthwork construction materials will be sourced from within the disturbance footprint of the haul road corridor as well as borrow areas within the Western Leases.

The project is located in a tropical setting and erosion has the potential to occur through direct rainfall impact loosening soil particles as well as overland flow washing soil particles away. An Erosion and Sediment Control Plan will be prepared for the construction of the project. The plan will include the following control measures that are proposed to manage the potential for erosion:

- All exposed batters and drains will be vegetated.

- Drains and batters will be lined with natural matting products (coconut fibre matt or mulch).
- The causeway surfaces will be regularly coated with a polymer coating to reduce sediment generation, particularly the breakup of the road surface during overtopping events.

The haul road drainage system is designed to limit the potential for suspended sediments to impact adjacent vegetation and downstream watercourses. The haul road surface is designed with a central crown to ensure drainage of the road surface. Runoff from the road will be captured by drains which feed into sediment ponds. Treated water from the sediment ponds will be released into surrounding vegetation. Clean water diversion drains will also be constructed to convey clean water away from the haul road formation.

The realigned access track and the construction access track will be cleared and graded to follow the natural ground elevation. No drainage infrastructure is proposed for these minor tracks.

6.2.2 Emerald River Bridge

The haul road design includes a crossing of the perennial Emerald River. The crossing consists of an elevated embankment on the northern floodplain, a bridge over the main channel of the river and a low-level causeway on the southern floodplain.

The bridge has been designed to minimise geomorphic impacts on the Emerald River by spanning the river channel without piers or encroaching abutments. The large span does not require structures to be constructed in the bed of the river or require disturbance of the main channel. This design allows bank full flood flows to pass beneath the bridge with negligible impact on flood levels, velocities and sediment transport capacity. Minor scouring may occur at the abutment of the Emerald River bridge under these flow conditions.

In larger flow events, the haul road embankment will divert floodwater onto the southern floodplain and across the causeway, allowing flood flows to overtop the haul road with minimal afflux. This is predicted to reduce peak flood velocities along the main river channel both upstream and downstream of the bridge. Peak velocities within the Emerald River channel under the bridge are predicted to increase, which could potentially cause localised contraction scour depths of up to 0.9 m. Scouring is not expected to extend much past the bridge extents because of the reduced velocities upstream and downstream of the bridge. Sediment is unlikely to fill the scour pool under the bridge during the falling limb of the flood events, as sediment transport rates are relatively low. Instead, filling of the pool may occur over time during successive smaller flood events and potentially from tidal flows. Any scour is likely to occur gradually and, therefore, sediment deposition along the downstream reach is not expected. Overall, given the relatively localised scour impacts, the haul road crossing is not expected to have a significant impact on the geomorphology or sediment transport rates of the Emerald River.

6.2.3 Southern Tributary Crossing

The haul road alignment will traverse an ephemeral tributary of the Emerald River, known as the Southern Tributary. The Southern Tributary crossing will consist of culverts in the channel and southern floodplain with a low-level causeway in between. Within the channel, the proposed culverts are an array of 7 x 1200 x 1200 mm box culverts. Within the southern floodplain, 6 x 1300 mm diameter pipe culverts are proposed to be excavated below ground level. A 100 m long low-level causeway will be constructed in between. Detailed design of the culverts will be conducted prior to construction which will take into account best practice fish passage requirements.

Similar to the Emerald River bridge and low-level causeway design, the crossing design diverts floodwaters from the Southern Tributary channel to the causeway. This reduces tributary channel velocities and channel flow. The reductions would extend to the Emerald River confluence because the flows diverted to the southern floodplain do not drain back to the Southern Tributary channel. This also results in increased flows and flow velocities along the southern floodplain. There is a higher potential for floodplain scour along the southern bank of the Southern Tributary immediately upstream of the culvert crossing and across the causeway section of the haul road where velocities exceeding 2 m/s are predicted for the 10% and 2% Annual Exceedance Probability (AEP) events. Erosion protection (in the form of rip rap) is proposed to be installed in the elevated velocity areas in these locations in order to prevent scouring.

Erosion protection will also be placed in the excavated outlet channel downstream of the southern floodplain culverts to reduce the potential for scour. The overbank velocity increases along the southern floodplain are generally less than 0.1 m/s, which is negligible.

6.3 Potential Impacts on Emerald River Aquatic Ecology

6.3.1 Introduction

The Emerald River bridge will span the breadth of the river with no foundations in-channel. Therefore there are limited direct potential impacts from the bridge on aquatic ecology values. Instead, the potential impacts are limited to indirect flow-on effects from run-off of disturbed areas, etc. The following potential impacts were assessed:

- Impacts to aquatic habitats;
- Impacts to fish passage;
- Impacts to water and sediment quality/composition;
- Increased risks from pest flora and fauna.

These potential impacts are discussed in the following sections.

6.3.2 Aquatic Habitats

Aquatic habitats within the reaches associated with the Emerald River bridge have the potential to be impacted by altered hydrology around the structure and removal of riparian vegetation during construction. As the majority of the bridge structure is to occur outside the main channel there are limited impacts to altered hydrology. Modelling found up to 0.9 m of sediment could be scoured from beneath the bridge during high flow/flood events once constructed (REE, 2020). Filling of the scour pool may occur over time during successive smaller flood events. Any scour is likely to occur gradually and, therefore, sediment deposition along the downstream reach is not expected. As this scour will be localised it is expected to have little influence on downstream habitats.

The impacts of the construction and operation of the Emerald River bridge on the aquatic habitats will be limited to the bed habitat in the immediate vicinity of the structure during high flow events. There will be negligible influence on the downstream aquatic ecology values identified within this assessment.

6.3.3 Fish Passage

As no structures will be erected within the main channel of the Emerald River, the bridge will have negligible impact on fish passage within the channel. However, during flood events fish will move out onto the floodplain (where flow velocities are generally lower) to migrate upstream or downstream. Therefore, the embankments on either side of the channel can act as barriers during flood events. The inclusion of the low-level causeway within the southern plain will reduce the impacts to fish passage during flood events. Rip rap on either side of the causeway will disrupt stream flow and may further aid fish movement.

With these additional mitigation measures in place, the Emerald River bridge will have negligible influence on fish passage throughout the river.

6.3.4 Water and Sediment Quality

The reach of the Emerald River associated with the project site transitions from freshwater (in quality) to estuarine throughout the year following the cessation of flooding freshwater flows during the wet season. This transition will include the natural slow creep of estuarine waters back upstream. The construction and operation of the bridge will not affect these complex hydrological interactions, allowing natural shifts in water quality to continue throughout the year.

Therefore, the main potential impact to water and sediment quality/composition is associated with sediment laden runoff from cleared areas (including road surfaces). The clearing of vegetation can result in the erosion of soil from the cleared areas and the increased suspension of fine sediments in runoff. This can increase suspended solids in downstream waters leading to reduced primary production (via reduced light attenuation and smothering) and increased sedimentation.

The project will mitigate these potential impacts by:

- Including sediment dams within the drainage structures which will collect runoff from the road and allow sediment to drop out of suspension before passively releasing collected waters;
- Regularly covering the causeway with a protective polymer to reduce erosion;
- Revegetating all exposed batters;
- Lining batters with natural matting products (coconut fibre matt or mulch);
- Installing diversion drains to limit clean water from entering the disturbance area. This reduces the volume of water that must be treated for suspended sediments prior to release;
- Undertaking the majority of construction works around the Emerald River during times throughout the year with a low likelihood of significant rainfall occurring; and
- Utilising best practice soil erosion and sediment control measures during construction (i.e. deploying silt curtains, sediment fences, etc.).

These mitigation measures will effectively reduce the potential for sediment laden runoff to enter the downstream Emerald River, limiting the potential for any impacts.

6.3.5 Pest Flora and Fauna

Very few pest species have established a presence on Groote Eylandt, especially in terms of fauna. There are no cane toads (*Bufo marinus*) or feral pigs (*Sus scrofa*) present, which are observed throughout much of mainland northern Australia. Therefore, the operation of the haul road must continue the ongoing best practice management methods currently adopted across the island to reduce the potential for these species to be introduced to the island.

During the construction and operational phases of the project, environmental management measures will be required to:

- prevent the transportation of flora and fauna to the project site;
- prevent the introduction of additional pest species; and
- manage and reduce the area of occupancy of any known pests on the site.

GEMCO has a Weed Management Plan and a Cane Toad Management Plan in place, which describes the measures undertaken by GEMCO to manage weeds and cane toads in accordance with the *Biosecurity Act 2015*.

The existing weed and pest control measures include the following measures that will also be applied to the project site:

- Delivering education and awareness training about weeds and pest animals to all staff and contractors via site inductions.
- Implementing the following prevention measures during construction:
    - Use of vehicle inspection and wash down for all vehicles and plant prior to entering the project site during construction. The inspection procedure involves checking the entire piece of equipment for noticeable traces of soil/seeds and plant material. Plant or equipment that are observed to contain seeds or plant material will be refused access to the project site until it has been adequately cleaned;
    - Maintenance of roads and tracks to minimise weeds on tracks and to lessen the spread of weeds by vehicle movements;
    - Undertaking daily checks for weeds on work clothes or boots for any personnel working on the project site.
- Undertaking a pre-clearance survey prior to clearing. The pre-clearance survey will aim to identify the location of any weeds that exist in the area to be cleared. Any weeds that are identified will be GPS recorded and sprayed or removed prior to any clearing.
- Maintaining a database of weed control actions including the GPS location of any identified weeds, a record of the actions that have been undertaken and details of follow-up monitoring.
- Implementing appropriate treatment control programs for any priority weed species identified at the project site in accordance with existing mine site procedures. The control programs will aim to contain and reduce the extent of weed species and prevent the introduction of additional species. Control programs may involve chemical and mechanical methods, depending on the sensitivity of the receiving environment.
- Undertaking routine inspections of haul road verges for weeds. Weed control measures will be implemented in the event of weeds being recorded.
- Developing pest management strategies in consultation with relevant key stakeholders, such as the ALC.
- Passive monitoring of pest animals on the project site and implementing control options when necessary.
- During operations, haul trucks will follow a set, low risk route between the existing mine site and J Quarry, minimising the risk of spreading weeds. As such, haul trucks that follow this low risk route will not be subject to routine washdown. However, any high risk vehicles (i.e. vehicles operating within the existing GEMCO mine that are subject to existing weed infestations, off road areas etc) will need to be washed down in existing facilities prior to using the new haul road and accessing J Quarry.

6.4 Potential Impacts on the Southern Tributary Aquatic Ecology

6.4.1 Introduction

The Southern Tributary culvert array will span the main channel. Therefore, there is the potential for both direct and indirect impacts to the aquatic ecology values associated with the system. The following potential impacts were assessed and are discussed in the following sections:

- Impacts to aquatic habitats;

- Impacts to fish passage;
- Impacts to water and sediment quality/composition;
- Increased risks from pest flora and fauna.

6.4.2 AQUATIC HABITATS

Aquatic habitats within the reaches associated with the Southern Tributary crossing have the potential to be impacted by altered hydrology around the structure and removal of riparian vegetation during construction. As the culvert array will be constructed within the main channel, there will be direct impacts to the bed habitat currently occurring within the footprint and hydrological affects both upstream and downstream of the structure. Modelling found downstream flows will reduce as a result of the proposed crossing and the upstream southern bank is at greater risk from scouring/erosion (REE, 2020). However, this will be localised, and the influence of scouring will be reduced through the adoption of erosion protection measures.

The reduced downstream flows may limit channel-forming flows from operating within these lower reaches. Natural high flow events clean/sculpt watercourse channels maintaining their structure and form. The reduction in flows can lead to increased sedimentation with the systems less likely to be flushed during natural high flow events.

The clearing of riparian vegetation will be limited to the footprint of the proposed crossing and the upstream southern bank that will require erosion protection. These impacts will be localised and mitigation measures to reduce them are limited. However, any cleared areas adjacent to the crossing footprint will be appropriately rehabilitated.

Therefore, the construction and operation of the Southern Tributary crossing has the potential to influence aquatic habitats within the immediate vicinity of the structure as well as the downstream reaches until the confluence with the Emerald River. However, the impacts in the Southern Tributary are expected to be minor and will have a negligible influence on the downstream aquatic ecology values identified within the Emerald River.

6.4.3 FISH PASSAGE

Alteration to natural fish movement patterns via the installation of waterway barriers can negatively influence fish communities in various ways, including the following (Stockman & Harris, 2005; Kapitzke, 2010):

- Increased risk of injury or mortality during migration;
- Increased energy costs for fish during passage;
- Excessive delays to migration patterns which can lead to a loss of stored energy impacting the success of the next life history stage for the fish (i.e. migration, spawning, maturation, etc.);
- Increasing aggregations of fish downstream of the barrier resulting in an increase in predation pressure from larger species and/or starvation from a lack of prey/food source for the congregated numbers;
- Limiting access to spawning and/or breeding grounds/habitat;
- Reductions in genetic diversity of a fish population through isolation;
- Reduction of a species' range within a system; and
- Potential for impacts on the greater food web where fish communities have been inhibited from accessing (i.e. trophic cascades, etc.).

Several of the fish species recorded inhabiting the Emerald River catchment area must migrate for various stages of their life cycles. Fish species that are likely to use the tributary for various stages within their life histories and require passage to be maintained for the sustainability of their local populations include three different movement traits:

- three catadromous species;
- two amphidromous species; and
- fourteen potamodromous species.

Culverts are known barriers to fish passage during times of flow. This is generally associated with the increased flow velocities and the smoothness of the culvert itself (Kapitzke, 2010) which prevent fish from effectively traversing the culvert. Hydraulic barriers presented by culverts include (Kapitzke, 2010):

- High velocity;
- Reduced flow depth;
- Lack of resting places and/or shelter;
- Excess turbulence; and
- Water surface drop (i.e. washouts downstream of the culvert creating drops).

The installation of culverts can also impact fish passage through the accumulation of debris and/or sediment (causing blockage of the culvert) as well as the reduction of light (over extended distances).

The construction of culverts on the Southern Tributary therefore has the potential to impact fish passage in the tributary.

Therefore, it is considered best practice to adopt appropriate mitigation measures for fish passage within the engineering design and construction of the proposed crossing. Such measures will include the addition of baffles (on outer walls), bed roughening and solar powered waterproof LED lighting based on the final design of the culverts and the targeted primary species. Detailed design of the culverts will be conducted prior to construction which will take into account best practice fish passage requirements.

Additionally, during flood events, fish will move out onto the floodplain, where flows are generally lower, to migrate upstream or downstream. Therefore, the road alignment on either side of the channel can act as barriers during flood events. The inclusion of the low-level causeway within the adjacent floodplain will reduce the impacts to fish passage during flood events. Rip rap on either side of the causeway will disrupt stream flow and may further aid fish movement.

With appropriate fish passage measures adopted for the culverts, the project will have minimal influence on the passage of resident fish communities inhabiting the upper reaches of the Southern Tributary.

6.4.4 WATER AND SEDIMENT QUALITY

The main impact to water and sediment quality/composition in the Southern Tributary is associated with sediment laden runoff from cleared areas (including road surfaces) and reduced downstream flows within the main channel. The clearing of vegetation can result in the erosion of soil from the cleared areas and the increased suspension of fine sediments in runoff. This can increase suspended solids in downstream waters leading to reduced primary production (via reduced light attenuation and smothering) and increased sedimentation especially within the lower reaches of the Southern Tributary where flows will be reduced.

Erosion and sediment control measures adopted for the Emerald River crossing will also apply to the Southern Tributary. These measures are discussed in Section 6.3.4 and will effectively reduce the potential for sediment laden runoff to enter the Southern Tributary, limiting the potential for any downstream water quality impacts.

6.4.5 Pest Flora and Fauna

Weed and pest control measures to be adopted for the project are described in Section 6.3.5. These measures will also apply to work at the Southern Tributary and will assist to prevent the introduction or spread of weeds as a result of the project.

6.5 Potential Impacts to Threatened and Migratory Species

The following listed species have been recorded from the project site or assessed as having a high or moderate potential to be present:

- Dwarf Sawfish (*Pristis clavata*) listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act;
- Largetooth Sawfish (*Pristis pristis*) listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act;
- Green Sawfish (*Pristis zijsron*) listed as listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act;
- Narrow Sawfish (*Anoxypristis cuspidate*) listed as Migratory Marine under the EPBC Act; and
- Estuarine Crocodile (*Crocodylus porosus*) listed as Migratory Marine under the EPBC Act.

As discussed in Section 6.3, there are limited potential direct impacts from the Emerald River bridge on aquatic ecology values. This is largely due to the bridge design whereby the bridge will span the breadth of the river with no foundations in-channel. The potential indirect effects from the bridge are also discussed in Section 6.3 and are considered to be minor. As such, the potential impact of the Emerald River bridge on threatened or migratory species that may potentially inhabit this portion of the river are expected to be minimal. In addition, flood modelling and a geomorphological assessment undertaken for the project (REE, 2020; WRM, 2020) suggest that the project will have negligible influence on the Emerald River downstream of the project site and/or on coastal/marine ecosystems. As such, threatened or migratory species that may potentially inhabit the Emerald River downstream of the bridge are also unlikely to be impacted by the bridge.

As discussed in Section 6.4, culverts are proposed to be constructed in the Southern Tributary. Therefore, there is the potential for both direct and indirect impacts to the threatened or migratory species that have the potential to be present in this watercourse. Two of the identified listed species were determined to have the potential to utilise the Southern Tributary (refer to Table A7.1 in Appendix 7), namely:

- the Largetooth Sawfish; and
- the Estuarine Crocodile.

An assessment of significance was undertaken on each of these species to determine the potential to be impacted by the construction of the culverts on the Southern Tributary (refer to Appendix 7). These assessments were undertaken in accordance with the Significant Impact Guidelines (SIG) to determine the significance of predicted impacts to threatened and migratory species. The SIG are designed specifically to determine whether an activity is considered, under the EPBC Act, to have a significant impact on a species.

Both assessments found that the project will not have a significant impact on the two listed species identified as likely to occur within the Southern Tributary. This was evidenced by the lack of critical habitat for both species within the upper reaches of the Southern Tributary, limiting the value the system provides the species to incidental foraging habitat during the wet season. This, combined with the fact the populations of the two species are wide spread across northern Australia, resulted in negligible impact occurring to either of the species from the proposed development. Please refer to Appendix 7 for a full discussion on this determination.

6.6 CUMULATIVE IMPACTS

There are no other significant developments proposed in the vicinity of the waterways affected by the project that have the potential to result in cumulative impacts with the project. Approved mining activities within the Western Leases have controls in place for erosion and sediment control. The approved, but as yet undeveloped, Eastern Leases Project includes a bridge over the headwaters of the Emerald River, approximately 6.5 km upstream from the project site. The crossing has been designed with low flow drainage culverts, allowing flows larger than the design event to flow over the culvert to maintain drainage within the watercourse. Erosion and sediment controls will also be put in place to manage potential impacts. These measures, along with the considerable distance upstream from the proposed Emerald River bridge, mean there is no potential for any significant cumulative impacts.

7. CONCLUSIONS

Aquatic ecology surveys of freshwater and estuarine habitats within reaches of the Emerald River were undertaken in July 2018. Various other aquatic ecology studies have been performed throughout the Emerald River catchment allowing this study to be more targeted on threatened species rather than the entire species assemblage.

The presence of Estuarine Crocodiles was a limiting factor influencing sampling techniques employed. Estuarine Crocodiles were encountered throughout the estuarine reaches of the Emerald River. Therefore, safety concerns for samplers greatly influenced the methods adopted at each monitoring site.

In accordance with the untouched nature of the project site, habitat condition assessments found the targeted systems to be in good to excellent condition. Main channel monitoring sites were characterised by sandy beds with only the downstream estuarine site dominated by mangrove mud. Targeted ephemeral wetlands were characterised by an organic rich soil and sand substrate within Melaleuca Woodlands with a sedge dominant understory.

Water quality results clearly showed the interaction between freshwaters and estuarine waters across the project site. The saltwater wedge was found to push under the freshwater upstream, past the site of the proposed Emerald River haul road crossing, despite the riparian community resembling a freshwater creek assemblage. The freshwater was generally slightly acidic with exceptionally low ion levels suggesting it is similar in nature to rainwater and likely spring fed (i.e. filtered through shallow aquifers). Some metals noted in the waters and sediment results (i.e. manganese and uranium) are known to be associated with the underlying surface geology across the island.

Macroinvertebrate (27 freshwater and 35 estuarine taxa), fish (5 freshwater and 26 estuarine/marine species) and aquatic flora (7 freshwater and 5 mangrove species) communities across the project site were found to be diverse and healthy with no anthropogenic factors influencing community assemblages. No listed species (other than the Estuarine Crocodile and the Olive Seasnake (declared Marine Migratory and Marine, respectively, under the EPBC Act)) were observed in the project site.

An assessment of the likelihood of listed species to utilise the project site was undertaken. Preferred habitat of the listed protected sawfishes was observed within the estuarine reaches. However, numerous studies with considerable combined effort (Webb, 1992; Thornburn, 2010; URS, 2012; Cumberland Ecology, 2015), did not record sawfish species (or Speartooth Shark) utilising the island's watercourses. It is predicted that if these species use the Emerald River (including the Southern Tributary) it would be on an opportunistic basis for a limited time due to the limited size (and associated limited resources) of the Emerald River estuarine section.

The impact assessment found that minimal impacts to aquatic ecosystems will occur in the Emerald River main channel because of the design of the bridge. Impacts within the Southern Tributary have a greater potential to cause harm to the identified aquatic ecology values of the system. However, the adoption of best practice environmental management measures (including those for maintaining fish passage through culverts) will limit these impacts to negligible. Further, an assessment of significance of two protected species with the potential to inhabit the Southern Tributary found the project would not have a significant impact on the resident populations of either species.

8. REFERENCES

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FIGURES

Figure 1: Location Plan

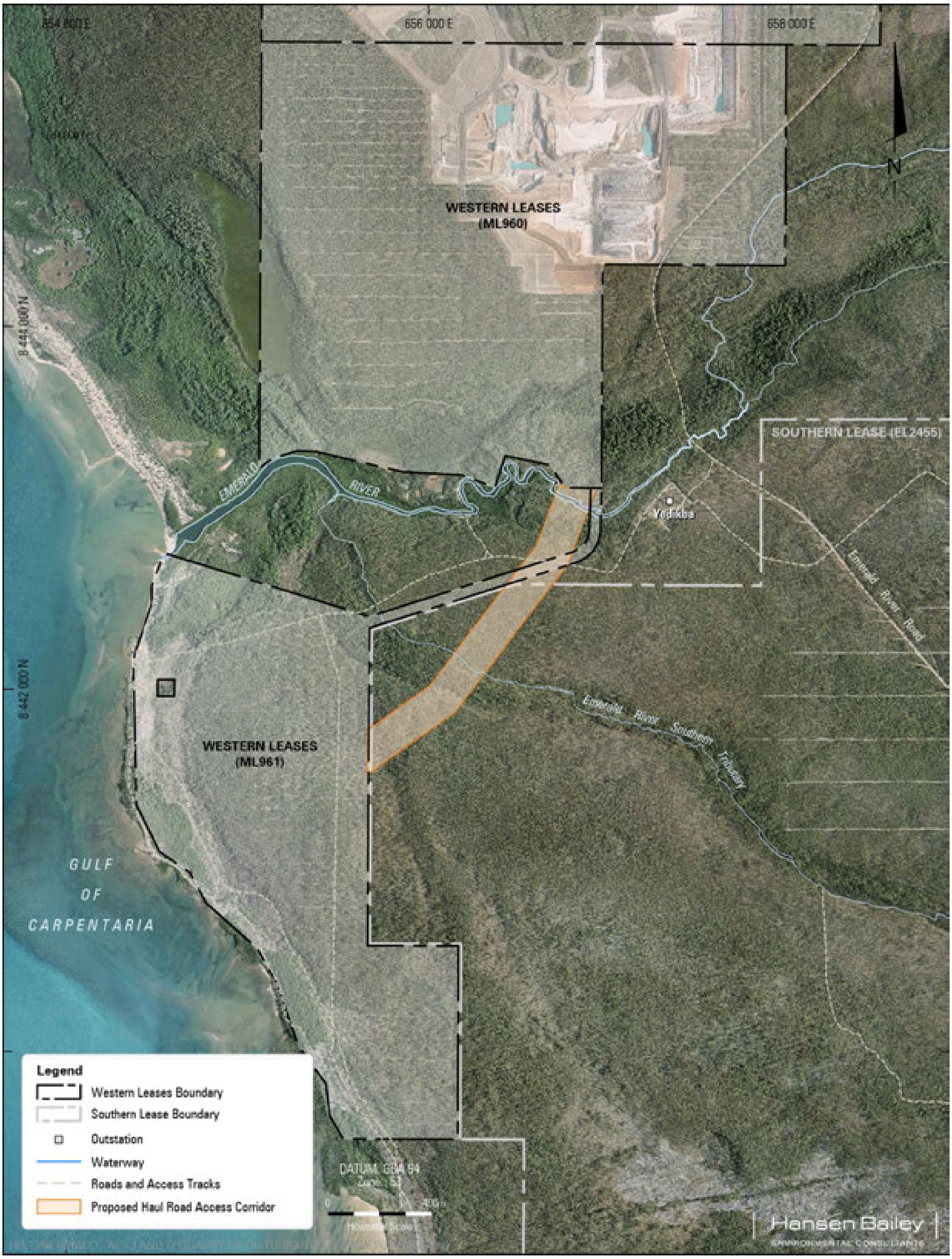

Figure 2: Location of J-Quarry access corridor

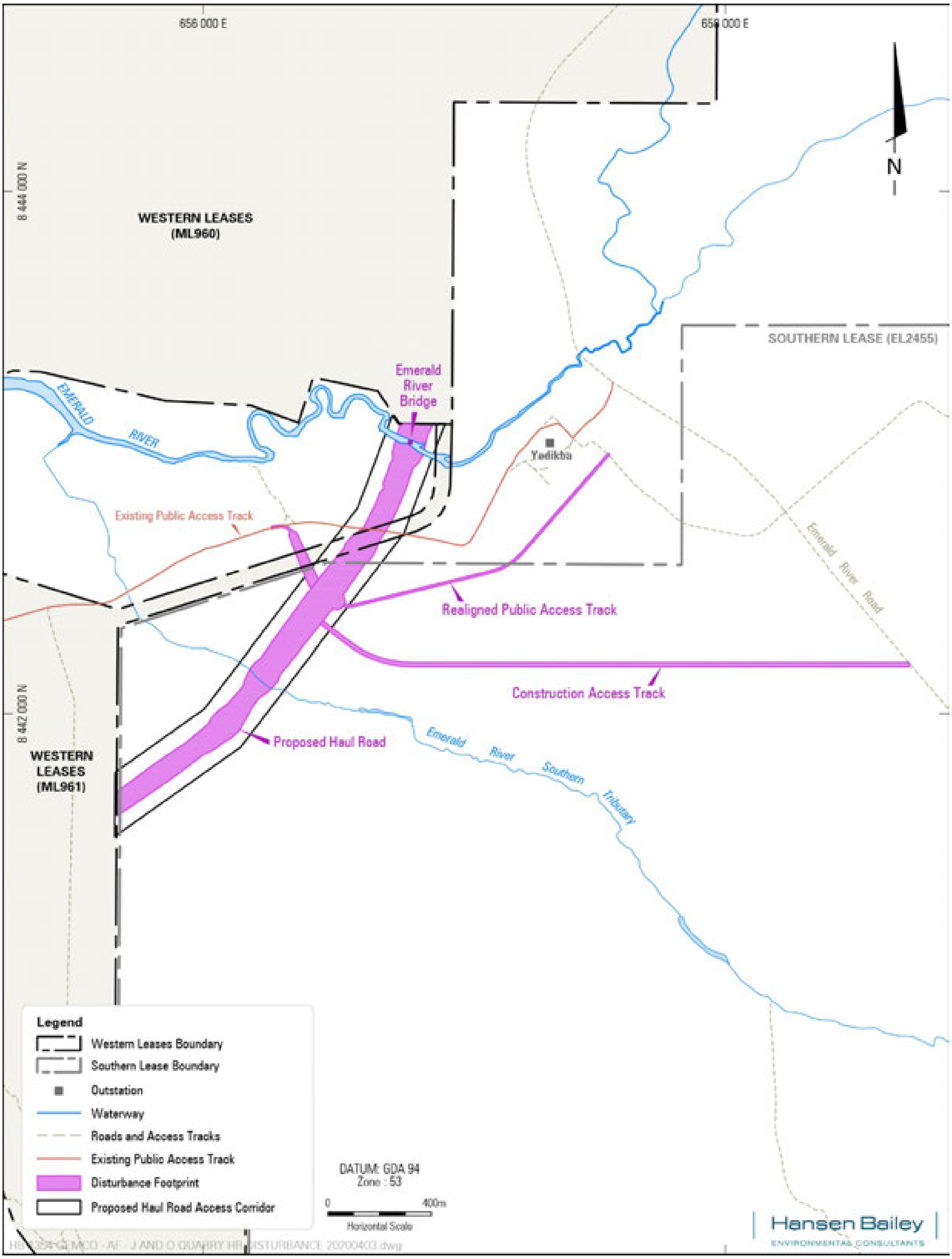

Figure 3: Project layout

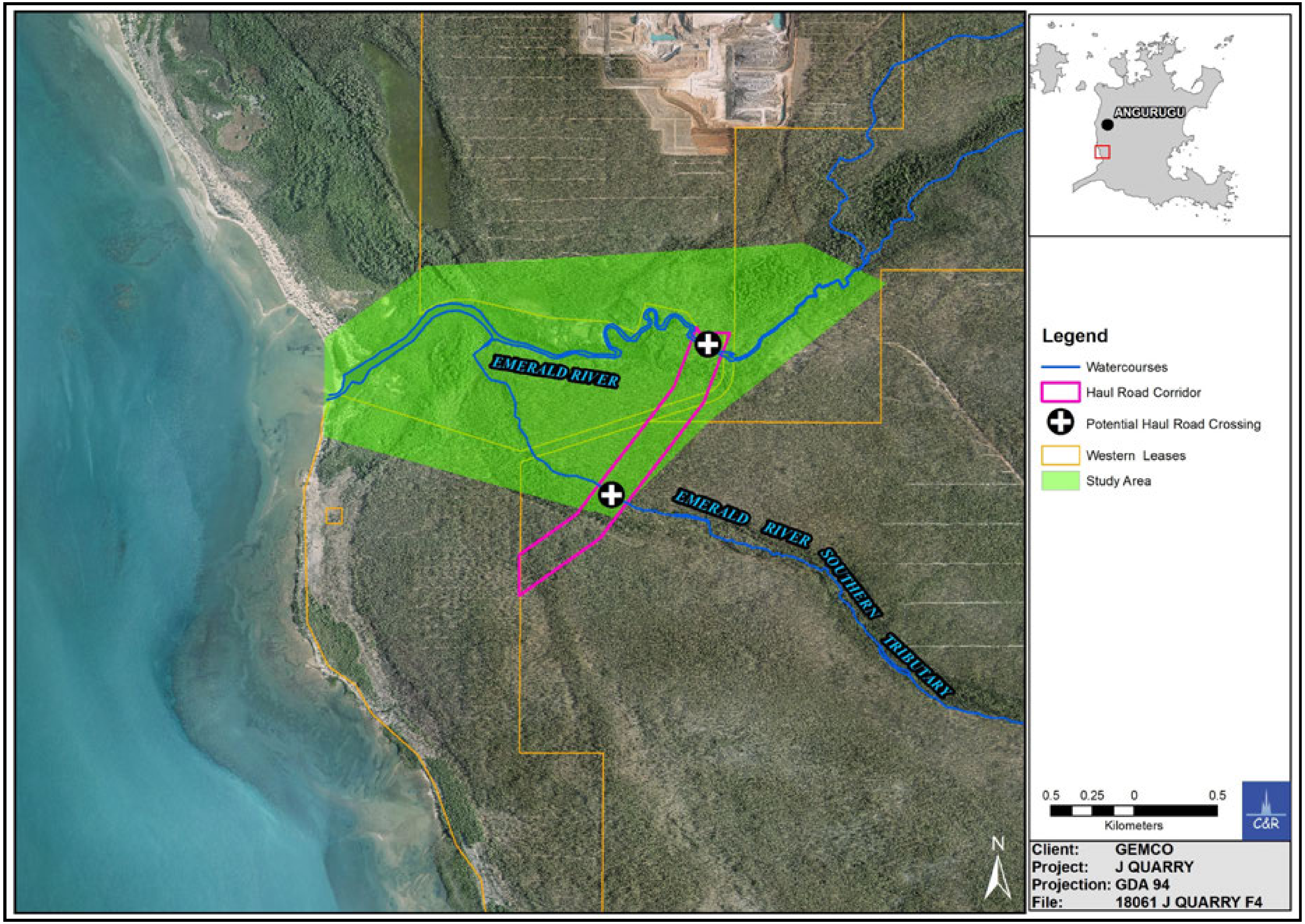

Figure 4: Project site

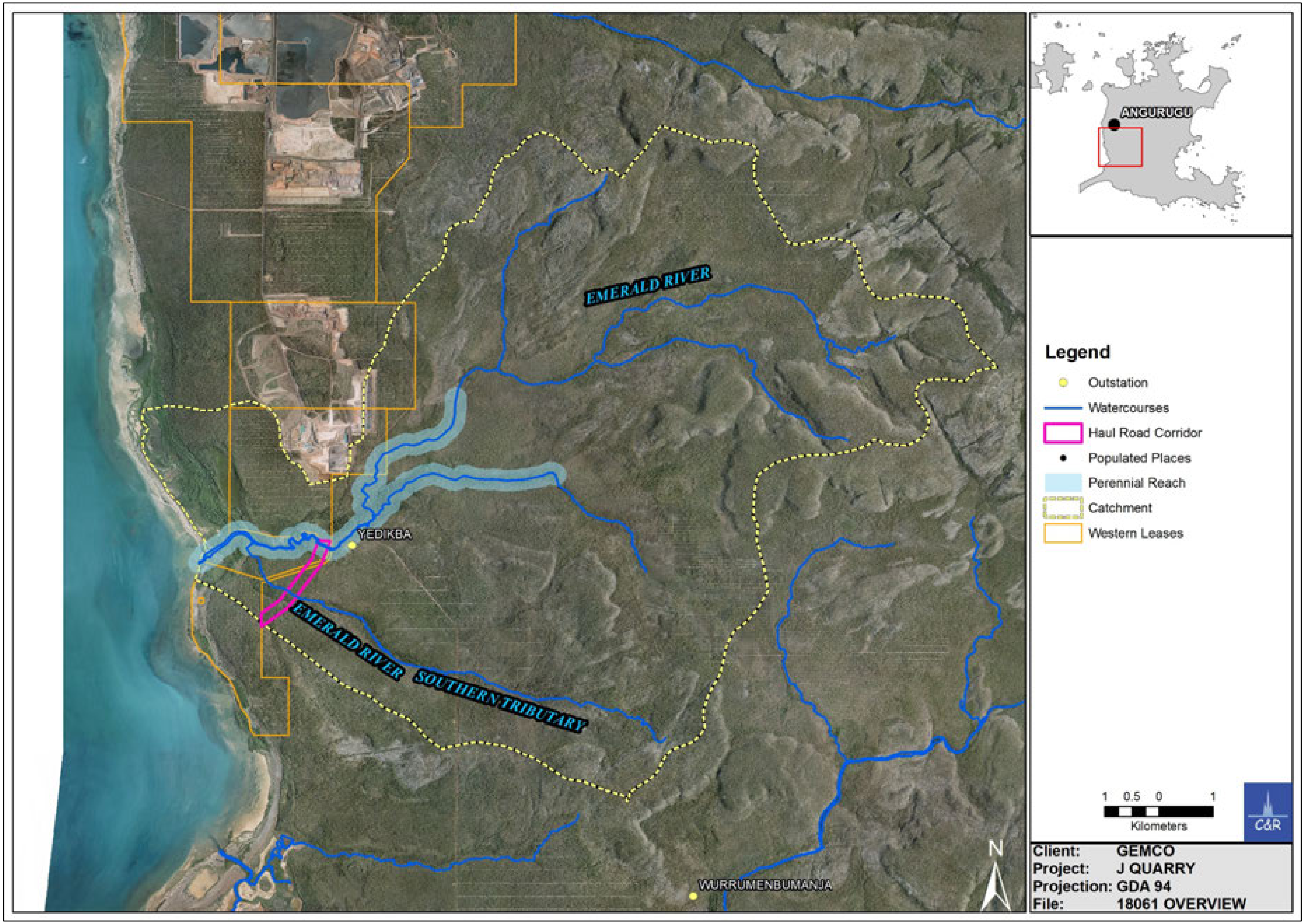

Figure 5: Emerald River and associated tributaries that traverse the project site

Figure 6: Remnants of the jetty and boat slip on the Emerald River - part of the original Mission built in 1921 (coordinates: 136.441711°, -14.079216°)

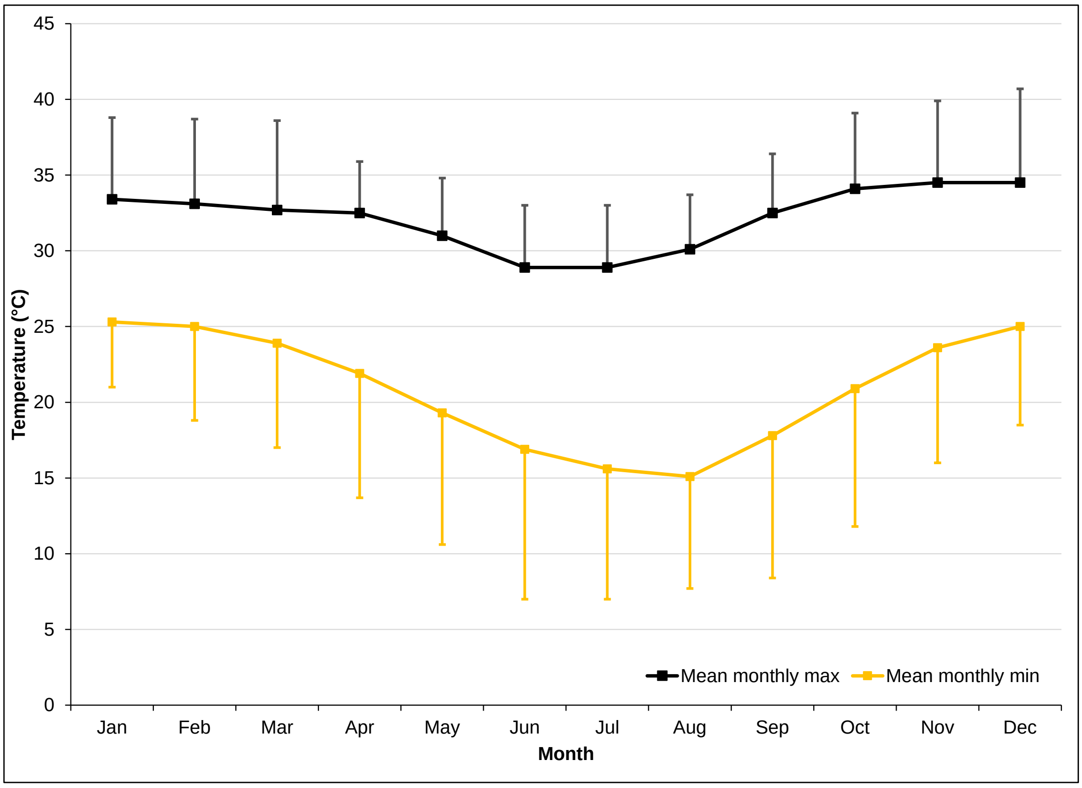

Figure 7: Mean monthly maximum and minimum temperatures recorded at Groote Eylandt, with error bars displaying the absolute maximum and minimum ever recorded in each month (1999-2018; Station No.: 14518) (BOM, 2020)

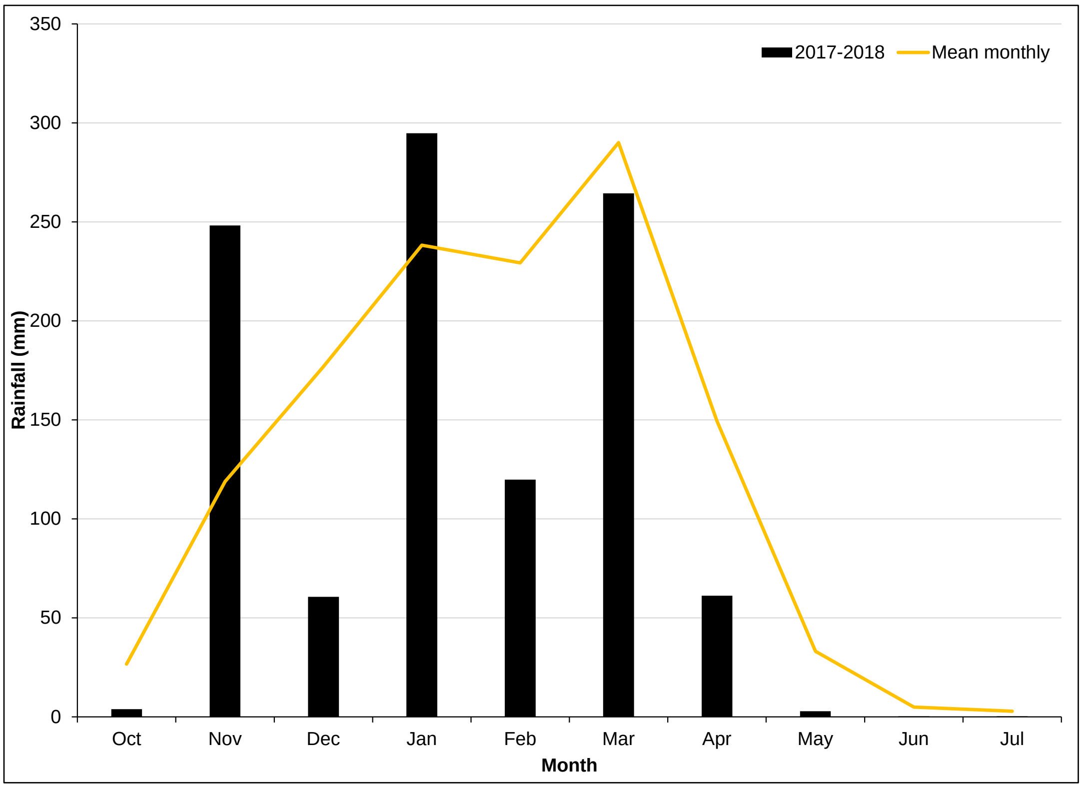

Figure 8: 2017-2018 monthly rainfall totals compared against historic means (1999-2018; Station No.: 14518) (BOM, 2018)

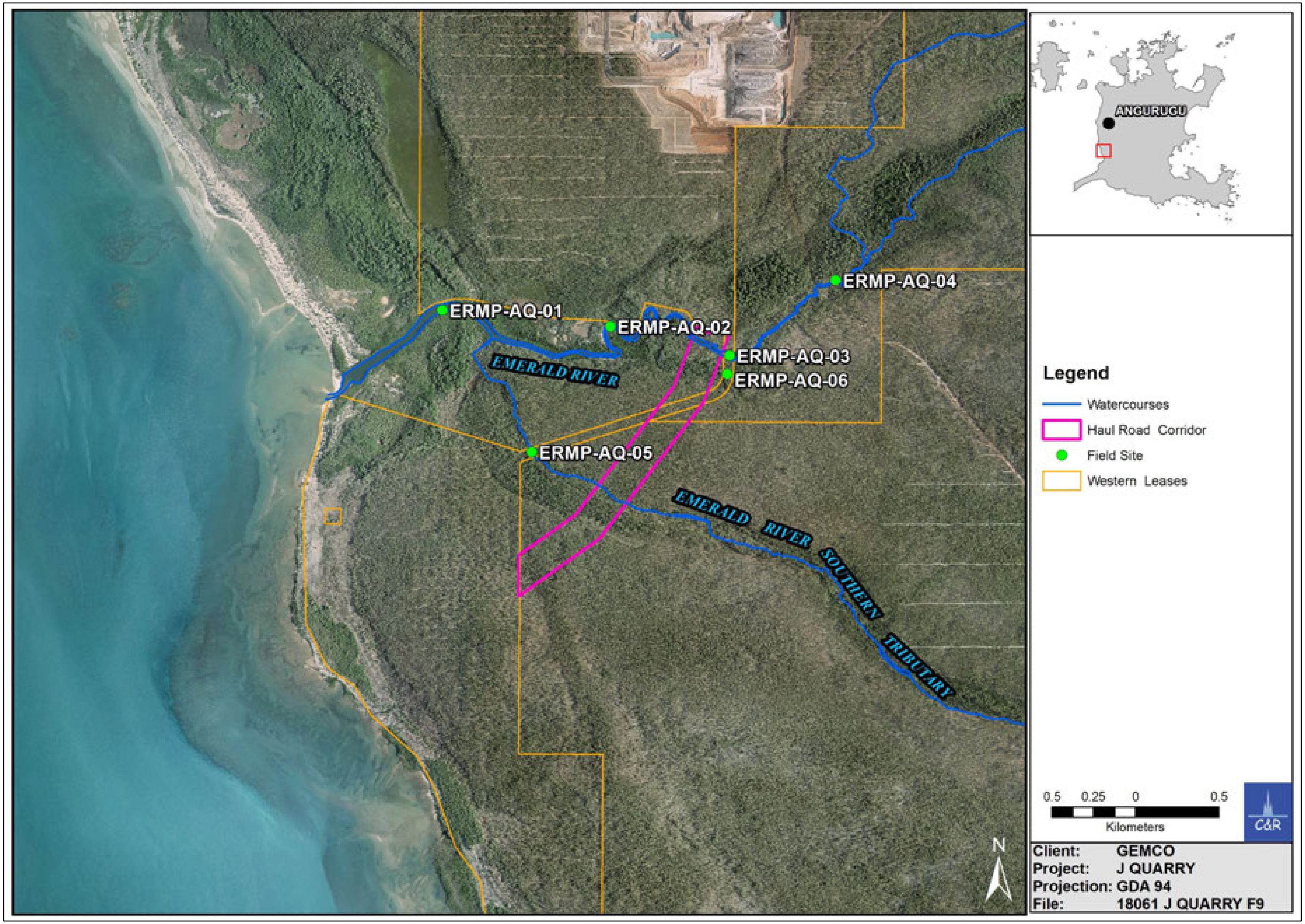

Figure 9: Monitoring site locations throughout the Emerald River catchment

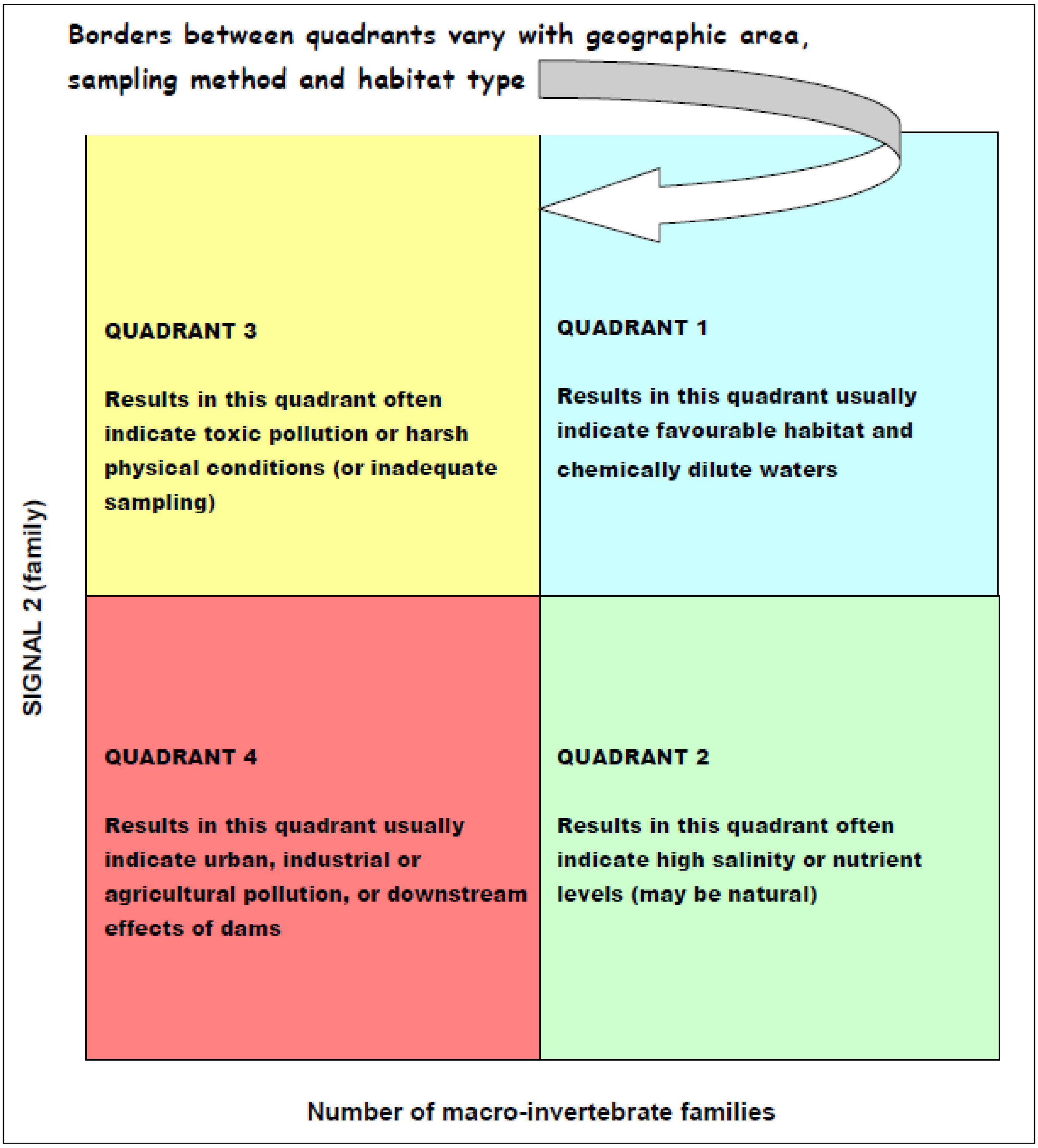

Figure 10: Habitat condition represented by each quadrant of the SIGNAL 2 / Family Bi-plot (extracted from Chessman 2001)

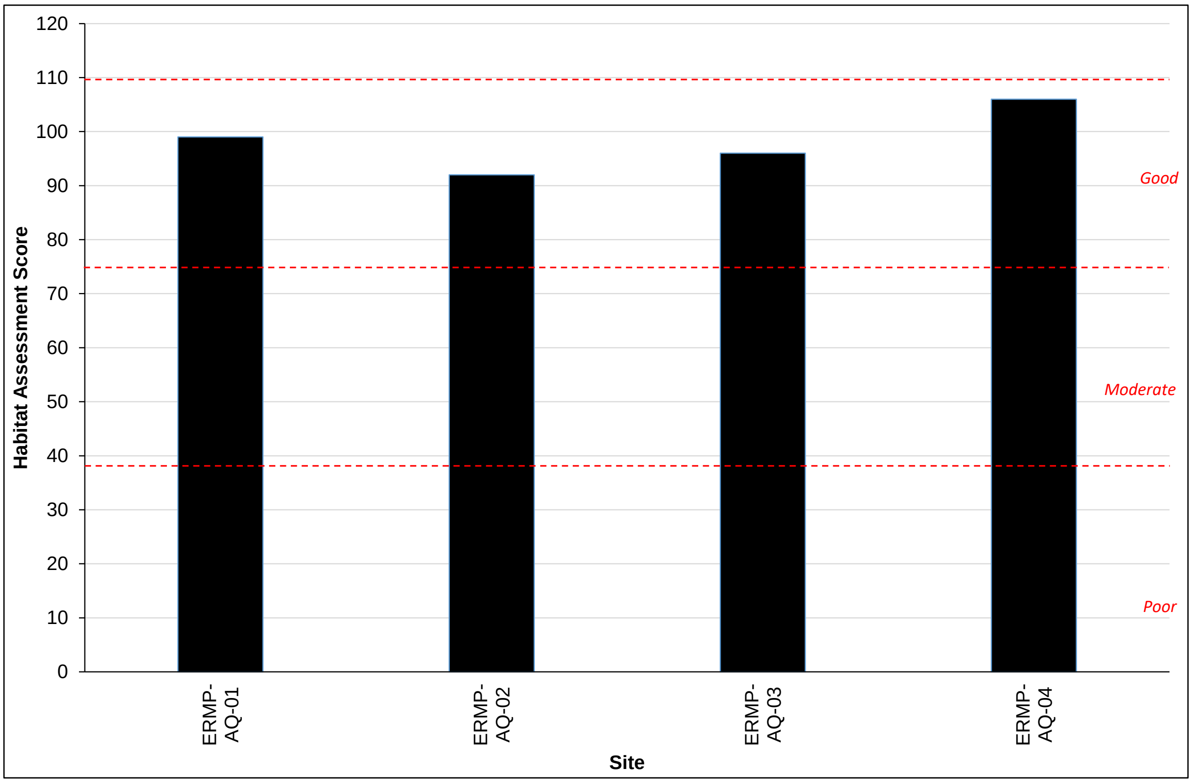

Figure 11: Habitat condition assessment results for each site

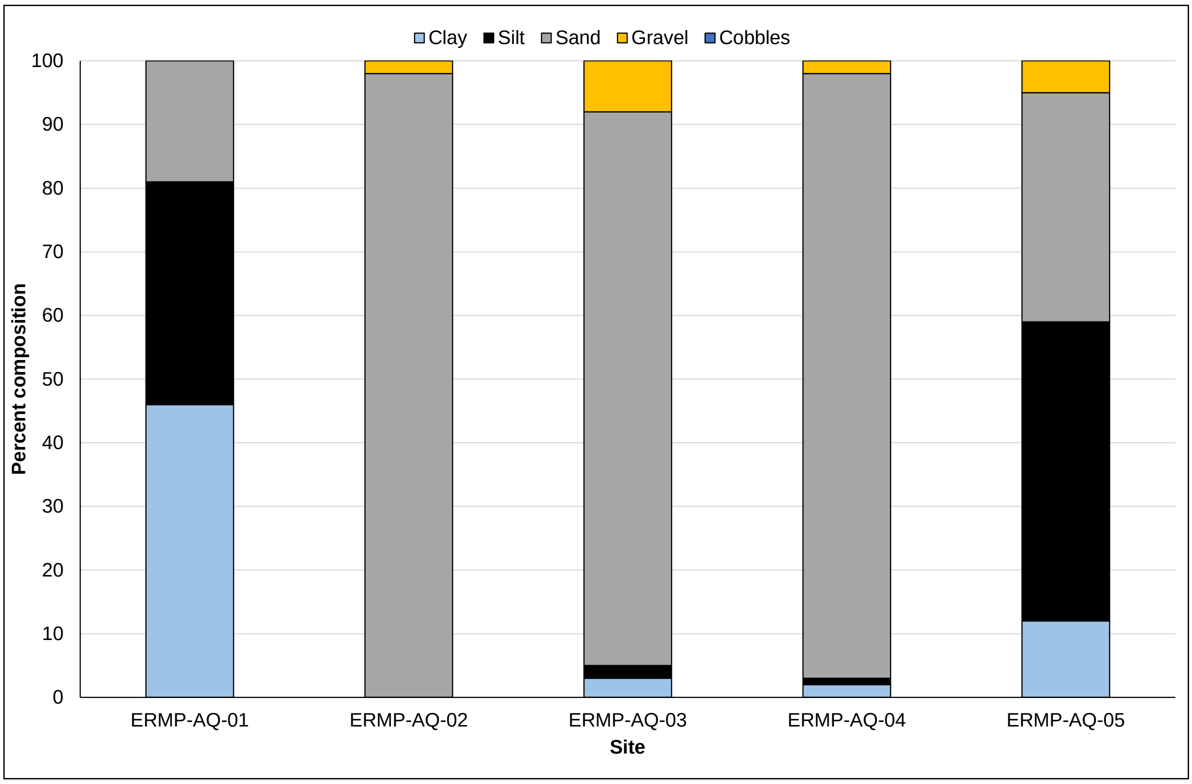

Figure 12: Particle size distribution recorded at each site

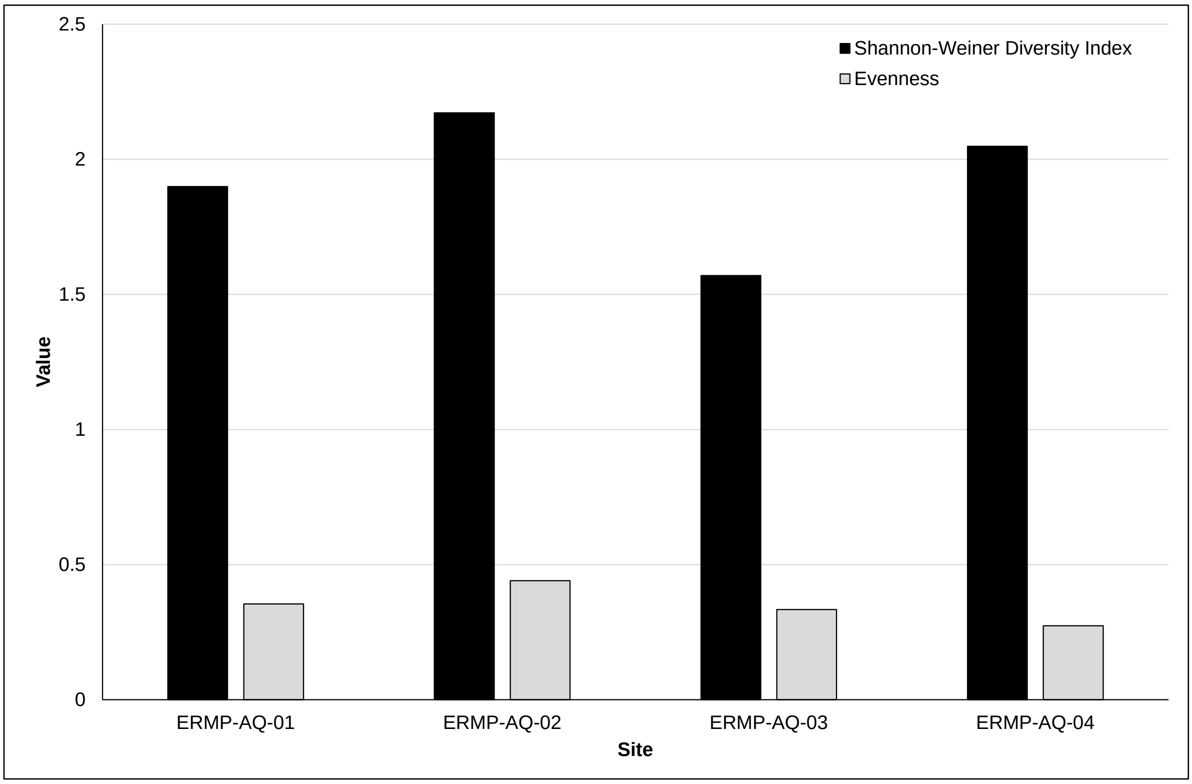

Figure 13: Shannon-Wiener Diversity Index and Evenness values for macroinvertebrate communities recorded at each site

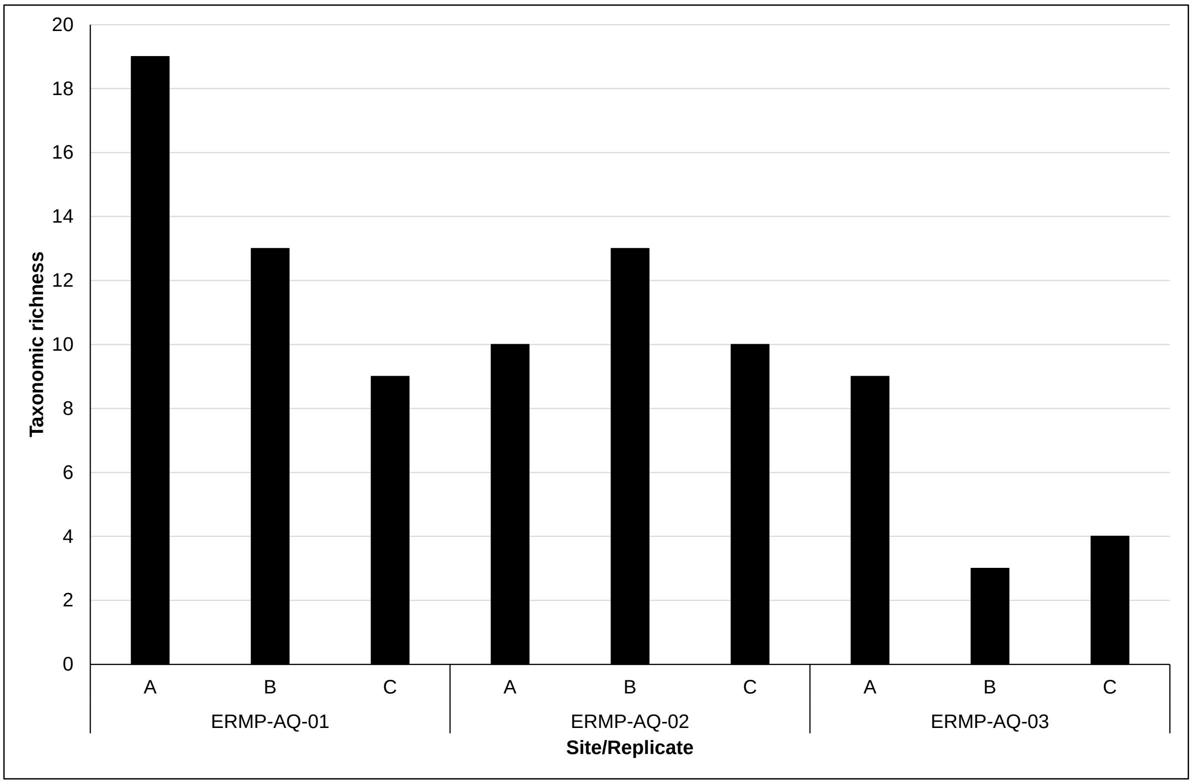

Figure 14: Taxonomic richness of macroinvertebrate communities within estuarine samples

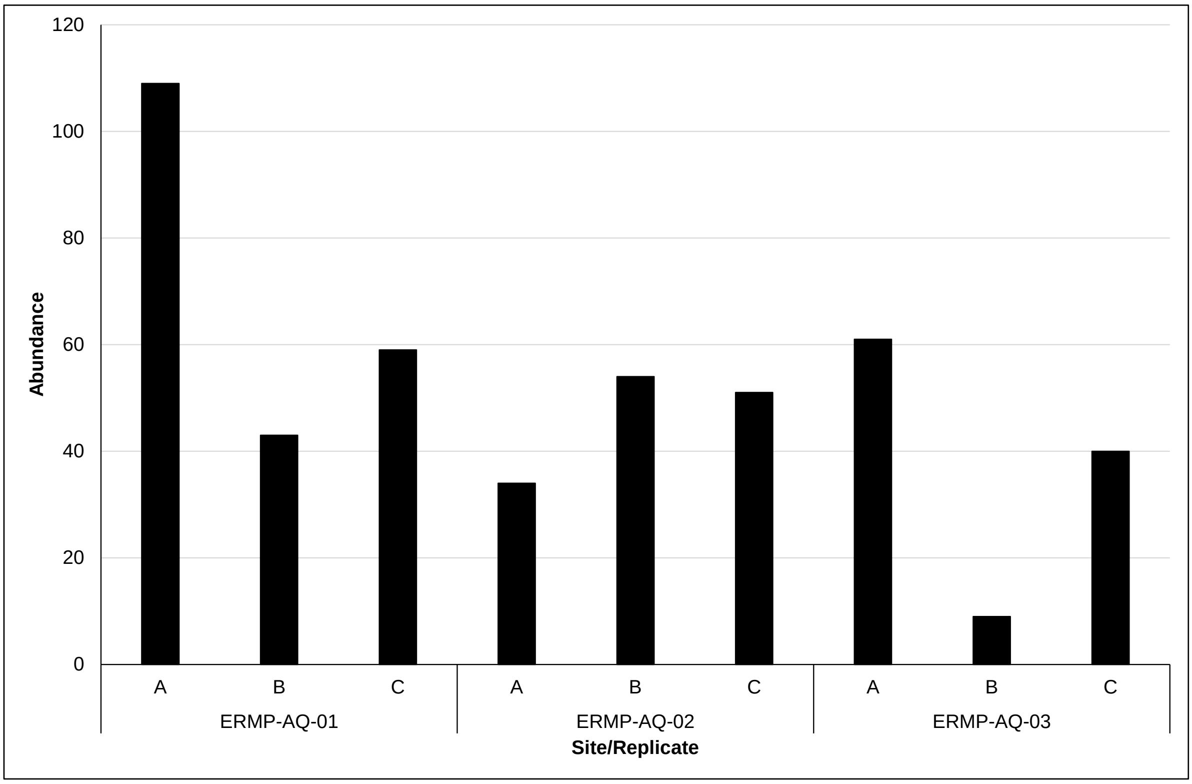

Figure 15: Macroinvertebrate community abundance at each site

Figure 16: Multi-dimensional scaling (MDS) plot of the macroinvertebrate community samples collected within the bed habitat at estuarine sites as well as their similarity (percent) to each other

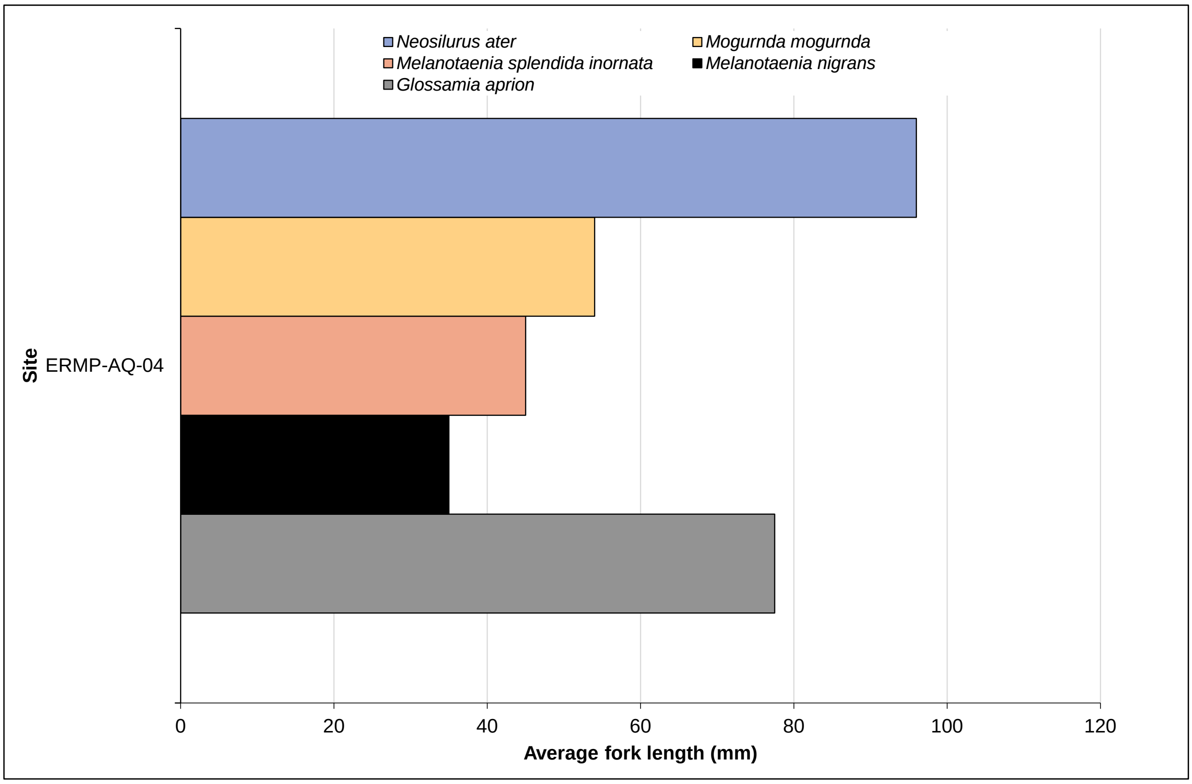

Figure 17: Average fork lengths of freshwater fish caught at ERMP-AQ-04

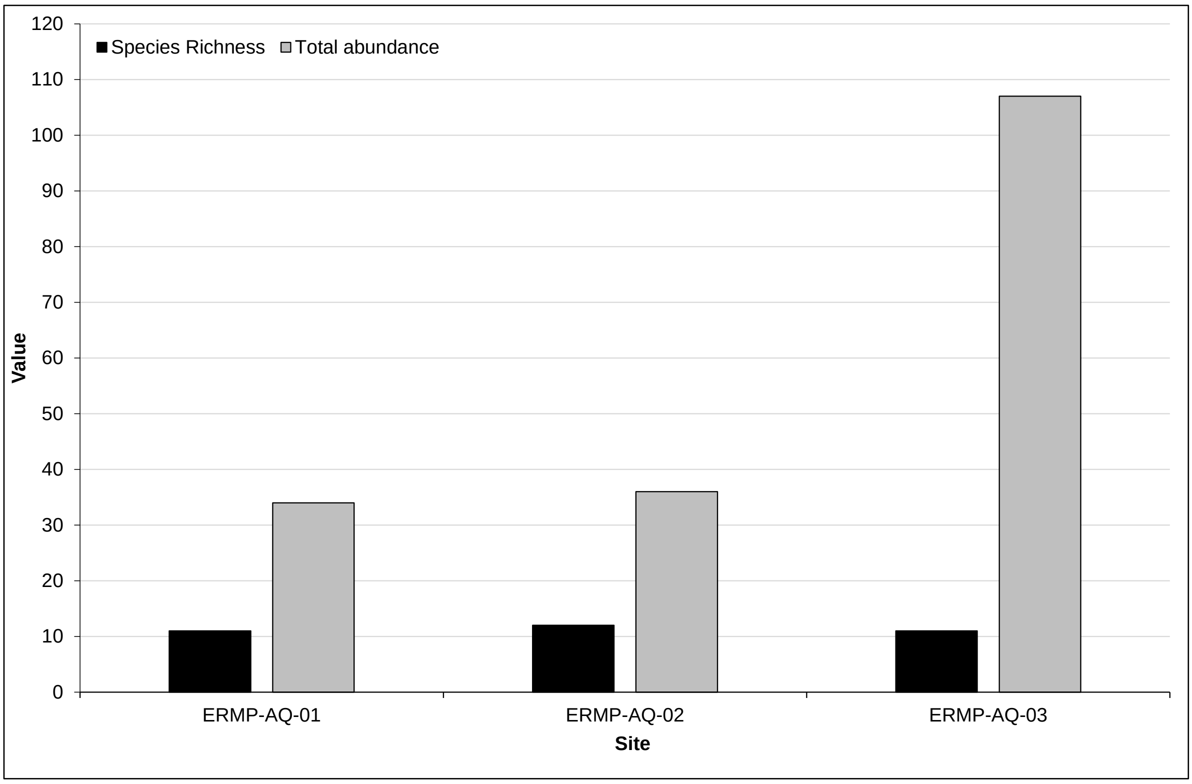

Figure 18: Species richness and total abundance of fish at estuarine sites

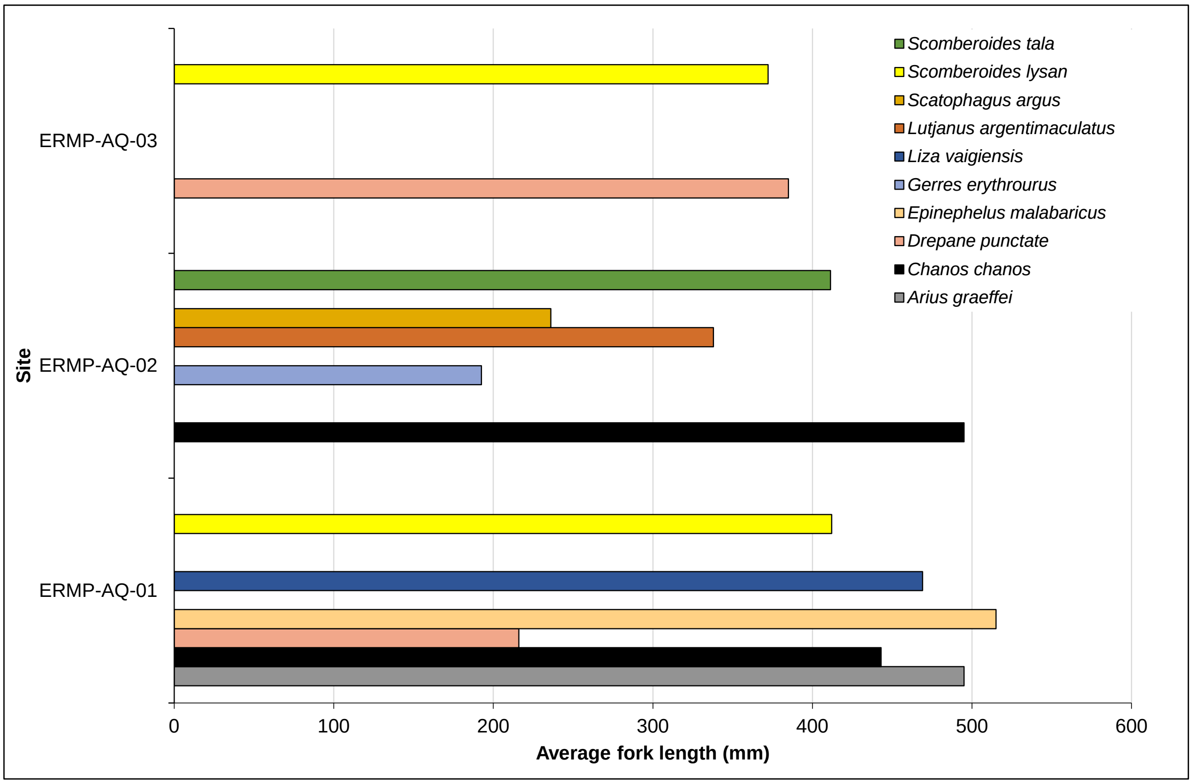

Figure 19: Average fork lengths of estuarine fish species caught

APPENDIX 1 – DRONE SURVEY RESULTS

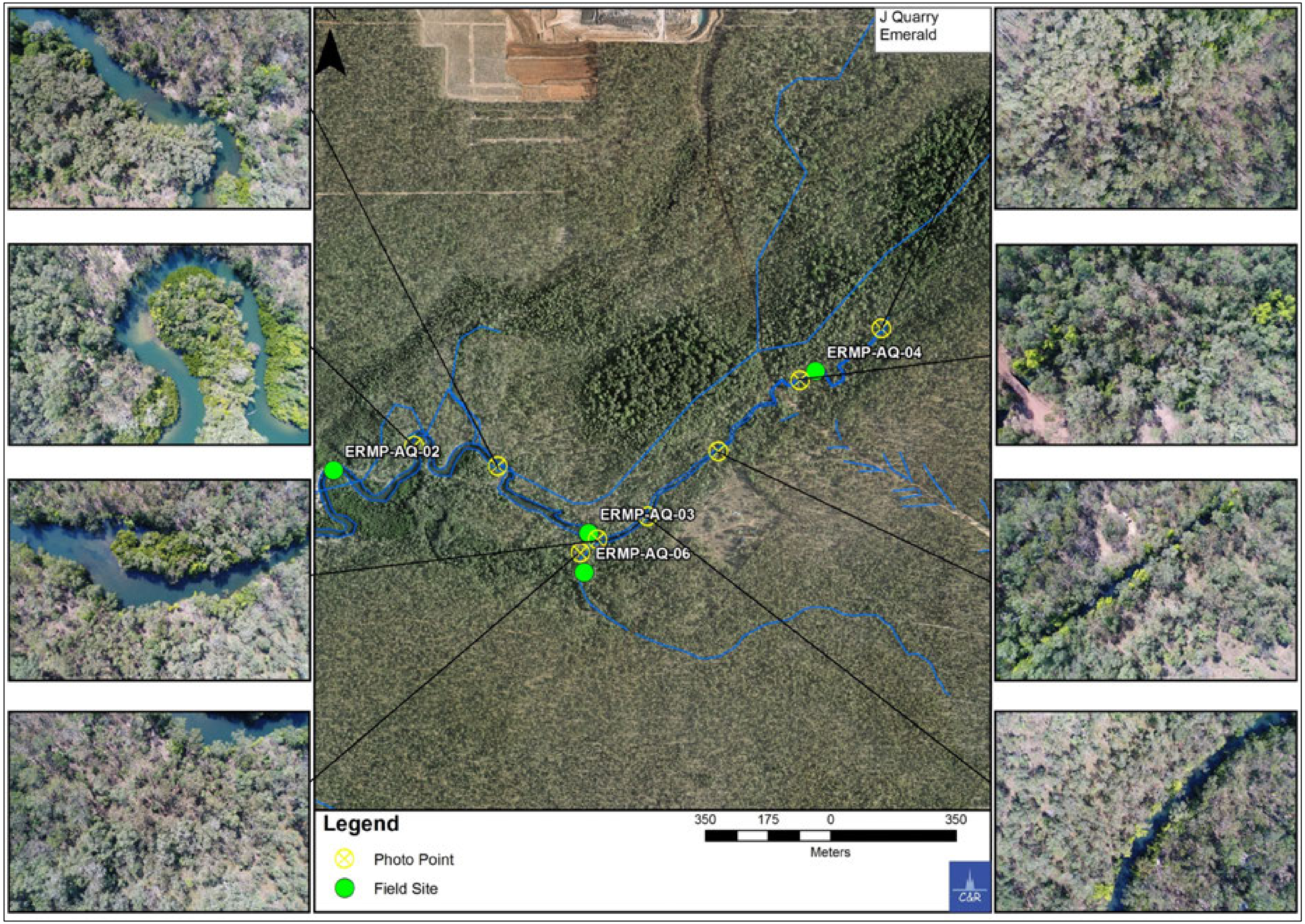

Figure A1.1: Habitat structure throughout the project site

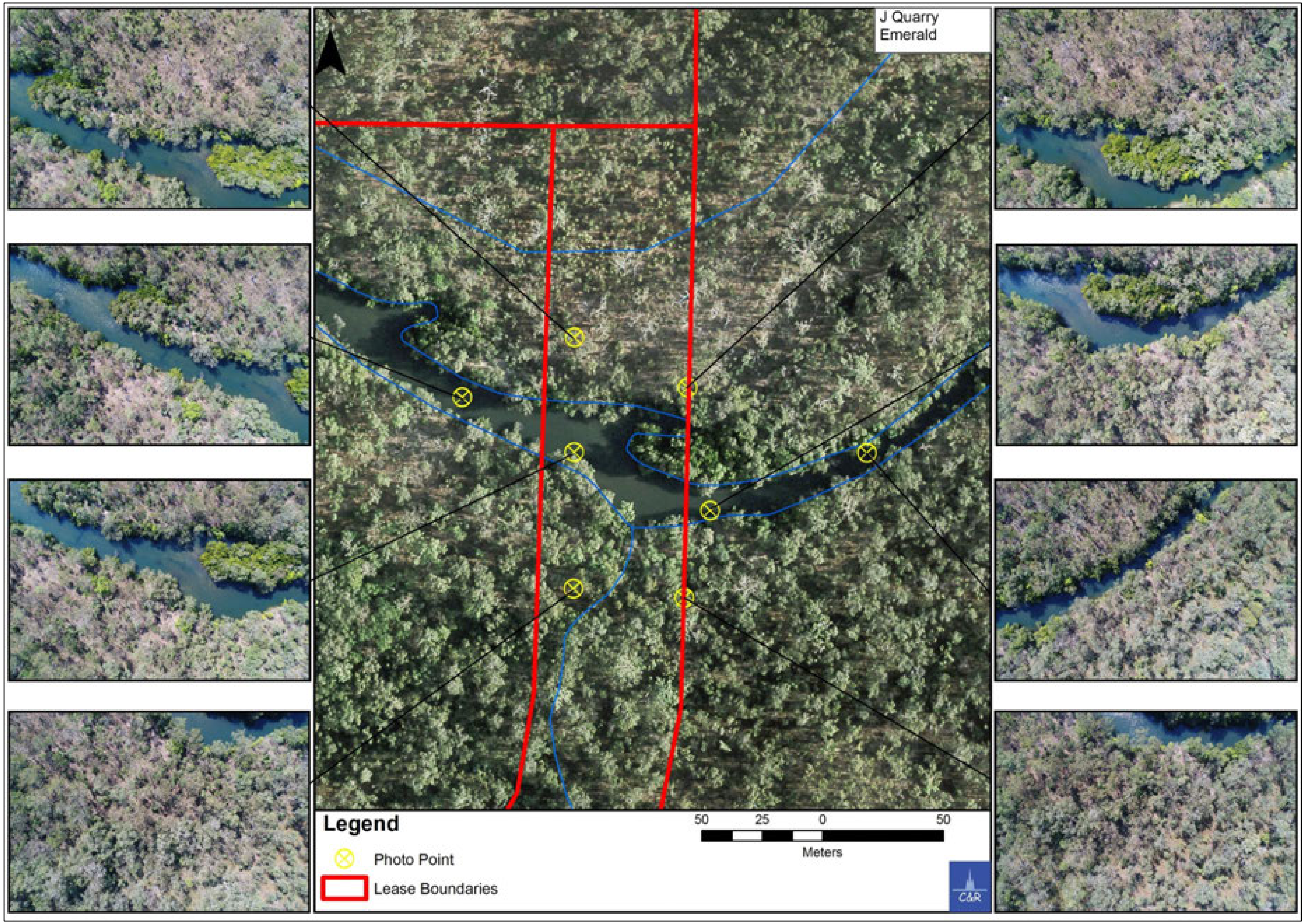

Figure A1.2: Overview of habitat structure around the lease boundary associated with the proposed J Quarry Access Corridor

APPENDIX 2 – WATER QUALITY RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1817831**	Page	: 1 of 5
Client	: **GEMCO**	Laboratory	: Environmental Division Brisbane
Contact	: MIKE CHAPMAN	Contact	: Customer Services EB
Address	: ENVIRONMENT DEPARTMENT ALYANGULA GROOTE EYLANDT NT, AUSTRALIA 0885	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: EZ18032 S & E Leases Water Monitoring Program	Date Samples Received	: 24-Jul-2018 08:30
Order number	: 4541042761	Date Analysis Commenced	: 24-Jul-2018
C-O-C number	: ----	Issue Date	: 31-Jul-2018 08:55
Sampler	: MATT KNOTT AND BEN CUFF		
Site	:		
Quote number	: SY/089/18 V3		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EK067G (Total Phosphorous as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	----
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	----
Compound	CAS Number	LOR	Unit	EB1817831-001	EB1817831-002	EB1817831-003	EB1817831-004	--------
				Result	Result	Result	Result	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**7**	<5	<5	<5	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.8**	**0.5**	**0.4**	**0.9**	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**3620**	**3740**	**1900**	<1	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**70**	**75**	**47**	**4**	----
Total Alkalinity as CaCO3	----	1	mg/L	**70**	**75**	**47**	**4**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1670**	**1660**	**801**	**2**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**10800**	**11100**	**6210**	**10**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**185**	**190**	**118**	<1	----
Magnesium	7439-95-4	1	mg/L	**766**	**794**	**390**	<1	----
Sodium	7440-23-5	1	mg/L	**6460**	**6650**	**3240**	**9**	----
Potassium	7440-09-7	1	mg/L	**226**	**238**	**119**	<1	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	<0.01	**0.03**	----
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Boron	7440-42-8	0.05	mg/L	**2.99**	**3.17**	**0.48**	<0.05	----
Barium	7440-39-3	0.001	mg/L	**0.010**	**0.011**	**0.009**	**0.008**	----
Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0005	<0.0005	<0.0001	<0.0001	----
Cobalt	7440-48-4	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Manganese	7439-96-5	0.001	mg/L	**0.035**	**0.056**	**0.064**	**0.040**	----
Nickel	7440-02-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.005	<0.005	**0.002**	<0.001	----
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	----
Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	----
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	----
Compound	CAS Number	LOR	Unit	EB1817831-001	EB1817831-002	EB1817831-003	EB1817831-004	--------
				Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Zinc	7440-66-6	0.005	mg/L	<0.025	<0.025	<0.005	<0.005	----
Uranium	7440-61-1	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	**0.04**	**0.08**	----
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Boron	7440-42-8	0.05	mg/L	**2.91**	**2.84**	**0.39**	<0.05	----
Barium	7440-39-3	0.001	mg/L	**0.011**	**0.010**	**0.009**	**0.009**	----
Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0005	<0.0005	<0.0001	<0.0001	----
Cobalt	7440-48-4	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Manganese	7439-96-5	0.001	mg/L	**0.034**	**0.050**	**0.064**	**0.084**	----
Nickel	7440-02-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	----
Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L	<0.026	<0.026	<0.005	<0.005	----
Uranium	7440-61-1	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	**0.07**	**0.16**	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG050G LL-F: Dissolved Hexavalent Chromium by Discrete Analyser - Low Level								
Hexavalent Chromium	18540-29-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
EG050G LL-T: Total Hexavalent Chromium by Discrete Analyser - Low Level								
Hexavalent Chromium	18540-29-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.03**	**0.03**	**0.02**	<0.01	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**ERMP-AQ-01**	**ERMP-AQ-02**	**ERMP-AQ-03**	**ERMP-AQ-04**	**----**
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	----
Compound	CAS Number	LOR	Unit	**EB1817831-001**	**EB1817831-002**	**EB1817831-003**	**EB1817831-004**	**--------**
				Result	Result	Result	Result	----
EK058G: Nitrate as N by Discrete Analyser - Continued								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	<0.01	**0.03**	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.01**	<0.01	**0.03**	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**2.2**	**0.6**	<0.1	<0.1	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ **Total Nitrogen as N**	----	0.1	mg/L	**2.2**	**0.6**	<0.1	<0.1	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**341**	**349**	**193**	**0.40**	----
Total Cations	----	0.01	meq/L	**359**	**370**	**182**	**0.39**	----
Ionic Balance	----	0.01	%	**2.60**	**2.92**	**2.89**	----	----

APPENDIX 3 – SEDIMENT QUALITY RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1818342**	Page	: 1 of 10
Client	: **GEMCO**	Laboratory	: Environmental Division Brisbane
Contact	: MIKE CHAPMAN	Contact	: Customer Services EB
Address	: ENVIRONMENT DEPARTMENT ALYANGULA GROOTE EYLANDT NT, AUSTRALIA 0885	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: Southern Leases Aquatic Ecology	Date Samples Received	: 30-Jul-2018 09:40
Order number	: 4541042761	Date Analysis Commenced	: 31-Jul-2018
C-O-C number	: ----	Issue Date	: 03-Aug-2018 17:08
Sampler	: MATT KNOTT		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 17		
No. of samples analysed	: 17		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	ERMP-AQ-05
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	19-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1818342-001	EB1818342-002	EB1818342-003	EB1818342-004	EB1818342-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	72.4	22.3	25.1	25.2	21.9
EA150: Particle Sizing								
+75µm	----	1	%	17	97	95	97	40
+150µm	----	1	%	11	95	94	95	31
+300µm	----	1	%	6	71	82	76	23
+425µm	----	1	%	2	35	61	52	20
+600µm	----	1	%	1	10	37	23	16
+1180µm	----	1	%	<1	2	12	5	10
+2.36mm	----	1	%	<1	1	7	<1	3
+4.75mm	----	1	%	<1	1	2	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	46	<1	3	2	12
Silt (2-60 µm)	----	1	%	35	<1	2	1	47
Sand (0.06-2.00 mm)	----	1	%	19	98	87	95	36
Gravel (>2mm)	----	1	%	<1	2	8	2	5
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.30	2.66	2.70	2.66	2.58
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	16700	380	1170	500	21400
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Iron	7439-89-6	50	mg/kg	42200	1430	9470	410	106000
EG020-SD: Total Metals in Sediments by ICPMS								
Arsenic	7440-38-2	1.00	mg/kg	16.6	<1.00	2.37	<1.00	12.6
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	39.9	1.2	8.2	1.1	37.9
Copper	7440-50-8	1.0	mg/kg	10.5	<1.0	1.9	<1.0	11.3
Cobalt	7440-48-4	0.5	mg/kg	7.9	<0.5	0.9	<0.5	21.3
Lead	7439-92-1	1.0	mg/kg	15.9	<1.0	1.9	<1.0	24.8
Manganese	7439-96-5	10	mg/kg	417	<10	73	72	2020

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03	ERMP-AQ-04	ERMP-AQ-05
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	19-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1818342-001	EB1818342-002	EB1818342-003	EB1818342-004	EB1818342-005
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Nickel	7440-02-0	1.0	mg/kg	**11.2**	<1.0	<1.0	<1.0	**9.3**
Selenium	7782-49-2	0.1	mg/kg	**0.8**	<0.1	**0.2**	<0.1	**1.6**
Silver	7440-22-4	0.1	mg/kg	**0.1**	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	**96.2**	**4.3**	**36.4**	**2.5**	**181**
Zinc	7440-66-6	1.0	mg/kg	**23.7**	<1.0	**2.5**	<1.0	**6.0**
EG020T: Total Metals by ICP-MS								
Molybdenum	7439-98-7	0.1	mg/kg	**1.4**	**0.8**	**1.5**	<0.1	**1.2**
Uranium	7440-61-1	0.1	mg/kg	**3.0**	**0.2**	**0.9**	<0.1	**3.2**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	**0.02**	<0.01	<0.01	<0.01	**0.04**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1819219**	Page	: 1 of 5
Client	: **GEMCO**	Laboratory	: Environmental Division Brisbane
Contact	: MIKE CHAPMAN	Contact	: Customer Services EB
Address	: ENVIRONMENT DEPARTMENT ALYANGULA GROOTE EYLANDT NT, AUSTRALIA 0885	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: Southern Leases Aquatic Ecology	Date Samples Received	: 08-Aug-2018 11:53
Order number	: 4541042761	Date Analysis Commenced	: 20-Aug-2018
C-O-C number	: ----	Issue Date	: 22-Aug-2018 09:42
Sampler	: MATT KNOTT		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 22		
No. of samples analysed	: 11		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
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General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :
- CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
- LOR = Limit of reporting
- ^ = This result is computed from individual analyte detections at or above the level of reporting
- ø = ALS is not NATA accredited for these tests.
- ~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ERMP-AQ-01 <63µm Fraction	ERMP-AQ-02 <63µm Fraction	ERMP-AQ-03 <63µm Fraction	ERMP-AQ-04 <63µm Fraction	ERMP-AQ-05 <63µm Fraction
			Client sampling date / time	19-Jul-2018 00:00	18-Jul-2018 00:00	18-Jul-2018 00:00	17-Jul-2018 00:00	19-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819219-012	EB1819219-013	EB1819219-014	EB1819219-015	EB1819219-016
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	19800	13000	13000	10300	27700
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Iron	7439-89-6	50	mg/kg	50900	52600	63000	10300	71900
EG020-SD: Total Metals in Sediments by ICPMS								
Arsenic	7440-38-2	1.00	mg/kg	16.1	20.2	16.7	1.08	6.87
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	44.8	31.8	31.6	15.4	44.0
Copper	7440-50-8	1.0	mg/kg	16.2	64.9	44.1	27.7	18.1
Cobalt	7440-48-4	0.5	mg/kg	7.7	5.6	12.9	10.4	16.4
Lead	7439-92-1	1.0	mg/kg	16.1	15.5	20.2	10.6	25.1
Manganese	7439-96-5	10	mg/kg	424	194	946	2280	1090
Nickel	7440-02-0	1.0	mg/kg	12.1	8.6	8.7	7.3	11.5
Selenium	7782-49-2	0.1	mg/kg	0.6	1.0	1.3	1.3	1.1
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	88.6	137	150	58.3	205
Zinc	7440-66-6	1.0	mg/kg	24.8	49.6	28.1	15.6	7.9
EG020T: Total Metals by ICP-MS								
Thorium	7440-29-1	0.1	mg/kg	3.7	3.3	4.0	0.9	4.1
Molybdenum	7439-98-7	0.1	mg/kg	1.0	10.1	11.6	0.4	1.0
Uranium	7440-61-1	0.1	mg/kg	3.0	5.6	4.1	1.5	3.9
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	0.02	0.03	0.06	0.04	0.05
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.58	6.09	5.69	3.76	6.28
GEO26: Sieving								
-63µm	----	0.01	%	71.9	6.49	9.75	4.16	44.8

APPENDIX 4 – MACROINVERTEBRATE DATA

Table A4.1: Macroinvertebrate communities inhabiting each monitoring site

Phylum	Class/order	Family	Sub-Family	ERMP-AQ-04	ERMP-AQ-01			ERMP-AQ-02			ERMP-AQ-03		
				Edge	A	B	C	A	B	C	A	B	C
Acarina	Acarina			24									
Annelida	Polychaeta	Cirratulidae			56	25	39						
Annelida	Polychaeta	Cossuridae				2							
Annelida	Polychaeta	Dorvillidae			1								
Annelida	Polychaeta	Eunicidae							2				
Annelida	Polychaeta	Glyceridae			1								
Annelida	Polychaeta	Maldanidae			7		3						
Annelida	Polychaeta	Opheliidae							2				
Annelida	Polychaeta	Paraonidae						1			1		
Annelida	Polychaeta	Pilargidae				1							
Annelida	Polychaeta	Sabellidae							1	1			
Annelida	Polychaeta	Spionidae			2	2		5	3	7			
Annelida	Polychaeta	Syllidae					1			2			
Ascidiacea	Ascidiacea				9		2		1				
Cnideria	Anthozoa	Actiniaria								2			
Crustacea	Amphipoda	Hyalellidae									5	2	
Crustacea	Amphipoda	Ischyroceridae						2	8	6	2		
Crustacea	Amphipoda	Lysianassidae			1								
Crustacea	Copepoda			8									
Crustacea	Decapoda	Palaemonidae		8									
Crustacea	Ostracoda			8	2	1							
Crustacea	Tanaidacea	Tanaidae			1				2		8		1

Phylum	Class/order	Family	Sub-Family	ERMP-AQ-04	ERMP-AQ-01			ERMP-AQ-02			ERMP-AQ-03		
				Edge	A	B	C	A	B	C	A	B	C
Echinodermata	Ophiuroidea				1								
Insecta	Coleoptera	Elmidae		16									
Insecta	Coleoptera	Gyrinidae		16									
Insecta	Coleoptera	Hydraenidae		8									
Insecta	Coleoptera	Scirtidae		56									
Insecta	Diptera	Ceratopogonidae		48									
Insecta	Diptera		Chironominae	864				1	2	1			
Insecta	Diptera	Chironomidae	Orthocladiinae	32									
Insecta	Diptera		Tanypodinae	128									
Insecta	Diptera	Simuliidae		248									
Insecta	Diptera	Tabanidae		24									
Insecta	Diptera	Tipulidae		8									
Insecta	Ephemeroptera	Baetidae		48									
Insecta	Ephemeroptera	Caenidae		16									
Insecta	Odonata	Coenagrionidae		8									
Insecta	Odonata	Libellulidae		8									
Insecta	Odonata	Lindeniidae		8									
Insecta	Odonata	Zygoptera_Juvinile		16									
Insecta	Trichoptera	Calamoceratidae		16									
Insecta	Trichoptera	Ecnomidae		24									
Insecta	Trichoptera	Hydropsychidae		8									
Insecta	Trichoptera	Hydroptilidae		24									
Insecta	Trichoptera	Leptoceridae		72									

Phylum	Class/order	Family	Sub-Family	ERMP-AQ-04	ERMP-AQ-01			ERMP-AQ-02			ERMP-AQ-03		
				Edge	A	B	C	A	B	C	A	B	C
Insecta	Trichoptera	Philopotamidae		24									
Mollusca	Bivalvia	Mactridae						1					
Mollusca	Bivalvia	Tellinidae				3			1				
Mollusca	Gastropoda	Buccinidae			1	1	4	2	8	2	7	4	21
Mollusca	Gastropoda	Calyptraeidae									1		
Mollusca	Gastropoda	Cerithiidae			3	1	5	2	13	11	8	3	3
Mollusca	Gastropoda	Cylichnidae			6	1	2	1	5	1	28		15
Mollusca	Gastropoda	Epitoniidae				1							
Mollusca	Gastropoda	Eulimidae			2								
Mollusca	Gastropoda	Naticidae						18	6	18			
Mollusca	Gastropoda	Phasianellidae			2	3	1	1			1		
Mollusca	Gastropoda	Rissoidae			6		2						
Mollusca	Gastropoda	Terebridae			3								
Mollusca	Scaphopoda	Dentalidae			2	1							
Sipuncula	Sipuncula	Sipuncula			3	1							

***Macrobrachium sp.* (Freshwater prawn)** are common throughout northern Australian with some species also occurring within New South Wales and South Australia (Jones & Morgan, 2002). It is a diverse genus with some species of *Macrobrachium* inhabiting marine systems, generally utilising estuarine and intertidal areas (Jones & Morgan, 2002)

Figure A4.1: Adult *Macrobrachium sp.*

***Scylla serrata* (Mud crab)** is an importat commercial and recreational species that are common throughout northern Australia, with their range expanding from Carnarvon (WA) across the north and down to northern NSW on the east coast (Jones & Morgan, 2002). There are two species of Mud crab in Australia, with *S. serrata* being the smaller and darker coloured of the two (Jones & Morgan, 2002). In accordance with their name, the species genreally occurs in tidal estuaires commonly burying themselves within soft muddy substrates (Jones & Morgan, 2002).

Figure A4.2: Adult *Scylla serrata* (Mud crab)

***Uca sp.* (Fiddler crab)** is a smaller marine crab with over 16 different species, generally found in tropical and sub-tropical climates around Australia (Jones & Morgan, 2002). The male develops one large colourful claw that it uses for displaying to rivals or during courtship (Jones & Morgan, 2002). The species generally occur in mangrove muddy/sandy areas and can tolerate a wide range of salinities from almost fresh to seawater (Jones & Morgan, 2002).

APPENDIX 5 – FISH DATA AND ECOLOGY

Table A5.1: Comparison of fish species caught within historic freshwater fish surveys compared to the current results

Family	Species	Common name	Angurugu River		Emerald River			
			Webb (1992)	URS (2012)	Webb (1992)	URS (2012)	Cumberland (2015)	C&R (2018)
Ambassidae	*Ambassis agrammus*	Sailfin Glassfish	✓	✓	✓	✓	✓	
	Denariusa australis	Pennyfish				✓	✓	
Apogonidae	*Glossamia aprion*	Mouth Almighty	✓	✓	✓	✓		✓
Atherinidae	*Craterocephalus stercusmuscarum*	Fly-specked Hardyhead	✓	✓				
Chanidae	*Chanos chanos*	Milkfish[EV]				✓		
Eleotridae	*Hypseleotris Compressor*	Empire Gudgeon	✓	✓		✓		
	Mogurnda mogurnda	Northern Trout Gudgeon		✓	✓	✓	✓	✓
	Oxyeleotris nullipora	Poreless Gudeon					✓	
Latidae	*Lates calcarifer*	Barramundi[EV]	✓	✓				
Megalopidae	*Megalops cyprinoides*	Tarpon[EV]	✓	✓	✓			
Melanotaeniidae	*Melanotaenia nigrans*	Blackbanded Rainbowfish	✓	✓	✓	✓	✓	✓
	Melanotaenia splendida inornata	Chequered Rainbowfish		✓		✓		✓
	Melanotaenia trifasciata	Banded Rainbowfish	✓		✓			
Plotosidae	*Neosilurus ater*	Black Eel-tail Catfish	✓	✓		✓		✓

Family	Species	Common name	Angurugu River		Emerald River			
			Webb (1992)	URS (2012)	Webb (1992)	URS (2012)	Cumberland (2015)	C&R (2018)
	Neosilurus hyrtlii	Hyrtl's Catfish	✓	✓	✓	✓		
Pseudomugilidae	*Pseudomugil gertrudae*	Spotted Blue Eye	✓	✓		✓		
Scatophagidae	*Scatophagus argus*	Spotted Scat[EV]		✓				
	Scatophagus multifasciata	Striped Scat[EV]		✓				
Synbranchidae	*Ophisternon bengalense*	One Gill Eel		✓				

[EV] Indicates fish species considered estuarine vagrants.

Ecology of Local Fish Species

Table A5.3 displays the life history and ecological traits of the species of freshwater fish identified within the project site. Most species of fish caught during the study exhibited broad tolerances to the fundamental environmental conditions of concern to fish survival (Table A5.3). This is common of freshwater fish species that inhabit ephemeral watercourses, as each species must be able to withstand large natural fluctuations of environmental parameters in order to establish populations. For instance, the electrical conductivity of such systems can fluctuate widely from the wet season, when there are large volumes of freshwater input, to the dry season, when the remnant pools that act as refuges experience increases in ionic concentrations due to evaporative processes (Townsend, 2002).

The resident native fish species all display similar reproductive life histories (Table A5.3). All of the native species time their reproductively active period with the warmer wet season months (summer). The influx of water during this period ensures a substantial increase in primary production and therefore an increase in food availability for juvenile fish.

Many of the fish species found prefer to adhere their eggs to macrophytes or the roots of terrestrial plants exposed within the undercut banks. As outlined within the aquatic flora section of this report (Section 5.9.1), all sites possessed considerable macrophyte cover generally associated with undercut banks. Trailing vegetation was also often noted at many creek sites that would be suitable as long as water levels kept them inundated for an extended period of time.

Table A5.2: Environmental tolerances and life history of the fish species caught during current surveys (Pusey *et al.* 2004)

Species	Common name	Environmental tolerances					Life history / Ecology
		Temp (ºC)	EC (µS/cm)	pH (Units)	DO (mg/L)	Turbidity (NTU)	
Glossamia aprion	Mouth almighty	14.1 – 38	2 – 1,429	4.9 – 9.1	1.1 – 11.9	0.1 – 200	This species reaches sexual maturity at <12 months old. Spawning is triggered when water temperatures exceed 22°C in the late dry season/early wet season. Spawning is suggested to occur in lentic habitats after which the females transfer the eggs to the male's mouth. Males then brood the eggs and young in their mouth for approximately two weeks prior to dispersal. Mouth almighty movement patterns are not well understood although they are thought to move into lowland lagoons for spawning with young dispersing across the riverine landscape at the end of the incubation period. The species predominantly feeds on aquatic insects, fish, macrocrustaceans and microcrustaceans.
Melanotaenia nigrans	Blackbanded Rainbowfish	23 – 28[a]	NDA	5.5 – 7.0[a]	NDA	NDA	Little information is available on the species. However, they prefer lily lagoons, rainforest creeks and small creeks in swampy areas. If occurring in large streams they will generally keep to quiets backwaters or areas of reduced flow.[a]
*Melanotaenia splendida inornata***	Chequered rainbowfish	15 – 32.5	6 – 790	6 – 8.47	1.1 – 11.6	0.1 – 16	Rainbowfish reach sexual maturity in less than 1 year and generally spawn within the summer months. They deposit their adhesive eggs onto macrophyte beds or root masses. Fertilised eggs will hatch after approximately 7 to 12 days. Rainbowfish will commence an upstream migration with the onset of the wet season. Their diet is dominated by aquatic insects, algae and terrestrial invertebrates.
*Morgunda morgunda***	Northern trout gudgeon	11.9 – 31.7	72 – 2,495	5.6 – 8.8	0.6 – 12.8	0.2 – 200	Purple-spotted gudgeon reach sexual maturity at approximately 6 months old. Their spawning period in northern Queensland occurs at the beginning of the wet season (September – November), where an individual can spawn up to 7 times during this period, laying up to approximately 1,500 eggs on each occasion). The eggs are deposited on hard substrates such as rocks, woody debris and macrophytes. The male then guards them until they hatch, which can take up to 2 weeks. The species has a very broad diet mainly targeting aquatic and terrestrial insects, but also preying on crustaceans, molluscs and

Species	Common name	Environmental tolerances					Life history / Ecology
		Temp (ºC)	EC (µS/cm)	pH (Units)	DO (mg/L)	Turbidity (NTU)	
							other fish. They are not known to migrate. However, further studies need to be undertaken.
Neosilurus ater	Black eel-tailed catfish, Butter Jew	21 – 33.4	2 – 790	4.5 – 9.1	0.6 – 11.2	0.1 – 360	Butter Jew reach sexual maturity within a year when individuals are in excess of 260mm total length. The species spawns in the summer months, where individuals migrate upstream with the onset of the wet season spawning in gravel beds generally in feeder tributaries. Their diet consists primarily of aquatic insects, molluscs, microcrustaceans and detritus, although they have been known to actively predate on fish.

NDA – No data available.

** Insufficient information/data is available for the Chequered rainbowfish and Northern trout gudgeon in relation to environmental tolerances and life history traits. Therefore, the data (and life history description) provided for these fish are actually that of the Eastern rainbowfish (*Melanotaenia splendida splendida*) and Purple-spot gudgeon (*Morgunda adspersa*), respectively. However, these species are very similar and the information provided likely provides insight into the life history traits and environmental tolerances of the both the captured species.

[a] Information acquired from Allen *et al.*, (2003).

Figure A5.1: ***Glossamia aprion***

Figure A5.7: ***Melanotaenia nigrans***

Figure A5.8: ***Melanotaenia splendida inornata***

Figure A5.10: ***Morgunda morgunda***

Figure A5.11: ***Neosilurus ater***

Table A5.3: Estuarine fish species identified at each site

Species	Common name	ERMP-AQ-01	ERMP-AQ-02	ERMP-AQ-03
Amniataba caudavittata	Yellowtail Grunter		3	
Arius graeffei	Lesser Salmon Catfish	1		
Chanos chanos	Milkfish	9	2	50
Craterocephalus mugiloides	Spotted Hardyhead			20
Drepane punctate	Sicklefish	1		1
Epinephelus malabaricus	Blackspotted Rockcod	1		
Gerres erythrourus	Short Silverbiddy		2	
Himantura toshi	Brown Whipray			2
Lates calcarifer	Barramundi			1
Leiognathus equulus	Common Ponyfish		5	
Liza macrolepis	Largescale Mullet	6		
Liza vaigiensis	Diamondscale Mullet	2	6	
Lutjanus argentimaculatus	Mangrove Jack		1	
Monodactylus argenteus	Diamondfish		4	15
Pastinachus sephen	Cowtail Stingray			5
Periopthalmus argentilineatus	Mudskipper	3		
Platycephalus endrachtensis	Northern Sand Flathead	1		
Scatophagus argus	Spotted Scat		2	2
Scomberoides commersonnianus	Giant Queenfish	6	5	4
Scomberoides lysan	Lesser Queenfish	1		1
Scomberoides tala	Barred Queenfish		2	
Terapon jarbua	Crescent Grunter		2	
Trachinotus bailloni	Smallspotted Dart	4		
Tylosurus gravialoides	Stout Longtom		3	
Valamugil buchanani	Bluetail Mullet			4
Zenarchopterus buffonis	Northern River Garfish			3

Table A5.4: Comparison of fish species caught within historic estuarine fish surveys compared to the current results

Family	Species	Common name	Taylor (1964)	Webb (1992)*	URS (2012)*	C&R (2018)
Abulidae	*Albula vulpes*	Bonefish		✓		
Ambassidae	*Ambassis dussumieri*	Barehead Glassfish	✓			
	Ambassis vachellii	Vachell's Glassfish		✓	✓	
Apogonidae	*Apogon hyalosoma*	Mangrove Cardinalfish	✓			
Ariidae	*Neoarius graeffei*	Lesser Salmon Catfish				✓
Atherinidae	*Atherinomorous endrachtensis*	Endracht Hardyhead	✓	✓	✓	
	Craterocephalus mugiloides	Spotted Hardyhead	✓			✓
	Craterocephalus spp.	Hardyhead			✓	
Belonidae	*Tylosurus crocodilus*	Crocodile Longtom	✓			
	Tylosurus gavialoides	Stout Longtom	✓	✓	✓	✓
Bothidae	*Pseudorhombus arsius*	Largetooth Flounder	✓			
	Pseudorbombus elevatus	Deep Flounder			✓	
Carangidae	*Carangoides chrysophrys*	Longnose Trevally	✓			
	Carangoides fulvoguttatus	Turrum		✓	✓	
	Caranx ignobilis	Giant Trevally			✓	
	Gnathanodon speciosus	Golden Trevally	✓		✓	
	Scomberoides commersonnianus	Giant Queenfish			✓	✓
	Scomberoides lysan	Lesser Queenfish	✓			✓
	Scomeroides tala	Barred Queenfish	✓			✓
	Trachinotus bailloni	Smallspotted Dart			✓	✓

Family	Species	Common name	Taylor (1964)	Webb (1992)*	URS (2012)*	C&R (2018)
Carcharinidae	*Carcharhinus melanopterus*	Blacktip Reef Shark		✓		
	Negaprion acutidens	Lemon Shark			✓	
Chanidae	*Chanos chanos*	Milkfish[EV]			✓	✓
Clupeidae	*Ecualosa thoracata*	White Sardine	✓			
	Nematalosa come	Hairback Herring		✓		
	Sardinella jussieu	Mauritian Sardine	✓			
	Spratelloides robustus	Blue Sprat			✓	
Dasyatidae	*Taeniura lymma*	Bluespotted Fantail Ray			✓	
	Himantura astra	Blackspotted Whipray			✓	
	Himantura toshi	Brown Whipray			✓	✓
	Himantura uarnak	Reticulate Whipray		✓	✓	
	Pastinachus sephen	Cowtail Stingray		✓		✓
Drepaneidae	*Drepane punctata*	Sicklefish			✓	✓
Eleotridae	*Butis butis*	Crimsontip Gudgeon		✓		
	Ophiocara porocephala	Spangled Gudgeon		✓		
Elopidae	*Elops hawaiensis*	Hawaiian Giant Herring			✓	
Engraulidae	*Stolephorus indicus*	Indian Anchovy		✓	✓	
Gerridae	*Gerres oyena*	Blacktip Silverbiddy		✓	✓	
	Gerres erythrourus	Short Silverbiddy	✓		✓	✓
	Gerres filamentosus	Threadfin Silverbiddy	✓	✓	✓	
	Gerres macracanthus	Longspine Silverbiddy		✓		

Family	Species	Common name	Taylor (1964)	Webb (1992)*	URS (2012)*	C&R (2018)
	Gerres subfasciatus	Common Silverbiddy	✓			
Glaucosomatidae	*Glaucosoma magnificum*	Threadfin Pearl Perch			✓	
Gobiidae	*Drombus ocyurus*	Bluemarked Drombus		✓		
	Drombus triangularis	Brown Drombus		✓		
	Istigobius decoratus	Decorated Sandgoby			✓	
	Periophthalmus argentilineatus	Mudskipper		✓	✓	✓
	Yongeichthys nebulosus	Hairfin Goby		✓		
Haemulidae	*Pomadasys kaakan*	Barred javelin			✓	
	Plectorhinchus gibbosus	Brown Sweetlips			✓	
Hemiramphidae	*Arrhamphus sclerolepis*	Snubnose Garfish		✓	✓	✓
	Hyporhamphus quoyi	Longtail Garfish	✓	✓	✓	
	Zenarchopterus gilli	Shortnose River Garfish	✓			
	Zenarchopterus buffonis	Northern River Garfish		✓		✓
Latidae	*Lates calcarifer*	Barramundi	✓	✓	✓	✓
	Psammoperca waigiensis	Sand Bass	✓			
Leiognathidae	*Gazza minuta*	Toothed Ponyfish		✓		
	Leiognathus equulus	Common Ponyfish		✓	✓	✓
	Leiognathus fasciata	Threadfin Ponyfish			✓	
	Nuchequula gerreoides	Ornate Ponyfish		✓		
Lethrinidae	*Lethrinus laticaudis*	Grass Emperor		✓	✓	
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove Jack	✓	✓	✓	✓

Family	Species	Common name	Taylor (1964)	Webb (1992)*	URS (2012)*	C&R (2018)
	Lutjanus carponotatus	Stripey Snapper		✓		
	Lutjanus fulviflamma	Blackspot Snapper		✓	✓	
	Lutjanus russellii	Moses' Snapper	✓	✓	✓	
Megalopidae	*Megalops cyprinoides*	Tarpon, Oxeye Herring		✓		
Monodactylidae	*Monodactylus argenteus*	Diamondfish	✓		✓	✓
Mugilidae	*Liza macrolepis*	Largescale Mullet			✓	✓
	Liza subviridis	Greenback Mullet	✓			
	Liza vaigiensis	Diamondscale Mullet	✓	✓	✓	✓
	Rhinomugil nasutus	Popeye Mullet		✓		
	Valamugil buchanani	Bluetail Mullet	✓		✓	✓
	Valamugil cunnesius	Roundheaded Mullet	✓			
Myliobatidae	*Aetobatus narinari*	Whitespotted Eagle Ray			✓	
Nemipteridae	*Scaevius milii*	Coral Monocle Bream	✓			
Opichthidae	*Scolecenchelys macroptera*	Narrow Worm Eel		✓		
Platycephalidae	*Platycephalus endrachtensis*	Northern Sand Flathead	✓	✓	✓	✓
	Onigocia spinosa	Midget Flathead			✓	
Rhinobatidae	*Glaucostegus typus*	Giant Shovelnose Ray		✓	✓	
Scatophagidae	*Scatophagus argus*	Spotted Scat	✓	✓	✓	✓
	Scatophagus multifasciata	Striped Scat	✓		✓	
Serranidae	*Epinephelus coioides*	Goldspotted Rockcod			✓	
	Epinephelus corallicola	Coral Grouper	✓			

Family	Species	Common name	Taylor (1964)	Webb (1992)*	URS (2012)*	C&R (2018)
	Epinephelus lanceolatus	Queensland Groper	✓		✓	
	Epinephelus malabaricus	Blackspotted Rockcod				✓
	Epinephelus tauvina	Greasy Rockcod	✓			
Siganidae	*Siganus lineatus*	Goldlined Rabbitfish	✓			
Sillaginidae	*Sillago analis*	Goldenline Whiting			✓	
	Sillago burrus	Western Trumpeter Whiting		✓	✓	
	Sillago cilliata	Sand Whiting	✓			
	Sillago Sihama	Northern Whiting		✓	✓	
Sparidae	*Acanthopagrus berda*	Pikey Bream	✓	✓	✓	
	Acanthopagrus latus	Western Yellowfin Bream			✓	
	Acanthopargus palmaris	Northwest Black Bream		✓	✓	
Sphyraenidae	*Sphyraena barracuda*	Great Barracuda	✓			
	Sphyraena jello	Pickhandle Barracuda		✓	✓	
Terapontidae	*Amniataba caudavittata*	Yellowtail Grunter	✓	✓	✓	✓
	Pelates quadrilineatus	Fourline Striped Grunter		✓		
	Terapon jarbua	Crescent Grunter			✓	✓

Figure A5.1: ***Neoarius graeffei***

Figure A5.2: ***Scomberoides commersonnianus***

Figure A5.3: ***Chanos chanos***

Figure A5.4: ***Drepane punctata***

Figure A5.5: ***Gerres erythrourus***

Figure A5.6: ***Periophthalmus argentilineatus***

Figure A5.7: ***Lutjanus argentimaculatus***

Figure A5.8: ***Liza vaigiensis***

Figure A5.9: ***Scatophagus argus***

Figure A5.10: ***Epinephelus malabaricus***

APPENDIX 6 – SEARCH RESULTS

Australian Government

Department of the Environment and Energy

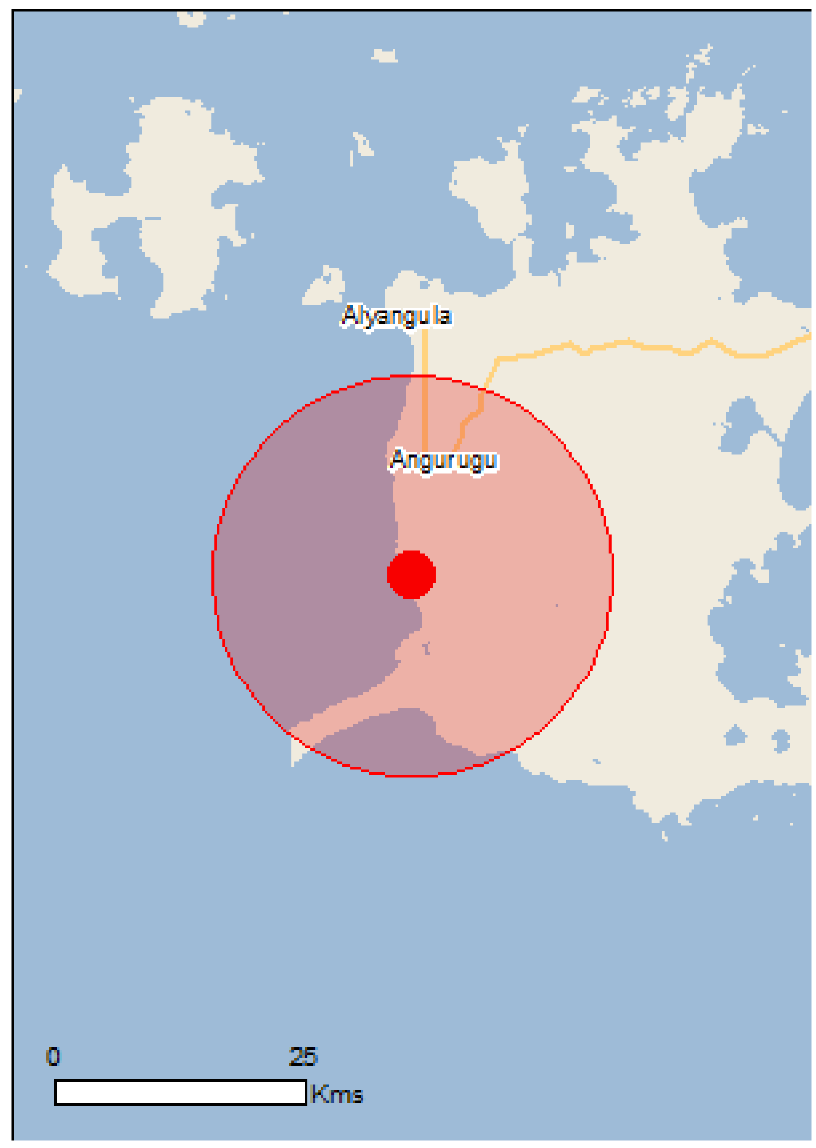
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 19/08/20 09:54:04



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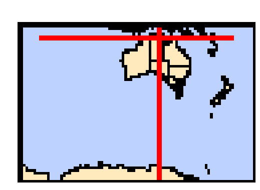

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	28
Listed Migratory Species:	44

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	75
Whales and Other Cetaceans:	10
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	3
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species

Name	Status	Type of Presence
		habitat may occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Notomys aquilo Northern Hopping-mouse, Woorrentinta [123]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area

Name	Status	Type of Presence
[Grampus griseus] Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
[Orcaella brevirostris] Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
[Orcinus orca] Killer Whale, Orca [46]		Species or species habitat may occur within area
[Sousa chinensis] Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
[Stenella attenuata] Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
[Tursiops aduncus] Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
[Tursiops truncatus s. str.] Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Anindilyakwa	NT

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
[Gulf of Carpentaria coastal zone]	North

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-14.07998 136.43277

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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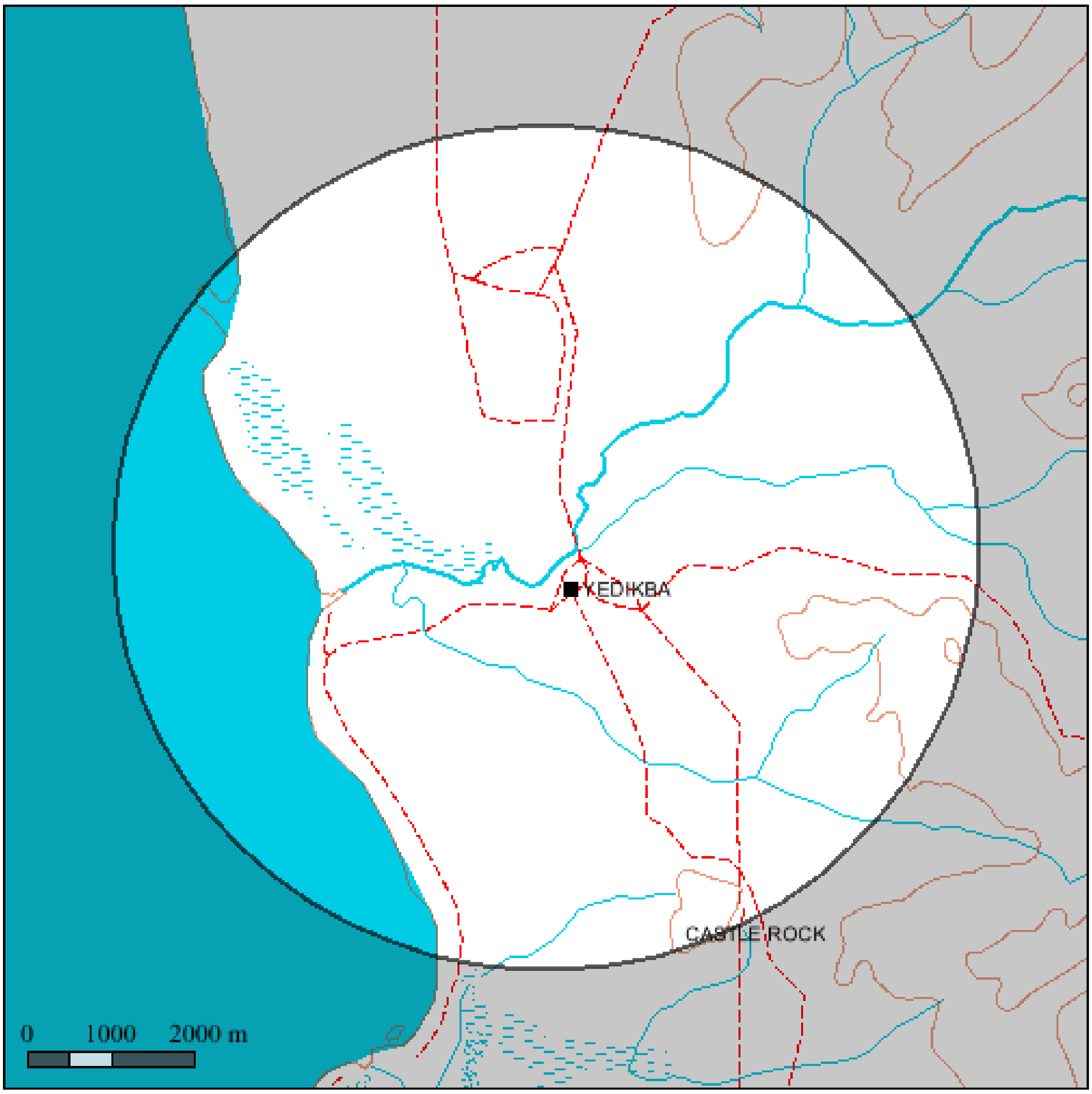
J Quarry

NT NRM Report

J Quarry

J Quarry encompasses an area of 78.4 sq km extending from 14 deg 1.0 min to 14 deg 7.0 min S and 136 deg 24.0 min to 136 deg 30.0 min E.
J Quarry is located in the Arnhem Coast, bioregion(s)

Location of J Quarry

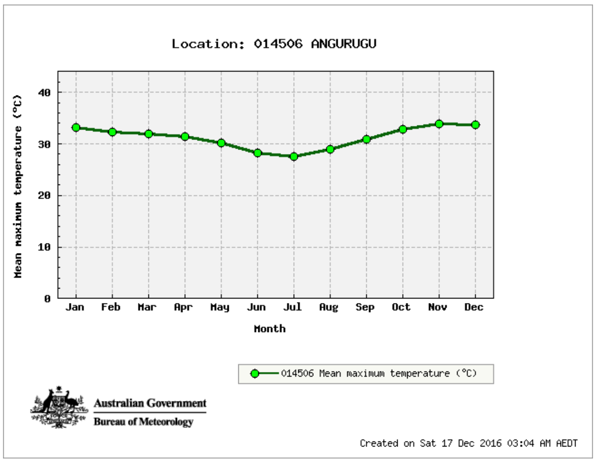


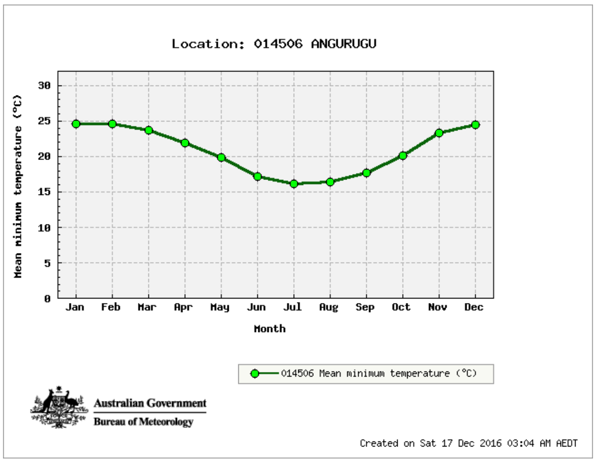
J Quarry Climate

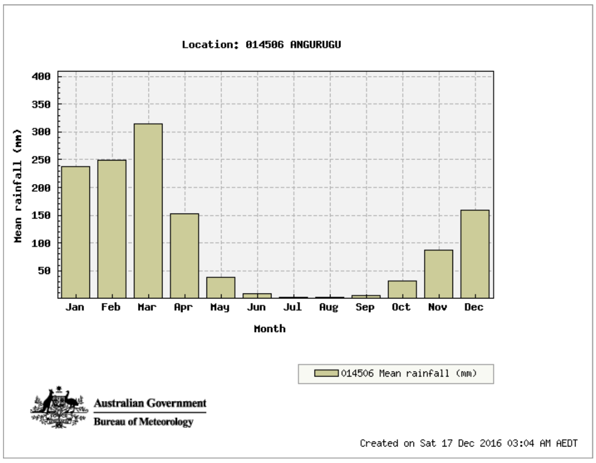
The closest long-term weather station is ANGURUGU (13 deg 59.0 min S, 136.4333E) 10 km N of the center of selected area

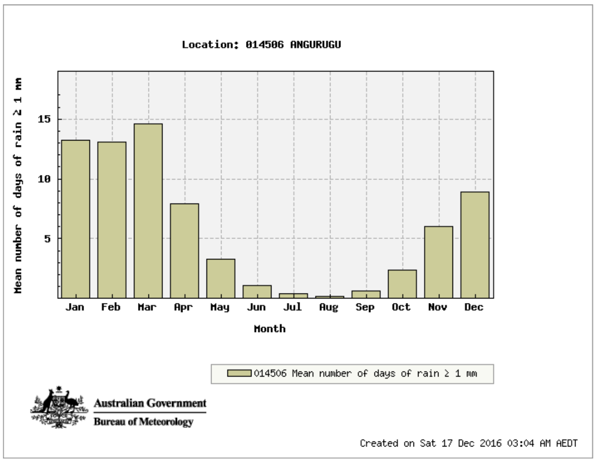
Statistics	Annual Values	Years of record
Mean max temp (deg C)	31.3	37
Mean min temp (deg C)	20.8	36
Average rainfall (mm)	1270.4	66
Average days of rain	71.7	67

Climate summaries from Bureau of Meteorology (www.bom.gov.au)









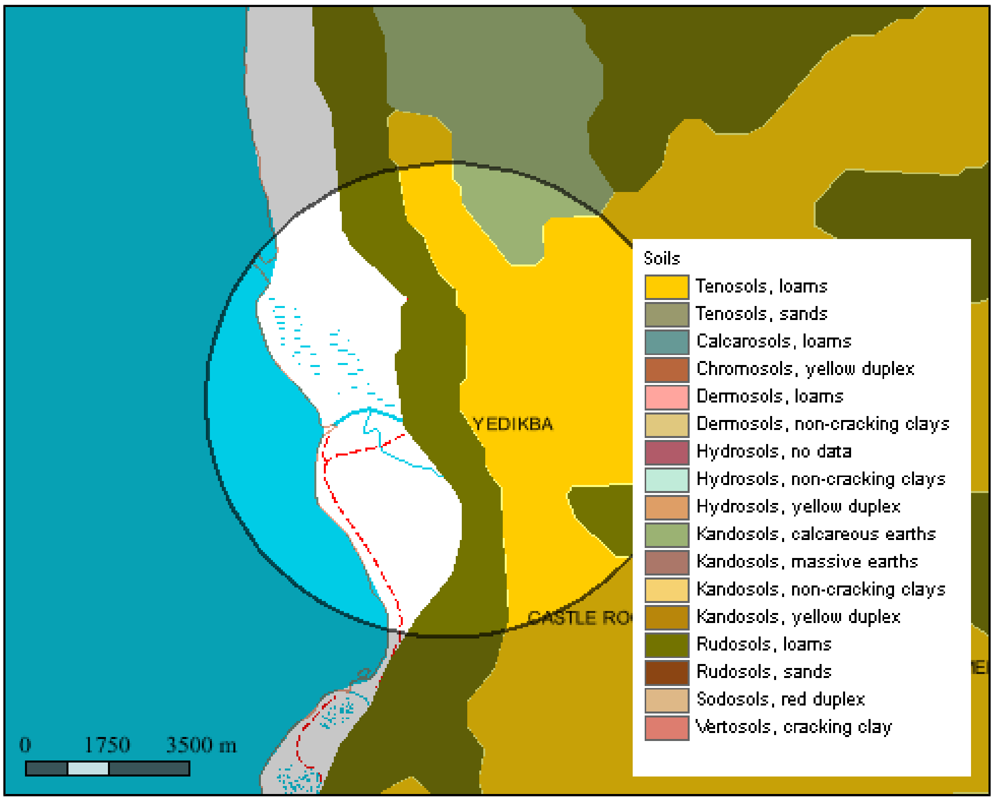
J Quarry Soils

Soil Types

Area of soil types (Northcote Factual Key)

Selected area is too small to produce reliable statistics

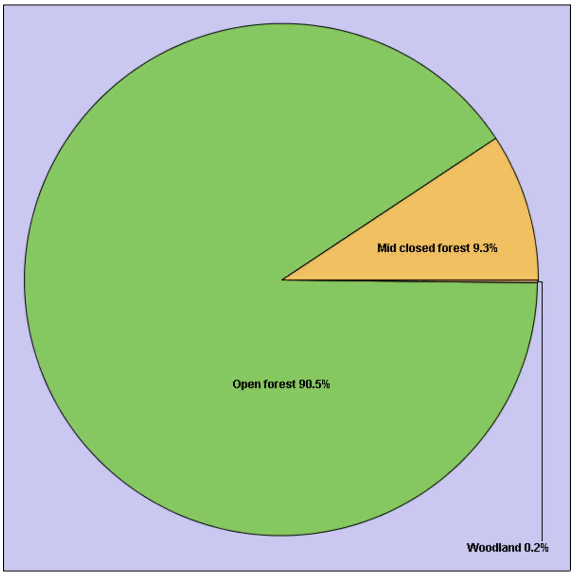
Soil Types



Soils 1:2M Layer is a copy of the NT portion (1:2,000,000 scale dataset) of the CSIRO Atlas of Australian Soils - K.H. Northcote et al. Data scale: 1:2,000,000 ANZLIC Identifier: 2DBCB771205D06B6E040CD9B0F274EFE
More details: Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

J Quarry Vegetation

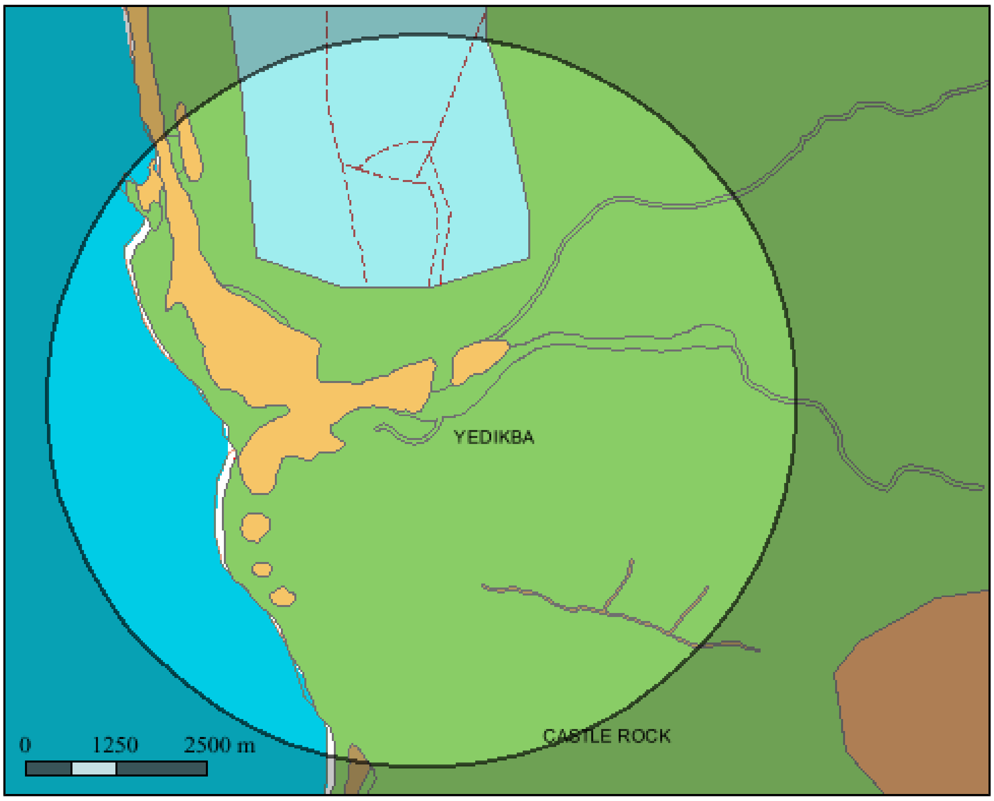
Vegetation Communities



Area of vegetation communities

Category	Area sq km	Area%
Open forest	57.83	73.77
Mid closed forest	5.92	7.55
Woodland	.12	.15

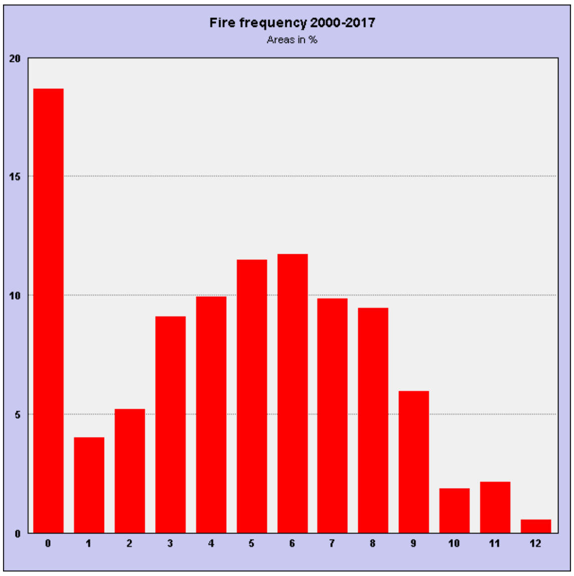
Vegetation Communities



The NVIS 2005 Layer is compiled from a number of vegetation and land unit survey maps that were recoded and re-attributed for the National Vegetation Information System (NVIS)
Data scale variable depending on location. ANZLIC Identifier:2DBCB771207006B6E040CD9B0F274EFE
More details:Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

J Quarry Fire History

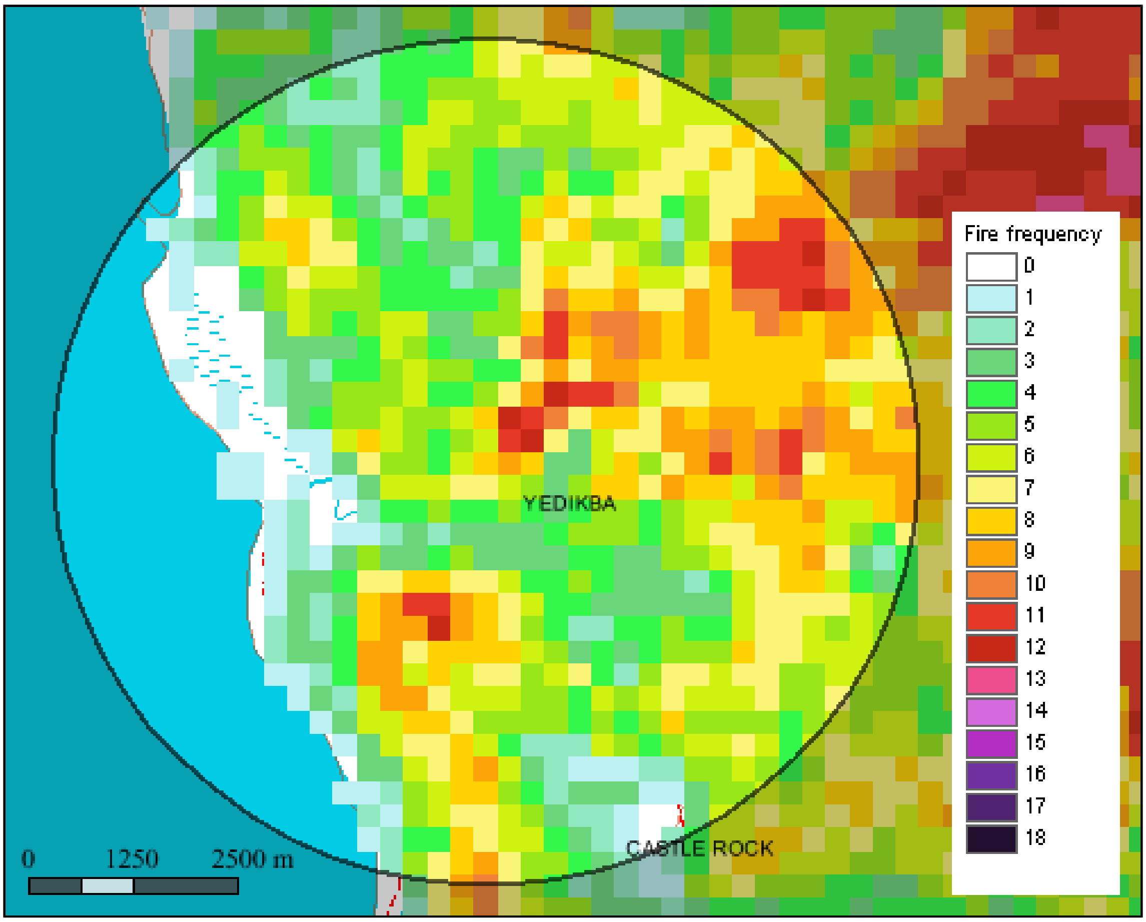
Fire frequency 2000-2017



area burnt for each fire frequency category 2000-2017

Category	Area sq km	Area%
0	14.64	18.68
1	3.15	4.02
2	4.08	5.20
3	7.13	9.09
4	7.79	9.94
5	9.01	11.50
6	9.19	11.72
7	7.74	9.87
8	7.41	9.45
9	4.67	5.95
10	1.46	1.86
11	1.69	2.15
12	.45	.57

Fire frequency 2000-2017



The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite
Spatial Resolution: 250m x 250m pixels (at Nadir).

J Quarry Threatened Species

Threatened species recorded in J Quarry (Records Updated: Sept 2013)

Group	Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Birds	Lesser Sand Plover	*Charadrius mongolus*	VU	EN	.	1 (1977)	0 (Unknown)	0 (Unknown)
Birds	Eastern Curlew	*Numenius madagascariensis*	VU	CE	.	3 (1978)	0 (Unknown)	0 (Unknown)
Birds	Curlew Sandpiper	*Calidris ferruginea*	VU	CE	.	2 (1978)	0 (Unknown)	0 (Unknown)
Mammals	Northern Quoll	*Dasyurus hallucatus*	CR	EN	176443	4 (2007)	1 (1922)	2 (2005)
Mammals	Brush-tailed Rabbit-rat	*Conilurus penicillatus*	EN	VU	176414	2 (2007)	8 (1922)	0 (Unknown)
Mammals	Northern Hopping-mouse	*Notomys aquilo*	VU	VU	176436	11 (2007)	6 (2006)	0 (Unknown)

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

J Quarry Threatened Species Grid

Threatened species recorded in the grid cell(s) in which J Quarry occurs (Records Updated: Sept 2013)

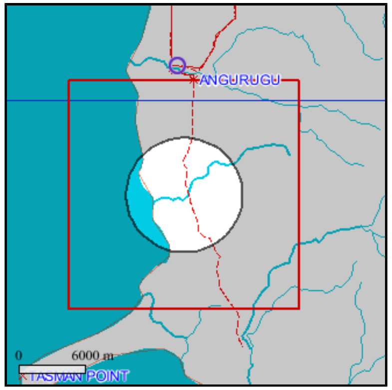
Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	Latest Observation Date	#Specimens	Latest Specimen Date	#Surveys	Latest Survey Record
Reptiles	Cheloniidae	*Chelonia mydas*	Green Turtle		VU	162	1999	0	Unknown	0	Unknown
Reptiles	Cheloniidae	*Eretmochelys imbricata*	Hawksbill Turtle	VU	VU	67	1997	2	1972	0	Unknown
Reptiles	Cheloniidae	*Lepidochelys olivacea*	Olive Ridley	VU	EN	4	1994	0	Unknown	0	Unknown
Reptiles	Cheloniidae	*Natator depressus*	Flatback Turtle		VU	91	1999	0	Unknown	0	Unknown
Reptiles	Varanidae	*Varanus mertensi*	Mertens` Water Monitor	VU		1	1969	1	1969	2	2009
Birds	Columbidae	*Geophaps smithii*	Partridge Pigeon	VU	VU	0	Unknown	3	Unknown	0	Unknown
Birds	Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	VU	EN	5	1997	0	Unknown	0	Unknown
Birds	Scolopacidae	*Limosa lapponica*	Bar-tailed Godwit	VU		4	1996	1	1922	0	Unknown
Birds	Scolopacidae	*Numenius madagascariensis*	Eastern Curlew	VU	CE	6	1996	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris tenuirostris*	Great Knot	VU	CE	3	1998	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris canutus*	Red Knot	VU	EN	1	1978	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	VU	CE	4	1996	0	Unknown	0	Unknown
Birds	Estrildidae	*Erythrura gouldiae*	Gouldian Finch	VU	EN	1	1971	0	Unknown	0	Unknown
Mammals	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	CR	EN	5	2007	1	1922	24	2009
Mammals	Muridae	*Conilurus penicillatus*	Brush-tailed Rabbit-rat	EN	VU	4	2007	8	1922	1	2005
Mammals	Muridae	*Notomys aquilo*	Northern Hopping-mouse	VU	VU	26	2007	6	2006	3	2009

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap J Quarry



J Quarry Weeds and Potential Weeds

Introduced plants recorded in the grid cell(s) in which J Quarry occurs and that have been identified as problem weeds in one or more locations in northern Australia. Occurrence based on Northern Territory Government databases.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Lamiaceae	*Hyptis suaveolens*	Hyptis	*B C*		*G&M*	1	1995
Poaceae	*Melinis repens*	Red Natal Grass			*DEU*	1	1995
Plantaginaceae	*Scoparia dulcis*	Bitter Broom			*DEU*	0	Unknown
Fabaceae	*Stylosanthes hamata*	Caribbean Stylo			*DEU*	1	1995
Fabaceae	*Stylosanthes humilis*	Townsville Lucerne			*DEU*	0	Unknown

Status Codes:
1. NATIONAL STATUS CODES
Alert, Alert List for Environmental Weeds (Please call Exotic Plant Pest Hotline 1800 084 881 if you think you have seen this weed)
Sleeper, National Sleeper Weed
Target,Targeted for eradication. (www.landmanager.com.au/view/index.aspx?id=449837)
WONS, Weeds of National Significance

2. NT STATUS CODES
A, NT Class A Weed (to be eradicated)
B, NT Class B Weed (growth & spread to be controlled)
C, NT Class C Weed (not to be introduced) (www.landmanager.com.au/view/index.aspx?id=449869)

3. OTHER STATUS CODES
C&E, Csurhes, S. & Edwards, R. (1998) Potential Environmental Weeds in Australia. Candidate Species for Preventative Control. Environment Australia, Canberra (www.landmanager.com.au/view/index.aspx?id=394504)
CYP, Draft Cape York Peninsula Pest Management Plan 2006-2011 (www.landmanager.com.au/view/index.aspx?id=371200)
DEU, Plants listed as environmental weeds by the Desert Uplands Strategic Land Resource Assessment (www.landmanager.com.au/view/index.aspx?id=332123)
G&M, Grice AC, Martin TG. 2005. The Management of Weeds and Their Impact on Biodiversity in the Rangelands. Cooperative Research Centre (CRC) for Australian Weed Management and CSIRO Sustainable Ecosystems. Commonwealth Australia (www.landmanager.com.au/view/index.aspx?id=163572)
Gr, Groves et al. 2003. Weed categories for natural and agricultural ecosystem management. Bureau of Rural Sciences (www.landmanager.com.au/view/index.aspx?id=388018)
K0, High Priority Weeds not yet established in the Katherine region
K1, High Priority Weeds posing environmental threats in the Katherine region
K2, High Priority Weeds posing existing threats in the Katherine region, as described in the Katherine Regional Weed Management Strategy 2005-2010 (www.landmanager.com.au/view/index.aspx?id=130286)
MP, Northern Territory Parks & Conservation Masterplan (www.landmanager.com.au/view/index.aspx?id=144141)
NAQS, North Australian Quarantine Strategy Target List (www.landmanager.com.au/view/index.aspx?id=449416)
NSW, Declared Noxious Weed in NSW (www.landmanager.com.au/view/index.aspx?id=449983)
Q1, QLD Class 1 Weed (not to be introduced, kept or supplied-
Q2, Class 2 Weed (eradicate where possible, not to be introduced, kept or supplied)
Q3, Qld Class 3 Weed (to be controlled near environmentally sensitive areas- not to be supplied/sold without a permit) (www.landmanager.com.au/view/index.aspx?id=190714)
SA, Declared Plant in South Australia (www.landmanager.com.au/view/index.aspx?id=449996)
WeedsAus, Listed as a significant weed by Weeds Australia (www.landmanager.com.au/view/index.aspx?id=14576)
WA1, WA Weed Class P1 (movement prohibited)
WA2, WA Weed Class P2 (aim to eradicate)
WA3, WA Weed Class P3 (control infestations)
WA4, WA Weed Class P4 (prevent spread)
WA5, WA Weed Class P3 (control infestations on public land) (www.landmanager.com.au/view/index.aspx?id=449884).

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Plants listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap J Quarry

J Quarry Pest and Potential Pest Animals

Animals with pest potential recorded in the grid cell(s) in which J Quarry occurs. Occurrence based on Northern Territory Government databases.

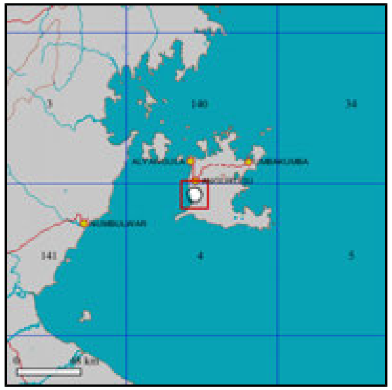
Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Red-tailed Black-cockatoo	*Calyptorhynchus banksii macrorhynchus*	N	.	223765	3 (1978)	3 (1922)	0 (Unknown)
Sulphur-Crested Cockatoo	*Cacatua galerita*	N	.	223772	16 (2009)	1 (1921)	3 (2009)
Agile Wallaby	*Macropus agilis*	N	.	223786	4 (2007)	7 (1923)	11 (2009)
Dingo / Wild dog	*Canis lupus*	N	.	183280	8 (2007)	0 (Unknown)	2 (2009)

NT STATUS CODES:
Int, Introduced species (all non-prohibited vertebrates, and all other exotic species (www.landmanager.com.au/view/index.aspx?id=280771)
N, Native species with pest potential.
P, Prohibited species (all exotic vertebrates except those listed as non-prohibited (www.landmanager.com.au/view/index.aspx?id=450509)

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Potential pest animals listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap J Quarry



Soils and vegetation graphs and tables refer to area of soils and vegetation only. Fire graphs and tables refer to entire selected area including sea if present. Calculations are derived from map images or vector data, and should be taken as a guide only. Accuracy cannot be guaranteed. For small areas, figures should be rounded to the nearest whole number.

Fire map layers used in these reports have been updated in 2018 so their pixels are aligned to the same grid.

APPENDIX 7 – SIGNIFICANT IMPACT ASSESSMENT OF LISTED SPECIES

Table A7.1: Likelihood of identified listed species inhabiting the project site

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
Glyphis glyphis	Speartooth Shark	Critically Endangered	Vulnerable	Very Low	Very Low	***Range*** The species' known range includes various rivers that drain into the Arafura Sea and along the northwest side of Cape York Peninsula but there are no known records from within the Gulf of Carpentaria or around Groote Eylandt (Field *et al.*, 2008). The nearest record is from the Alligator River region in the NT over 300km away in a straight line. ***Preferred Habitat*** Speartooth Sharks prefer fast flowing, turbid river waters which are not present on the project site. The species has only been recorded in estuarine/tidal reaches of river systems in northern Australia (Stevens *et al.*, 2005). The majority of the specimens recorded within the rivers have been juveniles or sub-adults, with the only adult specimen (based on weight) to be collected part of by-catch in an offshore NT fishery (Field *et al.*, 2008). Based on this it is hypothesised that the species breeds in coastal waters and before females return to estuaries to spawn with the juveniles using tidal rivers as nursery grounds (Stevens *et al.*, 2005). ***Diet*** The species primarily feeds on fish, with an analysis of stomach content from specimens caught within the

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Wenlock River suggesting they feed on bottom dwelling fish and crustaceans along the soft substrate (Peverell *et al.*, 2006). It is thought that their small eyes and slender teeth have adapted them to predating in turbid waters (Fowler, 1997). ***Conclusion*** Based on the species preferring large, fast flowing, turbid tidal rivers it is very unlikely the species inhabits the exceptionally clear waters of the project site. It should be noted that despite several different studies and considerable fishing effort on various major watercourses across Groote Eylandt, no Speartooth Sharks have been recorded (Webb, 1992; Thornburn, 2010; URS, 2012; Cumberland Ecology, 2015).
Pristis clavata	Dwarf Sawfish	Vulnerable Migratory Marine	Vulnerable	No	Moderate	***Range*** These three species are thought to have historically had vast global distributions although more recent data suggests that the Australian populations are one of the last significant populations of each of these species (Stevens *et al.*, 2005). Within Australia, they display overlapping ranges across the tropical north. All three sawfish species have been recorded occurring within the coastal waters north of Groote Eylandt (Field *et al.*, 2008). Although, despite several different studies and considerable fishing effort on various major watercourses across Groote Eylandt, no sawfish have been recorded (Webb, 1992; Thornburn, 2010; URS, 2012; Cumberland Ecology, 2015).
Pristis pristis	Largetooth Sawfish	Vulnerable Migratory Marine	Vulnerable	Moderate	Moderate	
Pristis zijsron	Green Sawfish	Vulnerable Migratory Marine	Vulnerable	No	Moderate	

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Preferred Habitat All three species utilise both coastal and riverine habitats. Adults are thought to breed in coastal waters, potentially in aggregations before the females return to estuaries to spawn. Each of the species can enter rivers throughout their lifecycle (especially during the wet season) although Green Sawfish and Dwarf Sawfish only inhabit the tidal reaches of these systems until they are sub-adults before moving into coastal waters. The Largetooth Sawfish is known to access upstream freshwater lagoons at times of flooding (Field *et al.*, 2008). ***Diet*** All three species prefer to forage in shallow, muddy/sandy substrates on crustaceans, molluscs and schooling fish (Allen. 1982). ***Conclusion*** These habitats and prey communities were observed in the Emerald River estuary, suggesting these three species could utilise the system. However, Dwarf Sawfish and Green Sawfish do not inhabit fresh waters (as observed in the Southern Tributary) so would not venture upstream of the estuary. The Largetooth Sawfish would have a moderate likelihood of utilising the freshwater reaches of the Southern Tributary and the main channel of the Emerald River.

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						The species would potentially use the main channel of the Emerald River to access freshwater lagoons located far upstream of the project site. However, the species will likely only utilise the downstream reaches of the Southern Tributary for foraging because of its ephemeral nature and the lack of preferred habitat (large off-channel wetlands/permanent pools) within the upper reaches.
Balaenoptera musculus	Blue whale	Endangered Migratory Marine	-	No	No	***Range*** The Blue whale is found in oceans worldwide from polar to tropical waters. The species distribution in Australian waters is likely widespread throughout the continent. Despite this, Australian coastal and continental shelf waters are only generally used for migration and opportunistic feeding by the species and are therefore of no particular significance to the species (DEH, 2005). ***Preferred Habitat*** Blue whales prefer deep oceanic waters, although will traverse the shallower coastal waters when migrating. The only significant foraging areas within Australian waters are associated with the southern continental shelf in Western Australia. South Australia and Victoria (DEH, 2005). ***Diet***

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						The species feeds primarily on krill, although it is also known to eat fish and squid (Kawamura, 1980). ***Conclusion*** The project site does not encompass any of the preferred habitats of the Blue whale. Therefore, the species would not inhabit the waters of Emerald River.
Caretta caretta	Loggerhead Turtle	Endangered Migratory Marine Marine	Vulnerable	No	Very Low	***Range*** The Loggerhead Turtle is a large (up to 1m long carapace and weighing up to 500kg) oceanic/marine species that occurs worldwide within tropical and sub-tropical waters. In Australia they inhabit tropical and warm, temperate waters of Queensland, Northern Territory, Western Australia and northern New South Wales (DoEE, 2017). ***Preferred Habitat*** This species will inhabit coastal waters, coral reefs, bays and estuaries. There are two unique breeding populations in Australia: 1. The eastern Australia population, which nests within the southern Great Barrier Reef on various islands and along the coastline; and 2. The western Australia population which breeds in the Ningaloo reef region, also on various islands and the adjacent coastline (DoEE, 2017).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Diet The Loggerhead Turtle is carnivorous, preying on shellfish, crustaceans, sea urchins and jellyfish (DoEE, 2017). ***Conclusion*** While they are known to enter larger estuaries, the species is very unlikely to enter the Emerald River due to its narrow, shallow entrance and short estuarine reach. Further, as the project site is situated in the western portion of the Gulf of Carpentaria it is a significant distance from both of the two distinct Australian populations breeding areas, suggesting there is no aggregations of individuals in the region. Therefore, it is considered highly unlikely that the species would inhabit the project site.
Chelonia mydas	Green Turtle	Vulnerable Migratory Marine Marine	Near threatened	No	Low	***Range*** Green turtles occur throughout the Indo-Pacific Region, within warm temperate and tropical waters (DoEE, 2017). In Australia they inhabit the coastal waters of Queensland, Northern Territory, Western Australia and northern New South Wales (DoEE, 2017). ***Preferred Habitat*** The species prefers seaweed rich coral reefs and inshore seagrass beds suggesting they inhabit estuaries and coastal waters where these habitats are

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						found (DoEE, 2017). There are seven different breeding populations within Australia with one attributed to the Gulf of Carpentaria. There are two nesting areas within the Gulf of Carpentaria with Groote Eylandt part of the Eastern Arnhem Land nesting area. However, Chatto and Baker (2008) found no evidence of turtle nesting on the western coast (where the project site is located) of Groote Eylandt between 1993 and 1997, despite the southern and eastern coasts of the island displaying some of the densest turtle rookery sites in the NT. ***Diet*** Juvenile Green Turtles are considered carnivorous feeding predominantly on crustaceans and invertebrates before becoming herbivorous as adults and feeding primarily on seagrass and algae (Cogger, 2000; Whiting, 2000). ***Conclusion*** While this marine species is known to enter estuaries, it is generally to forage on seagrass beds. No seagrass beds were observed within the Emerald River. Therefore, it is very unlikely the species would enter the system to forage. Further, despite extensive surveys there is no known turtle nesting areas on the western side of Groote Eylandt, where the project area occurs. Therefore, the species is unlikely to come to

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						land in the area. Hence, there is a low likelihood of the species utilising the project site.
Dermochelys coriacea	Leatherback Turtle	Endangered Migratory Marine Marine	Critically endangered	No	No	***Range*** The Leatherback Turtle is the largest marine turtle in the world with a total length of up to 2.2m and weighing up to 700kg. The species has a global distribution and is known to migrate long distances between countries. In Australia they inhabit both tropical and temperate waters and are known to inhabit waters in all Australian states (Hamann *et al.,* 2006). ***Preferred Habitat*** The species is highly pelagic, only venturing close to shore during the nesting season (Sarti Martinez, 2000). Within Australia, the species is generally observed foraging over continental shelf waters (Hamann *et al.,* 2006). They return to sandy beaches to nest with a small rookery known to occur on the Cobourg Peninsula in the NT (Chatto & Baker, 2008). However, the majority of individuals observed in Australian waters will migrate to neighbouring countries to nest (Hamann *et al.,* 2006). ***Diet*** The Leatherback Turtle is considered carnivorous feeding primarily on jellyfish, salps, squid, siphonophores and other gelatinous invertebrates (Bjorndal, 1997).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Conclusion The species is predominantly pelagic and would not enter a small river like the Emerald River. Further, extensive surveys undertaken by the NT government every year between 1991 and 2004 (Chatto & Baker, 2008) indicate there is no known turtle nesting areas on the western side of Groote Eylandt, where the project area occurs. Therefore, the species is unlikely to come to land in the area or inhabit the project site.
Eretmochelys imbricate	Hawksbill Turtle	Vulnerable Migratory Marine Marine	Vulnerable	No	Low	***Range*** The Hawksbill Turtle inhabits tropical, sub-tropical and temperate waters in oceans worldwide. Within Australia they have been recorded in New South Wales, Queensland, NT and Western Australian marine waters (DoEE, 2017). ***Preferred Habitat*** For the first 10 years of the species life it is pelagic, drifting on ocean currents and often associated with rafts of *Sargassum* (a floating marine plant) (Carr, 1987). When they are larger they settle on tropical tidal coral and rocky reefs, although they are sometimes also found inhabiting seagrass beds in coastal waters. The archipelago north-east of Groote Eylandt (i.e. >50km from the project site in a straight line) is suggested to be one of the most important rookeries in the world (Hoenner *et al.,* 2016). However, the species is not known to nest on the

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						western side of Groote Eylandt (Chatto & Baker, 2008). ***Diet*** During their juvenile pelagic phase the species is planktivorous. As adults the species is thought to prefer sponges although it is omnivorous and known to also eat hydroids, cephalopods, gastropods, cnidarians, seagrass and algae Whiting 2000). ***Conclusion*** While this marine species is known to enter estuaries it mainly forages on sponges. No sponge gardens, or rocky beds likely to house sponge gardens, were observed within the Emerald River. Therefore, it is very unlikely the species would enter the system to forage. Further, despite extensive surveys there is no known turtle nesting areas on the western side of Groote Eylandt, where the project area occurs. Therefore, the species is unlikely to come to land in the area.
Lepidochelys olivacea	Olive Ridley Turtle	Endangered Migratory Marine Marine	Vulnerable	No	Low	***Range*** The Olive Ridley Turtle has a circumtropical distribution worldwide, nesting in nearly 60 different countries (Abreu-Grobois & Plotkin, 2008). Within Australia they inhabit marine waters in Queensland, the NT and Western Australia.

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Preferred Habitat Similar to the Hawksbill Turtle, Olive Ridley Turtles have a pelagic juvenile phase where they are dispersed on the ocean currents (Musick & Limpus, 1997). Large immature and adult turtles inhabit soft bottom habitats in continental shelf waters at depths of up to 100m but typically occurring between 11m and 40m deep. Unlike other marine turtles of similar size in tropical Australian waters, they do not inhabit coral reefs or inshore seagrass beds (Robins, 2002; Limpus, 2008). There has been patchy nesting on various beaches throughout northern Australia but no concentrated nesting (Cogger & Lindner, 1969; Chatto, 1998; Guinea, 1994). ***Diet*** The species prefers gastropods and bivalve molluscs suggesting they are predominantly bottom feeders, although they are also known to feed on crabs, shrimp, tunicates, jellyfish, salps and algae (Conway, 1994; Bjorndal, 1997). ***Conclusion*** Despite extensive surveys, there is no known turtle nesting areas on the western side of Groote Eylandt, where the project area occurs. Little is known of this species within Australia, except that they prefer soft-bottom habitats in 11-40m protected coastal waters. While soft-muddy bottoms are observed within the

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						lower reaches of the Emerald River they do not exceed 6m deep. Based on this assessment the Olive Ridley Turtle has a low potential to utilise the estuarine reaches within the project site.
Natator depressus	Flatback Turtle	Vulnerable Migratory Marine Marine	-	No	Low	***Range*** The Flatback Turtle is one of only two marine turtles to not exhibit a global distribution. It only inhabits sub-tropical and tropical waters of the Australian continental shelf and up to the coastal waters of Papua New Guinea and Indonesia (Spring, 1982; Samertian & Noija, 1994). ***Preferred Habitat*** Adult Flatback Turtles inhabit soft bottom habitats over the continental shelf of northern Australia, although their full extent is not well known (Zangeri *et al.,* 1988). They generally feed in shallow, turbid, inshore waters at depths of <10m to >40m, targeting seagrass beds, bays, lagoons and estuaries that have soft bed sediments (Robins, 1995). The species is only known to nest on Australian beaches throughout eastern Queensland, the NT and Western Australia with four known nesting sites on the south-east coast of Groote Eylandt (Limpus *et al.,* 1989; Chatto & Baker, 2008). ***Diet*** Little information is available on the diet of Flatback Turtles, with juveniles known to eat gastropods, squid and siphonophores, while cuttlefish and crinoids

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						comprise some of the diet of adults (Zangeri *et al.,* 1988; Chatto, *et al.,* 1995). ***Conclusion*** Despite extensive surveys, there is no known turtle nesting areas on the western side of Groote Eylandt, where the project area occurs. Based on these surveys, the Flatback Turtle has a low potential to utilise the estuarine reaches within the project site.
Carcharodon carcharias	Great White Shark	Vulnerable Migratory Marine	-	No	No	***Range*** The Great White Shark inhabits all oceans worldwide utilising temperate and sub-tropical waters in both hemispheres, but it is also known to venture into tropical waters (Bruce, 2008). In Australia, the species is known to inhabit coastal waters from central Queensland on the east coast, down around the southern coastline and up to north-west Western Australia (Paterson, 1990). The closest observation to the project site is from Mackay in north Queensland (Paterson, 1990). The species has not been documented inhabiting NT waters. ***Preferred Habitat*** The species generally inhabits inshore rocky reefs, surf beaches and shallow coastal bays, although they are also known to take long open ocean journeys between South Africa and Australia (DEWHA, 2009).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Diet Great White Sharks will predate on fish, other sharks, rays, marine mammals, squid, crustaceans and seabirds (Estrada *et al.,* 2006). ***Conclusion*** The species has not been recorded in NT waters previously and does not inhabit river systems. Therefore, the species will not inhabit any reaches of the Emerald River.
Rhincodon typus	Whale Shark	Vulnerable Migratory Marine	-	No	No	***Range*** Whale Sharks inhabit tropical and warm temperate waters worldwide (Compagno, 1984). They have been sighted in all States and Territories (with a coastline) throughout Australia except Tasmania (Compagno, 1984). ***Preferred Habitat*** The species lives a predominantly oceanic, pelagic lifestyle, although it often enters inshore coastal waters such as lagoons in coral atolls (Compagno, 1984). ***Diet*** The Whale Shark is a filter feeder, consuming planktonic and nektonic prey.

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Conclusion Based on the assessment of preferred habitat, the species would not inhabit the project site.
Anoxypristis cuspidata	Narrow Sawfish	Migratory Marine	-	No	Moderate	***Range*** The Narrow Sawfish inhabits tropical coastal waters throughout northern Australia, from the Pilbara region of Western Australia to the central Queensland east coast (Kyne & Pillans, 2014). ***Preferred Habitat*** Juveniles of the species inhabit the tidal reaches of estuaries and rivers as well as coastal mud and sand flats, while adults are generally found offshore (Kyne & Pillans, 2014). Unlike the other species of sawfish, the Narrow Sawfish is often found inhabiting the mid reaches of the water column. Little is known of their breeding behaviour. ***Diet*** Not well known, but based on physiological traits, the species is thought to possess a similar diet to the other species of sawfish, predating on crustaceans, molluscs and schooling fish (Allen. 1982). ***Conclusion*** The species prefers tidal reaches of rivers as juveniles and is not known to inhabit freshwater systems. Therefore, it has a moderate likelihood of inhabiting

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						the main channel of the Emerald River although it will not enter the freshwater Southern Tributary.
Balaenoptera edeni	Bryde's Whale	Migratory Marine	-	No	No	***Range*** Bryde's Whales occur worldwide in tropical to temperate waters (Kato, 2002). They have been recorded inhabiting coast waters of every Australian state except the NT (Bannister *et al.,* 1996). ***Preferred Habitat*** The species lives a pelagic lifestyle in coastal waters up to 200m deep, although some are noted to reach up to 1000m deep (Best *et al.,* 1984). ***Diet*** The species generally opportunistically feeds on shoaling organisms such as fish (Kato, 2002). ***Conclusion*** Based on their known range and preferred habitat, Bryde's Whale will not inhabit the project site.
Crocodylus porosus	Estuarine Crocodile	Migratory Marine Marine	-	High	Recorded	***Range*** Estuarine Crocodiles inhabit estuarine, coastal and freshwater systems through tropical northern Australia from Gladstone on the east coast of Queensland to Broome in Western Australia (McNamara & Wyre, 1993).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Preferred Habitat Estuarine Crocodiles can inhabit many habitats from freshwater billabongs or swamps to nearshore reefs, although their preferred habitat is the estuarine reaches of tropical rivers. Critical habitat to Estuarine Crocodiles is associated with breeding during the wet season, which usually occurs within elevated, isolated freshwater swamps that do not experience tidal movement (Webb *et al.*, 1987). ***Diet*** The species is known to feed on a wide variety of prey including, crustaceans, insects, fish, turtles, birds and mammals (Webb & Manolis, 1989). ***Conclusion*** The species was recorded inhabiting the project site.
Dugon dugon	Dugong	Migratory Marine Marine	-	No	Low	***Range*** Dugongs inhabit tropical and warm temperate coastal and island waters from Shark Bay in Western Australia, throughout the northern coastline to Moreton Bay in south-east Queensland (Marsh *et al.,* 2011). They are known to inhabit the waters between Blue Mud Bay and Groote Eylandt (Marsh *et al.,* 2008). ***Preferred Habitat***

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Dugong occurrence generally coincide with the presence of stable seagrass beds. There are 20 species of seagrass in tropical and warm temperate Australian waters that grow in four major habitats including tidal reaches of rivers, coastal, reef and deepwater (Carruthers *et al.,* 2002). ***Diet*** The species feeds almost entirely on seagrass (Anderson, 1989). ***Conclusion*** Dugongs do not inhabit freshwater systems and so will not enter the Southern Tributary. Further, no seagrass beds were observed in the Emerald River suggesting the species has a low likelihood of entering the system.
Manta alfredi	Reef Manta Ray	Migratory Marine	-	No	No	***Range*** Known in northern Australian waters from Perth in Western Australia around the northern coastline and down to Sydney (NSW) on the east coast (Bray, 2020). ***Preferred Habitat*** Often seen inshore around rocky and coral reefs in tropical waters, they also occur offshore and take large seasonal migrations to aggregation sites (Bray, 2020).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Diet The species is a filter feeder targeting plankton. ***Conclusion*** The species is highly unlikely to enter the Emerald River as its preferred habitat is not present within the system.
Manta birostris	Giant Manta Ray	Migratory Marine	-	No	No	***Range*** Wide spread, although relatively uncommon in Australian waters (Bray, 2020b). The species is known to aggregate around Ningaloo Reef in Western Australia in autumn to winter each year (Bray, 2020b). ***Preferred Habitat*** It is a pelagic species inhabiting coastal and open water environments. ***Diet*** The species is a filter feeder targeting plankton. ***Conclusion*** The species is highly unlikely to enter the Emerald River.
Orcaella heinsohni	Australian Snubfin Dolphin	Migratory Marine	-	No	Low	***Range***

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						The Australian Snubfin Dolphin occurs in northern Australian waters from Broome on the west coast to Brisbane River on the east coast (Parra *et al.,* 2002). Other than Australia, there is only one other record of the species within Papua New Guinea (Beasley *et al.,* 2002). ***Preferred Habitat*** The species inhabits coastal waters and estuaries although they are not thought to venture far upstream in river systems (Parra *et al.,* 2002). ***Diet*** The species primarily feeds on fish in shallow waters (<20m depth), close to river mouths (Parra *et al.,* 2002). ***Conclusion*** Based on the type of habitat present and the relatively small size of the system, the species has a low likelihood of venturing into the estuarine waters of the Emerald River but would not enter the Southern Tributary which is an ephemeral, freshwater system.
Orcinus orca	Killer Whale	Migratory Marine	-	No	No	***Range*** Killer whales occur worldwide throughout all oceans and contiguous seas, from equatorial regions to polar zones (DAWE, 2020). In Australia, they have been recorded in all states with the nearest confirmed

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						sighting in Yirrkala, NT (the north-eastern tip of Arnhem Land (Chatto & Warneke, 2000). ***Preferred Habitat*** The species is considered a pelagic, oceanic dweller in both warm and cold waters (DAWE, 2020). They are not known to enter small rivers (DAWE, 2020). ***Diet*** Their diet varies on the region in which they occur but generally the species consumes fish, birds and mammals (Saulitis *et al.,* 2000). ***Conclusion*** Based on their preferred habitat the Killer Whale will not inhabit waters associated with the project site.
Sousa chinensis	Indo-Pacific Humpback Dolphin	Migratory Marine	-	No	Low	***Range*** The species is thought to be widely distributed along the northern Australian coastline from Shark Bay in Western Australia to the Queensland/NSW border on the east coast (Parra & Cagnazzi, 2016). ***Preferred Habitat*** These humpback dolphins generally inhabit shallow, protected coastal waters such as inlets, estuaries, major tidal rivers, shallow bays, etc., rather than open waters (Parra & Cagnazzi, 2016).

Listed species	Common name	Status		Likelihood of occurrence		Comments
		EPBC Act	TPWC Act	Southern Tributary	Emerald River main channel	
						Diet They are thought to be opportunistic general feeders with a diet primarily comprised of fish and crustaceans (Parra & Cagnazzi, 2016). ***Conclusion*** As the Emerald River is not a major tidal river the species only has a low likelihood of entering the system. However, it would not inhabit the Southern Tributary as it is an ephemeral, freshwater system.

ASSESSMENT OF SIGNIFICANCE

The following listed species have been recorded from the project site or assessed as having a high or moderate potential to be present:

- Dwarf Sawfish (*Pristis clavata*) listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act;
- Largetooth Sawfish (*Pristis pristis*) listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act ;
- Green Sawfish (*Pristis zijsron*) listed as listed as Vulnerable and Migratory Marine under the EPBC Act and Vulnerable under the TPWC Act ;
- Narrow Sawfish (*Anoxypristis cuspidate*) listed as Migratory Marine under the EPBC Act; and
- Estuarine Crocodile (*Crocodylus porosus*) listed as Migratory Marine under the EPBC Act.

As discussed in Section 6.3, there are limited potential direct impacts from the Emerald River bridge on aquatic ecology values. This is largely due to the bridge design whereby the bridge will span the breadth of the river with no foundations in-channel. The potential indirect effects from the bridge are also discussed in Section 6.3 and are considered to be minor. As such, the potential impact of the Emerald River bridge on threatened or migratory species that may potentially inhabit this portion of the river are expected to be minimal. In addition, flood modelling and a geomorphological assessment undertaken for the project (REE, 2020; WRM, 2020) suggest that the project will have negligible influence on the Emerald River downstream of the project site and/or on coastal/marine ecosystems. As such, threatened or migratory species that may potentially inhabit the Emerald River downstream of the bridge are also unlikely to be impacted by the bridge.

As discussed in Section 6.4, culverts are proposed to be constructed in the Southern Tributary. Therefore, there is the potential for both direct and indirect impacts to the threatened or migratory species that have the potential to be present in this watercourse. Two of the identified listed species were determined to have the potential to utilise the Southern Tributary (refer to Table A7.1 in Appendix 7), namely:

- the Largetooth Sawfish; and
- the Estuarine Crocodile.

Assessments of significance have therefore been undertaken for these two species. The assessments have been prepared in accordance with the Significant Impact Guidelines (SIG). The SIG are designed specifically to determine whether an activity is considered, under the EPBC Act, to have a significant impact on a species.

Largetooth Sawfish

Scientific name: *Pristis pristis*

EPBC Act Status: Vulnerable

TPWC Act Status: Vulnerable

The following section provide an assessment of the potential for the Largetooth Sawfish population to be an important population. The presence of an important population is a key concept in undertaking an assessment of significance for species listed as Vulnerable under the EPBC Act. The remainder of the section assesses the potential for the project to have a significant impact on the species.

Important Population Assessment

Key source populations either for breeding or dispersal

Sawfish are known to inhabit the Gulf of Carpentaria although various studies have found no evidence of sawfish inhabiting the watercourses of Groote Eylandt (Field *et al.,* 2008). It is predicted that Largetooth Sawfish inhabit the coastal waters around Groote Eylandt. Largetooth Sawfish pups have been found in numerous major drainages along the mainland coast of northern Arnhem Land suggesting the region is a significant breeding area for the species (DoE, 2015). Further, within the Indo-west Pacific region, Australia likely represents one of the last viable population strongholds and is therefore seen as a globally important population centre (DoE, 2015).

Populations that are necessary for maintaining genetic diversity

Few studies have investigated the genetic structure of Largetooth Sawfish populations. However, genetic studies undertaken by Phillips *et al.* (2011) and Phillips (2012) presented two possible breeding behaviour scenarios:

1. Adult females return to their natal river systems to give birth while males disperse across northern Australia to breed; and/or
2. Breeding aggregations of Largetooth Sawfish occur within outer coastal waters where fish from all regions congregate. Females then return to their natal river systems to give birth.

These theories are evidenced by a degree of paternal mixing between populations located in Western Australia, Northern Territory and the Gulf of Carpentaria, but a highly restricted maternal gene flow (Phillips *et al.,* 2011; Phillips, 2012).

Based on these findings, if a local population (within the Emerald River system) was to become diminished they may not be repopulated as adult females return to their natal river systems to pup and there is thought to be little immigration from neighbouring catchments. Additionally, this infers that males from the local area are important at maintaining the genetic diversity across all three documented regions through either of the two possible breeding behaviours identified.

Populations that are near the limit of the species range

Groote Eylandt is situated in the north-western waters of the Gulf of Carpentaria in the NT. The species range encompasses Western Australia, the NT and Queensland, with populations known to extend down the eastern coast of Cape York Peninsula (DoE, 2015). Based on this assessment, the project site is not near the limit of the species range.

Conclusion

Based on the above assessment, a population of Largetooth Sawfish is likely to inhabit the coastal waters of Groote Eylandt and may extend into the Emerald River system. This population is considered to comprise an 'important population' as defined by the Significant Impact Guidelines to assist in maintaining genetic diversity within the Australian sawfish population.

Significant Impact Criteria

Lead to a long-term decrease in the size of an important population of a species

The Largetooth Sawfish are thought to breed in offshore coastal waters before the females return to the rivers to pup (Phillips, 2012). Juvenile sawfish will then utilise the estuarine, brackish and freshwater reaches of a river system as a 'nursery ground' prior to moving to near-shore coastal waters in adulthood. Within freshwater reaches, the species generally utilises the watercourse to move between large, permanent off-channel wetlands/lagoons (Peverell, 2009).

The main potential impact of the project on the Southern Tributary relates to the installation of culverts in the tributary channel. These culverts may be a barrier for Largetooth Sawfish moving to the upper freshwater reaches of the system. However, the Southern Tributary is ephemeral and has limited preferred habitat in the upstream reaches due to the lack of permanent off-channel wetlands/lagoons. Therefore, it is expected that the species are unlikely to venture far upstream on the Southern Tributary.

The construction of the culverts is unlikely to significantly affect water quality within the Southern Tributary. Water and sediment quality/composition in the Southern Tributary may be impacted by sediment laden runoff from cleared areas (including road surfaces) and reduced downstream flows within the main channel. However, erosion and sediment control measures will be adopted during construction of the culverts on the Southern Tributary. These measures include utilising best practice soil erosion and sediment control measures during construction (i.e. deploying silt curtains, sediment fences, etc.) and undertaking construction works during the dry season. These measures will effectively reduce the potential for sediment laden runoff to enter the Southern Tributary, limiting the potential for water quality impacts on the Southern Tributary, or downstream.

Based on this assessment, it is highly unlikely that the construction of the culverts on the Southern Tributary will lead to a long-term decrease of any resident Largetooth Sawfish population.

Reduce the area of occupancy of an important population

As described above, the Largetooth Sawfish are thought to breed in offshore coastal waters before the females return to the rivers to pup (Phillips, 2012), Juvenile sawfish will then utilise the estuarine, brackish and freshwater reaches of a river system as a 'nursery ground' prior to moving to near-shore coastal waters in adulthood. Within freshwater reaches the species generally utilises the watercourse to move between large, permanent off-channel wetlands/lagoons (Peverell, 2009).

The construction of the culverts on the Southern Tributary has the potential to reduce the area the Largetooth Sawfish may occupy in the Southern Tributary by removing a small area of habitat where the culverts will be constructed, or by restricting access to upstream reaches. These impacts are unlikely to affect the area of occupancy within the Southern Tributary as it is an ephemeral system with limited preferred habitat upstream of the proposed crossing location due to the lack of permanent off-channel wetlands/lagoons in the upstream reaches. Therefore, it is expected that the species would be unlikely to venture far upstream on the Southern Tributary. The project is also unlikely to significant affect water quality within the Southern Tributary and detailed design of the culverts will take into account best practice fish passage requirements. Based on this assessment, the construction of the culverts on the Southern Tributary will have negligible influence on the current (predicted) area of occupancy of any resident Largetooth Sawfish population.

The project will not limit the species from inhabiting the Emerald River. Therefore, the project will have no impact on the area of occupancy currently inhabited within the Emerald River system.

Fragment an existing important population into two or more populations

Largetooth Sawfish must access both the marine and estuarine to freshwater reaches associated with a river system to maintain a sustainable population. As the Southern Tributary has limited preferred habitat for the Largetooth Sawfish upstream of the proposed crossing location, it is expected that the species would be unlikely to venture far upstream on the Southern Tributary and does not need access to the upper reaches of the Southern Tributary to complete its life cycle. Further, works to construct the culverts will be undertaken within the dry season when the majority of flows have ceased and the likelihood of individual sawfish being caught upstream is minimal. It is therefore considered unlikely that a population of Largetooth Sawfish would be fragmented on the Southern Tributary.

Adversely affect habitat critical to the survival of a species

Juvenile to sub-adult Largetooth Sawfish inhabit tidal rivers and estuaries in tropical northern Australia, with some individuals moving into permanent freshwater lagoons (Peverell, 2009). Adult Largetooth Sawfish migrate to coastal marine environments, although there is limited information/data available on their life history traits.

As the Southern Tributary lacks permanent off-channel wetlands/lagoons in the upstream reaches, there is considered to be no critical habitat present in the upstream reaches of the Southern Tributary. Therefore, the project will not adversely affect habitat critical to the survival of the species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The construction and operation of the Southern Tributary crossing could potentially reduce the area of freshwater habitats available within the Emerald River catchment by removing habitat where the culverts will be constructed. However, the area of potential habitat to be removed is small and would not significantly affect the potential for the species to persist in the Emerald River catchment. The other potential impact relates to the culverts potentially restricting access to upstream reaches. However, as noted above, the species is not expected to currently utilise the upper reaches of the Southern Tributary. It is therefore unlikely that the project will significantly affect habitat to the extent the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

There are very few invasive species currently present on Groote Eylandt and specific management plans are also in place on all GEMCO mineral leases that target the risks of introducing cane toads as well as introducing and spreading weeds. The project is not anticipated to result in invasive species becoming established.

Introduce disease that may cause the species to decline

There is limited information on diseases likely to impact the Largetooth Sawfish. Therefore, it is difficult to determine the risks posed to the species by disease or the pathway in which such diseases may enter the system. However, the project is unlikely to create any new vectors with the potential to bring in any new diseases.

Interfere with the recovery of the species

DoE (2015) states the objectives of the Multi-Species Recovery Plan for Sawfish and River Sharks. Objective 5 is most relevant to the project which states '*Reduce and, where possible, eliminate any adverse impacts of habitat degradation and modification on sawfish and river shark species*'. This Significant Impact Assessment has detailed how the project will not affect the critical habitat to the Largetooth Sawfish and has concluded that any potential impacts are not likely to be significant. Based on this assessment it is highly unlikely that the project will interfere with the recovery of the species.

Conclusion

Largetooth Sawfish are predicted to have a moderate likelihood of inhabiting the Emerald River main channel and the lower reaches of the Southern Tributary. An assessment of the Significant Impact Criteria found the project is likely to have a negligible influence on a population of Largetooth Sawfish that would solely rely on the Emerald River catchment. In particular, there is considered to be no critical habitat present in the upstream reaches of the Southern Tributary due to a lack of permanent off-channel wetlands/lagoons.

The main potential impact on the Southern Tributary posed to aquatic fauna is the installation of culverts in the tributary channel. These culverts may potentially be a barrier for Largetooth Sawfish moving to the upper freshwater reaches of the system. However, considering there is no critical habitat present in the upstream reaches, it is expected that the species would be unlikely to venture far upstream on the Southern Tributary. Detailed design of the culverts will be conducted prior to construction which will take into account best practice fish passage requirements. In addition, works to construct the culverts will be undertaken within the dry season when the majority of flows have ceased and the likelihood of individual sawfish being caught upstream is minimal.

Based on this assessment, no significant impact is predicted to occur on Largetooth Sawfish that may utilise the Southern Tributary.

Estuarine Crocodile

Scientific name: *Crocodylus porosus*

EPBC Act Status: Marine Migratory

TPWC Act Status: Not Listed

The following section provides an assessment of the potential for the habitat that may be impacted by the project to be considered as important habitat for the Estuarine Crocodile.

Important Habitat and Ecologically Significant Proportion Assessment

Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species

Estuarine Crocodiles inhabit estuarine, coastal and freshwater systems through tropical northern Australia from Gladstone on the east coast of Queensland to the Pilbara region in Western Australia (Fukuda *et al.,* 2007). On Groote Eylandt, Estuarine Crocodiles occur in all major waterways including inhabiting both the Emerald River main channel and the Southern Tributary. However, the project area represents a small proportion of habitat available to this species on Groote Eylandt.

Juvenile crocodiles aged 2 to 6 years old can travel up to 80 km away from their nesting site, while adults are known to make long distance journeys, with records of individuals travelling up to 280 km or >5.5 km each day (Walsh & Whitehead, 1993; Brien *et al.*, 2008). This suggests that Estuarine Crocodiles inhabiting the Emerald River are part of a population that encompasses much of the western side of the Gulf of Carpentaria and likely an even greater area. A survey undertaken by Fukuda *et al.* (2007) recorded between one and six Estuarine Crocodiles (non-hatchlings) every kilometre of coastline surveyed throughout numerous watercourses in the NT. In recent years the NT population has been increasing pushing individuals to inhabit further upstream and marginal habitats (Leach *et al.,* 2009).

Due to the wide distribution of the species on Groote Eylandt and increasing abundance throughout the region, it is unlikely that the project site supports an ecologically significant proportion of the NT population.

Habitat that is of critical importance to the species at particular life-cycle stages

Critical habitat to Estuarine Crocodiles is associated with breeding during the wet season, which usually occurs within elevated, isolated freshwater swamps that do not experience tidal movement (Webb *et al.*, 1987). The reaches of the Emerald River associated with the project site are tidal. Elevated, isolated freshwater swamps that do not experience tidal movement are only found in the upper catchment areas of the Emerald River and the Southern Tributary, upstream of the project site. Additionally, the species is widely distributed on Groote Eylandt and throughout the NT, and as such the reaches of the Emerald River and Southern Tributary encompassed by the project site are unlikely to be of critical importance to the sustainability of the population.

Habitat utilised by a migratory species which is at the limit of the species range

Estuarine Crocodiles inhabit estuarine, coastal and freshwater systems throughout tropical northern Australia from Gladstone on the east coast of Queensland to the Pilbara region in Western Australia (Fukuda *et al.,* 2007). The project site is located in the Gulf of Carpentaria and is therefore not at the limit of the species range.

Habitat within an area where the species is declining

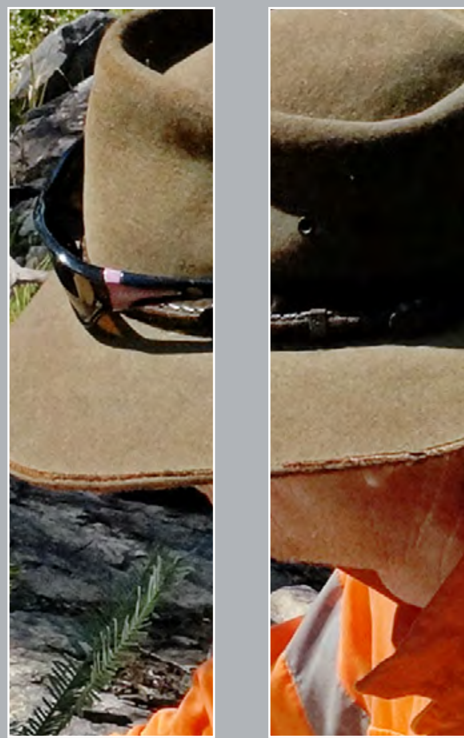
Leach *et al.* (2009) found that Estuarine Crocodile populations within Australian waters were increasing since the lows experienced in the 1970s when the species was close to extinction. The project site is therefore not located within an area where the species is declining.

Conclusion

Estuarine Crocodiles are known to inhabit the project site and the reaches of the Emerald River in proximity to the project site may be used seasonally by the species for nesting. However, the project site is not considered to encompass important habitat for this migratory species. Therefore a Significant Impact Assessment is not required. Based on this assessment, no significant impact is predicted to occur to the Estuarine Crocodile from the project.

D

Terrestrial Ecology Report



J Quarry Haul Road Project

Terrestrial Ecology Assessment Report

GEMCO/South32

2 November 2020

Final

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Glossary

Term / Abbreviation	Definition
ALC	Anindilyakwa Land Council
CAMBA	China–Australia Migratory Bird Agreement
DAWE	Federal Department of Agriculture, Water and the Environment
DENR	Northern Territory Department of Environment and Natural Resources
Disturbance Footprint	Represents the area in which the project will be undertaken and consists of three components, including the proposed access corridor, construction access track and realigned public access track, as shown in **Figure 3**
Eastern Leases	Mineral Leases (MLs) 31219 and 31220; formerly Exploration Licences in Retention (ELR) 28161 and 28162
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Existing GEMCO Mine	Mineral Leases 2, 3, 951, 952, 953, 956, 957, 958, 959, 960, 961 . The existing GEMCO mine is also referred to as the Western Leases within this report, and is shown on Figure 3.
GDE	Groundwater Dependent Ecosystem
GEMCO	Groote Eylandt Mining Company Pty Ltd
GIS	Geographic Information System
GPS	Global Positioning System
IR camera	Infra-red camera
JAMBA	Japan–Australia Migratory Bird Agreement
LiDAR	Light Detection and Ranging
littoral	Refers to environments that are within proximity of the sea or the sea shore (e.g. "littoral rainforests" or "littoral zone")
Locality	Area within 20 km radius of the centre of the Study Area
mesic	Refers to moderate to high moisture environments (such as rainforests) and the plants that are associated with such environments (e.g. "mesic vegetation" or "mesic plants")
microhabitat	Refers to very small, specialised habitats, such as a clump of grass or a space between rocks
MNES	'Matters of National Environmental Significance' that are listed by the EPBC Act
NR Maps	Northern Territory Natural Resource Maps search facility
NT	Northern Territory
physiographic	Refers to the features and attributes of the earth's land surface
PMST	Protected Matters Search Tool
RDP	Rapid Data Point
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
Significant Impact Guidelines	*Matters of National Environmental Significance Significant Impact Guidelines 1.1* (DotE 2013b)

Term / Abbreviation	Definition
South32	South32 Limited
Southern Lease	Exploration Licence (EL2455) shown on **Figure 1** and **Figure 2**
sp.	Singular of 'species' and used when the species was unable to be identified
spp.	Plural of 'species' and used when referring to a number of species within a genus
Study Area	Includes the Disturbance Footprint as well as all areas within a 2 km buffer from the Disturbance Footprint as shown in **Figure 5**. For the purposes of the assessment, only the terrestrial portion of the Study Area has been considered within this report.
Special Purpose Leases	Mineral Leases 382, 383, 392 and 393
TEC	Threatened Ecological Community
the project	The J Quarry Haul Road Project, including the proposed access corridor, construction access track and realigned public access track, as shown in **Figure 3**
TPWC Act	Territory Parks and Wildlife Conservation Act
TSMP	Groote Archipelago Threatened Species Management Plan
VMU	Vegetation Map Unit

1. Introduction

Cumberland Ecology was commissioned by Hansen Bailey on behalf of Groote Eylandt Mining Company Pty Ltd (GEMCO) to complete a terrestrial ecology report as part of the environmental approval application for the J Quarry Haul Road (the project). The proponent of the project is GEMCO, which has two shareholders - South32 Limited (60%) and Anglo Operations (Australia) Pty Ltd (40%).

This report utilises the following terms:

- Project: the J Quarry Haul Road project;
- Disturbance Footprint: represents the area in which the project will be undertaken and consists of three components, including the proposed access corridor, construction access track and realigned public access track; and
- Study Area: includes the Disturbance Footprint as well as all areas within a 2 km buffer from the Disturbance Footprint.

This report presents the results of the terrestrial ecology assessment undertaken by Cumberland Ecology. The assessment included desktop studies, as well as results from recent ecological surveys undertaken within the Study Area, and an assessment of impacts.

1.1. Purpose

The terrestrial ecology assessment provides ecological information and seeks to gain a comprehensive understanding of the terrestrial ecological values (including vegetation communities, fauna habitat and threatened species) of the Study Area. The purpose of this report is to document the findings of the baseline terrestrial ecology assessment of the Study Area and to provide an assessment of the potential impacts of the project on the terrestrial ecology values within the Study Area.

Specifically, the objectives of this terrestrial ecology report are to:

- Present the findings of ecological surveys undertaken within the Study Area;
- Identify and map the location of threatened flora and fauna species;
- Assess the likelihood as to whether threatened flora and fauna species could occur within the Study Area, and specifically within the Disturbance Footprint;
- Provide baseline ecology information on Matters of National Environmental Significance (MNES) within the Study Area;
- Describe the presence or likely occurrence of introduced and invasive species (both flora and fauna) in the Study Area;
- Describe the types and extent of potential impacts arising from the project; and
- Describe avoidance, mitigation and offset measures proposed to manage impacts.

This report will be used to support an application for regulatory approval for the project.

1.2. Project Description

GEMCO operates an existing manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650 km south-east of Darwin. The mine has been operating since the 1960s in multiple mineral leases known as the Western Leases (**Figure 1**). These tenements were granted in the 1960s, 1970s and 1980s. GEMCO's existing operations in the Western Leases are located on the northern side of the Emerald River. In 2023, mining is scheduled to progress into the southernmost mineral lease (ML961), which contains a future mining area known as J Quarry, located on the southern side of the Emerald River (**Figure 2**). ML961 includes an access corridor connecting the existing mine to J Quarry. However, GEMCO is unable to develop a haul road within the access corridor because of restrictions relating to an Aboriginal sacred site. An alternative alignment for the access corridor is therefore required.

The project involves the development of a haul road within an alternate alignment of the access corridor. The key elements of the project are shown in **Figure 3** and are limited to project elements and activities that are located beyond the existing tenements. The project involves:

- Construction of a haul road that links existing mining operations to J Quarry. On the northern side of the Emerald River, within the floodplain of the river, the road will be constructed on an embankment. On the southern side of the river it will be constructed as a causeway on the floodplain. A bridge will be required for crossing the Emerald River. The haul road will also traverse an ephemeral tributary of the Emerald River, known as the Emerald River Southern Tributary (**Figure 2**), via a series of culverts.
- Construction of a construction access track to enable construction equipment to access the area to the south of the Emerald River.
- Realignment of an existing public access track to enable safe public access to the western coast of Groote Eylandt. The realignment includes construction of an underpass of the haul road.

The project site for the purposes of environmental assessment is the area to be disturbed by these project elements (**Figure 3**). The project site is approximately 24 ha. All haul road development activities (and associated mining activities) located within the Western Leases are authorised under existing approvals and are not included in this assessment. Consistent with current mining activities, the haul road could be used up to 24 hours a day.

The land within the access corridor is Aboriginal land, designated under the Commonwealth *Aboriginal Land Rights Act (Northern Territory) 1976*. The project site comprises natural bushland dominated by *Eucalyptus* and *Melaleuca* open woodlands, as well as riparian woodlands along the Emerald River and the Emerald River Southern Tributary.

The township of Angurugu is located approximately 10 km to the north of the J Quarry Haul Road, and is the closest residential community (**Figure 1**). The Yedikba outstation is located approximately 450 m to the east of the haul road and is intermittently used by Traditional Owners.

1.3. Island and Regional Context

The Study Area is located on Groote Eylandt in the Northern Territory (NT), the third largest island off the Australian mainland. It is part of an archipelago to the east of Arnhem Land that has international significance because of the integrity of its flora and fauna. According to the NT Government (NRETAS 2009), Groote Eylandt and other islands in the archipelago have conservation values including:

- Nationally and internationally significant sites for nesting seabirds and turtles;
- Approximately 900 species of vascular plants and 330 vertebrates; and
- Known occurrences of a suite of threatened species including the nationally listed Northern Hopping-mouse (*Notomys aquilo*), Brush-tailed Rabbit-rat (*Conilurus penicillatus*) and Northern Quoll (*Dasyurus hallucatus*).

The main reason for the conservation significance of the island is thought to be the absence or near absence of key threatening processes that occur on the Australian mainland (NRETAS 2009). Of particular note, many of the feral animals that have impacted native flora and fauna on the mainland are absent from Groote Eylandt. In particular, feral cattle (*Bos taurus*), horses (*Equus caballus*), donkeys (*Equus asinus*), Water Buffalo (*Bubalus bubalis*), the Cane Toad (*Rhinella marina*), Rusa Deer (*Cervus timorensis*), Feral Pig (*Sus scrofa*), and the European Red Fox (*Vulpes vulpes)* are not established on the island.

Groote Eylandt is located in the Groote Sub-region of the Arnhem Coast Bioregion (DSEWPaC 2012) (**Figure 4**). The Arnhem Coast Bioregion comprises a coastal strip extending from just east of the Cobourg Peninsula to just north of the township of Numbulwar in south eastern Arnhem Land, and includes many offshore islands including Groote Eylandt. The Arnhem Coast Bioregion has a tropical monsoonal climate with a distinct wet and dry season, and high temperatures throughout the year (DEWHA 2008).

The vegetation within the Arnhem Coast Bioregion is characterised by eucalypt woodlands, monsoon vine forests and coastal communities such as mangroves (DEWHA 2008). Coastal vegetation includes well developed heathlands, mangroves and saline flats, with some floodplain and wetland areas (DLRM 2014). Inland from the coast, the dominant vegetation type is eucalypt tall open forest, typically dominated by *Eucalyptus miniata* (Darwin Woollybutt) and *Eucalyptus tetrodonta* (Darwin Stringybark), with smaller areas of monsoon rainforest and eucalypt woodlands (DLRM 2014). Well-developed coastal dune systems and rugged Cretaceous sandstone areas have been recorded on Groote Eylandt (DLRM 2014).

The whole of Groote Eylandt is Aboriginal land under the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976*. Furthermore, the Groote Eylandt Archipelago has been declared an Indigenous Protected Area; an area of Indigenous-owned land or sea where Traditional Owners have entered into an agreement with the Federal Government to promote biodiversity and cultural resource conservation (DotEE 2019s).

The bioregion is located entirely within Aboriginal land (DEWHA 2008). Land uses within the bioregion include bauxite and manganese mining, as well as tourism (DEWHA 2008). No national parks occur within the bioregion (DLRM 2014).

1.4. Description of the Study Area

The Study Area is partially located within the existing GEMCO mine, the Eastern Leases (an area in which mining is approved but has not yet commenced) and the Southern Lease (an exploration tenement) (see **Figure 5**).

The Study Area includes the catchment of the Emerald River and is characterised by areas of flat to undulating sand plains intersected by the Emerald River and Emerald River Southern Tributary (see **Figure 6**).

The vegetation across the Study Area comprises areas of rehabilitated vegetation, modified remnant vegetation and undisturbed remnant vegetation. The vegetation and habitats within the Study Area are in relatively good condition and are strongly influenced by topography and drainage. Eucalypt open forests and woodlands dominate the well-drained areas with Melaleuca-dominated vegetation occurring in swampy and riparian areas. Coastal and estuarine vegetation occurs in the western portion of the Study Area. Overall the vegetation is in a relatively good condition and is characterised by a high species and structural diversity, although the structure of the understorey and the condition of the ground layer has been modified by a regime of frequent fires. The Study Area provides a range of habitats for fauna species and is contiguous with native vegetation in other areas of Groote Eylandt. The Study Area comprises a matrix of land uses, including active mining areas, exploration areas, access roads/tracks, an outstation, a recreational swimming area adjacent to the Emerald River bridge and natural vegetation.

2. Regulatory Framework

2.1. Commonwealth Legislation

2.1.1. Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's principal piece of environmental legislation and is administered by the Federal Department of Agriculture, Water and the Environment (DAWE). It is designed to protect national environmental assets, known as MNES, which include threatened species of flora and fauna, endangered ecological communities, migratory species as well as other protected matters. Among other things, it defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna and communities.

Approval is required under the EPBC Act for any action (which includes a development, project or activity) that is considered likely to have a significant impact on MNES (including nationally threatened ecological communities (TECs) and species, and listed migratory species).

2.1.2. International Treaty Obligations on Migratory Species

Australia is signatory to several agreements relating to migratory species. Migratory species listed under the following agreements and conventions are protected in Australia by being listed as MNES (Migratory Controlling Provision) under the EPBC Act:

- China–Australia Migratory Bird Agreement (CAMBA);
- Japan–Australia Migratory Bird Agreement (JAMBA);
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

The CAMBA and JAMBA agreements list terrestrial, water and shorebird species which migrate between Australia and the respective countries. In both cases, the majority of listed species are shorebirds (DotE 2014a).

Both agreements require the parties to protect migratory birds by:

- Limiting the circumstances under which migratory birds are taken or traded;
- Protecting and conserving important habitats;
- Exchanging information; and
- Building cooperative relationships.

The JAMBA agreement also includes provisions for cooperation on the conservation of threatened birds. Australian government and non-government representatives meet every two years with Japanese and Chinese counterparts to review progress in implementing the agreements and to explore new initiatives to conserve migratory birds (DotE 2014a).

The ROKAMBA formalises Australia's relationship with the Republic of Korea in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (DotE 2014a).

In addition to these bilateral agreements, Australia is also a signatory of the Bonn Convention. This convention aims to conserve terrestrial, aquatic and avian migratory species throughout their range (CMS 2015).

2.2. Northern Territory Legislation and Guidelines

2.2.1. Territory Parks and Wildlife Conservation Act 1976

The *Territory Parks and Wildlife Conservation Act 1976* (TPWC Act) is the primary piece of legislation for managing the protection and conservation of biodiversity, and the sustainable use of wild populations (of predominantly terrestrial species) in the NT. The Act is administered by the NT Department of Tourism, Sport and Culture and the Department of Environment and Natural Resources (DENR) is responsible for Part IV, Divisions 1-5 which relates to animals and plants.

The TPWC Act makes provision for the study, protection, conservation and sustainable utilisation of wildlife throughout the NT. This legislation covers the classification and management of wildlife; classification and control of feral animals; permits for taking wildlife and entering land; designation and management of protected areas, including joint management with Traditional Owners; and private sanctuaries.

The management of wildlife under the TPWC Act is to be carried out in accordance with the Principles of Management (Section 31 of the TPWC Act), which promote:

> *(a) the survival of wildlife in its natural habitat;*
>
> *(b) the conservation of biological diversity within the Territory;*
>
> *(c) the management of identified areas of habitat, vegetation, ecosystem or landscape to ensure the survival of populations of wildlife within those areas;*
>
> *(d) the control or prohibition of:*
>
> > *(i) the introduction or release of prohibited entrants into the Territory; and*
> >
> > *(ii) any other act, omission or thing that adversely affects, or will or is likely to adversely affect, the capacity of wildlife to sustain its natural processes; and*
>
> *(e) the sustainable use of wildlife and its habitat.*

Under the TPWC Act, threatened flora and fauna species in the NT are classified under the following conservation categories:

- Extinct;
- Extinct in the Wild;
- Critically Endangered;

- Endangered;
- Vulnerable;
- Near Threatened;
- Least Concern;
- Data Deficient; and
- Not Evaluated.

These categories and associated assessment criteria are aligned with the classification system and criteria developed by the International Union for the Conservation of Nature for determining the conservation status of species.

Under the TPWC Act, species are considered as 'threatened' wildlife if they are classified as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable and are assigned protected wildlife status. The categories utilised under the TPWC Act are independent of the listing of wildlife under the EPBC Act as they relate only to their occurrence within the NT.

2.2.2. Weeds Management Act 2001

The *Weeds Management Act 2001* (WM Act) makes provision for the control and eradication of declared weeds in the NT. The Act is administered by the DENR.

Weeds that have been identified to have an impact on the NT's economic, environment, cultural and social values are declared under the WM Act. A weed may be declared as:

- Class A: To be eradicated;
- Class B: Growth and spread to be controlled; and
- Class C: Not to be introduced to the NT.

2.2.3. Land Clearing Guidelines 2019

The NT *Land Clearing Guidelines 2019* (DENR 2019) play a role in guiding good land development practice in the NT by establishing standards for native vegetation clearing. The guidelines recognise that decisions to clear native vegetation are significant because clearing will lead to at least some change in landscape function. The guidelines seek to manage clearing in a way that promotes the greatest possible net benefit from use of land cleared of native vegetation.

The purpose of the guidelines is to provide:

- Recommendations regarding best practice clearing of native vegetation;
- A standardised suite of environmental parameters requiring consideration; and
- Advice to consent authorities.

The guidelines aim to provide greater clarity and certainty around the acceptability of clearing applications to ensure consistent and transparent decision making. This is achieved by setting out matters for consideration in assessing applications and through applying the principles of natural justice to the process.

The guidelines are administered by the DENR. The guidelines are recognised formally under the NT *Planning Act 1999* and referenced in the NT Planning Scheme.

Mining and exploration activities are controlled by the NT *Mining Management Act 2001* rather than the *Planning Act* and mining/exploration activities are subject to a separate environmental approval process under the NT *Mining Management Act*. Mining activities within mineral licenses are not, therefore, required to formally consider the Land Clearing Guidelines.

3. Methodology

This section describes the methodology adopted for the terrestrial ecology assessment. Investigations for the assessment entailed a literature review and database assessment followed by review of previous fieldwork undertaken within the Study Area and for nearby areas of Groote Eylandt. The methods used for each component are explained in more detail in ***Section 3.1*** and ***Section 3.2***. The methodology to assess how likely a species is to occur in the Study Area and the approach to fauna habitat mapping are also described in ***Section 3.3*** and ***Section 3.4***.

3.1. Desktop Assessment

3.1.1. Database Analysis

A database analysis was conducted through consultation of the DAWE EPBC Protected Matters Search Tool (PMST) (DAWE 2020c) and the NT Natural Resource Maps (NR Maps) search facility (DNRM 2020).

The EPBC PMST generated a list of potentially occurring MNES listed species under the EPBC Act within a 20 km radius of the centre of the Study Area (i.e. the locality), which fully encompassed the Study Area (see **Appendix A**). The NR Maps search facility was used to generate records of flora and fauna, (including threatened species), known to occur within the locality. This information was used for the purposes of confirming the previous records of each species within the vicinity of the Study Area. The abundance, distribution and age of records generated within the search areas provided supplementary information to assess the likelihood of those threatened species to occur within the Study Area and Disturbance Footprint.

A map of threatened ecological communities in the NT (DSEWPaC 2013) was also consulted to determine the potential presence of threatened ecological communities within the Study Area.

3.1.2. Literature Review

Available literature on the ecology of Groote Eylandt was reviewed, including, but not limited to, in-house reports made available from GEMCO. Numerous ecological studies have been conducted within and in proximity to the Study Area, including several recent detailed flora and fauna investigations. Key documents reviewed for this terrestrial ecology report included:

- Cumberland Ecology (2020): GEMCO Western Leases and Surrounds. Vegetation Mapping Report;
- Heiniger et al. (2020): Status of mammals on Groote Eylandt: Safe haven or slow burn?;
- Cumberland Ecology (2019g): Vegetation Mapping Report. J and O Quarries and Surrounding Areas;
- Cumberland Ecology (2019e): Southern Lease Project – Baseline Terrestrial Ecology Report;
- Cumberland Ecology (2019c): GEMCO/South32 Southern Lease Small Mammal Research Project – Report;
- Anindilyakwa Land & Sea Rangers (2019): Northern Hopping Mouse Surveys: Final Report to Territory NRM July 2019
- Heiniger and Gillespie (2017): Survey of Threatened Mammal and Feral Cat Surveys on Groote Eylandt. Unpublished Report to the Anindilyakwa Land Council;

- Cumberland Ecology (2016): Southern Lease Project – Baseline Terrestrial Ecology Report;
- Cumberland Ecology (2015a): Eastern Leases Project – Terrestrial Ecology Assessment Report;
- URS Australia Pty Ltd (2012): Flora and Fauna Surveys of Western Groote Eylandt;
- G. Webb Pty Limited (1992): Flora and Fauna Surveys on the Western Side of Groote Eylandt, N.T. (1991-92);
- Brocklehurst and Cowie (1992): Flora Survey of the GEMCO Mining Lease on the Western Side of Groote Eylandt, Northern Territory; and
- Langkamp et al. (1981): Ecological gradients in forest communities on Groote Eylandt, Northern Territory, Australia.

Of these documents, Cumberland Ecology (2015a, 2016, 2019c, g, 2020) and Heiniger and Gillespie (2017) include detailed field surveys undertaken within the Study Area which forms the basis of the ecological data presented within this report. These studies are discussed in further detail in ***Section 3.2***. The other key datasets drawn upon within this assessment are from Cumberland Ecology (2019e), Anindilyakwa Land & Sea Rangers (2019), URS Australia Pty Ltd (2012) and Webb (1992). With the exception of Anindilyakwa Land & Sea Rangers (2019) and Heiniger and Gillespie (2017) which covers multiple locations on Groote Eylandt, the location of the study areas of the key datasets are shown in **Figure 5**.

Numerous other reports were consulted during the preparation of this terrestrial ecology report including those presenting the results of targeted surveys (Ward 2006b, a, 2007b, a, Firth 2008, Smith 2009, Rankmore 2011), pre-clearing/exploration surveys (Coffey Environments 2010, EMS 2013, 2014, Hansen Bailey 2016, Cumberland Ecology 2019a, b, d, f), impact assessment reports (EMS 2008, LES 2013), general reporting of species groups on Groote Eylandt (Davies and Tyler 1986, Noske and Brennan 2002) and remote sensing of vegetation (Crase and Hempel 2005). A summary of the suite of previous survey reports utilised within this assessment is provided in **Appendix B**.

A detailed review of threatened species information provided within the Threatened Species Information Sheets published by the NT Government and the Species Profiles and Threats Database published by DAWE was also undertaken as part of this assessment and is incorporated into the species descriptions and likelihood of occurrence assessment provided in **Section 6** and **Appendix H**, respectively.

Information within the reviewed literature was utilised in determining the likelihood of threatened species to occur within the Study Area and Disturbance Footprint.

3.1.3. Vegetation Mapping

A number of studies undertaken within GEMCO's mining leases included vegetation mapping components. Recently, DENR was commissioned by the ALC to undertake island-wide vegetation mapping of Groote Eylandt.

The suite of vegetation mapping information presented within the earlier vegetation mapping studies on Groote Eylandt was utilised by DENR, in conjunction with desktop assessments, additional field surveys and

Geographic Information Systems (GIS) software. An initial draft vegetation map was prepared in 2017, and included classification of vegetation into Vegetation Map Units (VMUs).

A suite of information on vegetation within the Southern Lease and surrounds, collected by Cumberland Ecology in 2017 and 2018 for the small mammal research project (2019c), was provided to DENR for incorporation into updated vegetation mapping. GEMCO also provided DENR with the aerial photography and LiDAR data collected in 2017. Incorporation of this additional data, in conjunction with further field data collected by DENR resulted in updated vegetation mapping being prepared in 2018. The vegetation mapping presented within this report outside of areas mapped by Cumberland Ecology is based on the latest available DENR vegetation mapping (i.e. prepared in 2018).

3.1.4. Aerial Photography and LiDAR

The most recent available aerial photography of the Study Area and immediate surrounds (flown by GEMCO in September 2017, May 2018 and May 2019) was utilised for this assessment. Light Detection and Ranging (LiDAR) data from the Study Area and surrounds from September 2017 was provided by GEMCO/South32 in the format of one metre contours and was also utilised for this assessment. The LiDAR data was used to assist with delineating catchments and waterways.

3.1.5. Geological Mapping

Geological mapping of the Study Area was sourced from the NT Department of Mines and Energy (2010) and further verified by GEMCO. This provided an indication of the underlying substrate which was used to inform habitat mapping.

3.1.6. Soil Mapping

Soil mapping of the Study Area was sourced from the National Resource Information Centre Digital Atlas of Australian Soils (Bureau of Rural Sciences 2016). Soils mapping was utilised to correlate vegetation types and habitat preferences of particular flora and fauna, to soil types present within the Study Area.

3.2. Field Surveys

3.2.1. Overview

Cumberland Ecology (2015a, 2016, 2019c, g, 2020) and Heiniger and Gillespie (2017) undertook field surveys within the Study Area, the results of which form the basis of the ecological data presented within this report. Detailed methods utilised by these studies is provided in **Appendix C**.

Table 1 summarises the field surveys undertaken within the Study Area. The location of flora and fauna surveys within, and in proximity to the Study Area is shown in **Figure 6** and **Figure 7**, respectively.

Table 1 Summary of field surveys within the Study Area

Study	Surveys within Study Area
Flora Surveys	
Cumberland Ecology (2015a)	• 1 secondary flora plot

Study	Surveys within Study Area
	• 13 track note points
Cumberland Ecology (2016)	• 6 primary flora plots • 110 track note points
Cumberland Ecology (2019g)	• 55 road note points • 147 rapid data points
Cumberland Ecology (2020)	• 26 rapid data points
Fauna Surveys	
Cumberland Ecology (2015a)	• 1 fauna survey site (terrestrial trapping, bird census, active search, ultrasonic call detection)
Cumberland Ecology (2016)	• 2 fauna survey sites (terrestrial trapping, bird census, active search, ultrasonic call detection); • 2 motion-sensor cameras • 1 harp trap site • Spotlighting tracks
Heiniger and Gillespie (2017)	• 2 motion-sensor camera sampling sites
Cumberland Ecology (2019c)	• 4 motion-sensor camera sampling sites

3.2.2. Vegetation Mapping

Vegetation mapping produced for this assessment utilises vegetation mapping by Cumberland Ecology (2019g, 2020) as a base, with the 2018 version of DENR's vegetation mapping used to fill in the remaining areas of the Study Area. The vegetation mapping surveys by Cumberland Ecology (2019g, 2020) included surveys specifically targeted towards the Disturbance Footprint and immediate surrounds.

The surveys within the Disturbance Footprint and immediate surrounds included a combination of driving and walking traverses and collection of data at Road Note points and Rapid Data Points (RDPs). Data collection at each Road Note point was undertaken in accordance with the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst et al. 2007). The following information was collected:

- Cover and height estimates for each stratum and for each growth form;
- Identification and recording of two to three dominant species in all strata/sub strata;
- Coordinates of each survey site using a hand-held Global Positioning System (GPS) unit; and
- Sample photograph of the assessed VMU.

At RDPs, data collected was the same data as the Road Note points, except that cover and height estimates were not recorded for growth forms. Road Note points were also used where changes to mapping were significant, such as assignment to a VMU with a different structure to that mapped by DENR.

Following completion of each round of field surveys by Cumberland Ecology (2019g, 2020), vegetation mapping was prepared. Vegetation communities were classified in accordance with the vegetation communities identified by DENR (which incorporates the Webb (1992) map units). The proposed updated vegetation maps and field survey results were provided to Dr. Nick Cuff from the NT Herbarium for review, and vegetation mapping was subsequently updated based on recommendations from Dr. Nick Cuff.

3.2.3. Targeted Surveys

During the consultation process for the project, DENR requested the following additional targeted surveys to be undertaken within the Disturbance Footprint:

- Northern Hopping-mouse spoil searches, and follow up camera surveys in the event suitable spoils are detected; and
- Surveys of large trees (>50 cm diameter at breast height), which may be suitable for use by the Masked Owl.

Cumberland Ecology undertook these targeted surveys within the Disturbance Footprint in October 2020. The surveys included traversing the width of the Disturbance Footprint and recording the following details:

- Presence of any spoils, including details on the location, size of the spoil, pop hole presence and size, and photograph.
- Presence of any large trees, including details on location and tree species.

As no suitable spoils were detected, no cameras were deployed.

The location of the targeted survey traverses are shown on **Figure 7**.

3.3. Likelihood of Occurrence Assessment

As described in ***Section 3.1.1***, database searches were undertaken to identify threatened species that are known to, or that have the potential to occur within the Study Area. The likelihood of such species occurring within the Study Area was then assessed based on the results of field surveys and the species were classified using the criteria presented in **Table 2**. The assessment was based on the species known ranges, number and age of records, and habitat preferences which were evaluated considering site characteristics observed during the field surveys.

Table 2 Criteria to assess potential for threatened species to occur within the Study Area

Likelihood to Occur	Definition
Present	The species was recorded within the Study Area during recent (2014-2019) terrestrial field surveys.
High	The species was not recorded within the Study Area during recent (2014-2019) terrestrial field surveys, but is known to occur within the surrounding area. Habitat of a similar and suitable quality is known to exist within the Study Area and it is deemed likely that the species will occur.

Likelihood to Occur	Definition
Moderate	The species was not recorded within the Study Area during recent (2014-2019) terrestrial field surveys, although it is known to occur in the wider region. Habitat was identified for the species within the Study Area during field surveys; however it is marginal, fragmented and/or small in size, or degraded.
Low	The species was not recorded within the Study Area during recent (2014-2019) terrestrial field surveys. The species is unlikely to occur due to a lack of, or limited, habitat within the Study Area, or extremely poor quality habitat within the Study Area, or no or very few recent records of the species occurring in the wider region.

In the case of the Northern Hopping-Mouse and Brush-tailed Rabbit-rat, the potential for the species to occur was also based on the wider results of Cumberland Ecology (2019c) and Heiniger and Gillespie (2017), given that these studies targeted these species in a much wider survey area surrounding the Study Area. Assessment of the Northern Hopping-mouse also considered the results of Anindilyakwa Land & Sea Rangers (2019), given that this study targeted this species across Groote Eylandt.

3.4. Fauna Habitat Mapping

Habitat types of the Study Area were developed based on the following:

- Vegetation mapping developed by Cumberland Ecology (2019g, 2020) and supplemented with the 2018 version of DENR's vegetation mapping;
- Observations made during recent (2014-2019) terrestrial surveys of the Study Area.
- Review of landform and vegetation structure.

The combined vegetation mapping (comprising Cumberland Ecology (2019g, 2020) and the 2018 version of DENR's vegetation mapping) provided a good starting point to model fauna habitat within the Study Area. The VMUs identified in the vegetation mapping were initially assessed to determine their alignment to the habitat types. Areas that were mapped as comprising combined VMUs, were assigned to the habitat type of the dominant VMU. As some VMUs comprised multiple habitat types, each individual polygon of mapped vegetation was assessed against recent available aerial imagery (September 2017, May 2018 and May 2019), 1 m contour data, geological mapping and mapping of white rock. Where polygons appeared to contain more than one habitat type, it was assigned to the dominant habitat type.

The fauna habitat mapping prepared for this assessment delineates the major types of habitats within the Study Area, many of which are relevant to the threatened species known or potentially occurring within the Study Area. The results of fauna habitat mapping are discussed in **Chapter 6**.

3.5. Assessment of Significance

Assessments of Significance were undertaken for threatened or migratory fauna species listed under the EPBC Act that are present or have a moderate or high potential to occur in the Disturbance Footprint. Assessments of Significance are threshold tests of significance prepared according to the *Matters of National Environmental*

Significance Significant Impact Guidelines 1.1 (DotE 2013b) (hereafter referred to as the 'Significant Impact Guidelines'). Assessment in accordance with the Significant Impact Guidelines were undertaken to gauge the significance of predicted impacts to threatened and migratory species. The guidelines are designed specifically to determine whether an activity is considered, under the EPBC Act, to have a significant impact on the species.

3.6. Limitations

No significant limitations to recent terrestrial surveys and habitat mapping were identified. As noted above, this assessment utilises information collected during recent terrestrial field surveys by Cumberland Ecology (2015a, 2016, 2019c, g, 2020) and Heiniger and Gillespie (2017), as well as relevant findings of numerous previous surveys conducted over several years and in all seasons in nearby areas with the same or very similar habitats. Moreover, as the aforementioned studies included collection of data within the Study Area and Disturbance Footprint, this provides a high degree of confidence in the mapping of vegetation communities and broad fauna habitats.

3.6.1. Flora

Vegetation mapping surveys were undertaken within the Disturbance Footprint and surrounding areas by Cumberland Ecology (2019g, 2020). The most recent DENR vegetation mapping has been used for any areas outside of the project-specific mapping that was completed. Whilst the most recent DENR vegetation mapping is considered to be largely representative of the Study Area, there may be locations where actual vegetation differs to what has been mapped due to:

- The scale of DENR's island-wide mapping (1:50,000) which may not pick-up narrow ecotonal areas or small patches of vegetation communities; and
- Differences in vegetation composition which may not be picked-up on aerial imagery for map units that are structurally similar. This is particularly the case for different *Melaleuca* dominated VMUs that differ slightly based on the relative dominance of grasses, sedges or ferns in the ground layer.

Notwithstanding these potential discrepancies, the combination of mapping prepared by Cumberland Ecology and DENR is considered the most accurate mapping available for the Study Area.

3.6.2. Fauna

Recent terrestrial fauna surveys by Cumberland Ecology (2015a, 2016, 2019c) and Heiniger and Gillespie (2017), were successful in detecting a wide range of vertebrate fauna, particularly birds, bats and non-flying mammals. It is likely that if additional field sampling was undertaken within the Study Area, more species may be identified, in particular frogs, reptiles and birds.

The data produced by the surveys are intended to be indicative of the types of species that could occur and are not an absolute census of all vertebrate fauna species occurring within the Study Area. Due to the design of the Cumberland Ecology (2019c) and Heiniger and Gillespie (2017) surveys which targeted terrestrial mammals, the assemblage of terrestrial mammals within the Study Area is considered to be well known.

As well as providing an overall census of the vertebrate fauna recorded within the Study Area, the recent terrestrial survey by Cumberland Ecology (2015a, 2016, 2019c) and Heiniger and Gillespie (2017), also targeted several of the threatened species predicted to occur.

3.6.3. Habitat Mapping

The threatened or migratory species for which habitat was mapped have varying habitat requirements. Some species, such as the Northern Quoll (*Dasyurus hallucatus*) occur within all terrestrial habitats on the island. Others such as Mertens' Water Monitor (*Varanus mertensi*) are much more specific in their preference for habitats, and are known to forage along streams and in riparian vegetation.

The most recent DENR vegetation mapping, in conjunction with field observations, and desktop review, is considered adequate to provide a basis for the habitat types within the Study Area.

4. Results: Overview of Environmental Values

This chapter provides an overview of the environmental values of the Study Area and surrounds, including information on landform, geology, soils, land systems, hydrology and vegetation.

4.1. Geology

Groote Eylandt was formed on a stable basement of Proterozoic quartzite. This basement quartzite forms extensive elevated outcrops in the centre of the island.

A blanket of Cretaceous marine sediments was subsequently deposited over the paleosurface of basement and reworked basement materials in the west of the island. The distribution of the Cretaceous marine sediments is generally confined to the western plains and valleys of the island. The upper Cretaceous sediments contain the manganese ore.

The manganese ore is a sedimentary layer, consisting of manganese strata occurring between clay and sand beds.

Much of the Cretaceous sediment profile (including some of the manganese ore) has been extensively modified by a long period of tropical weathering (or laterisation) during the Tertiary period. This has resulted in the development of thick laterite profiles up to 25 m thick.

The surface geology of the Study Area is shown in **Figure 8**, and includes Quaternary sediments, Tertiary laterite/lateritic clay, Cretaceous sediments and Proterozoic sediment (which represents the geological basement in this area). The surface geology strongly influences vegetation composition across the Study Area, as the geological surface erodes to provide sandy, relatively infertile soils, typically suitable only for native vegetation types, such as Eucalypts, Melaleucas and Cypress.

4.2. Soils

Broad scale soils mapping for the Study Area is shown in **Figure 9**, and **Table 3** provides a summary of the four soil mapping units occurring within the Study Area (Bureau of Rural Sciences 2016) . The soil mapping indicates that the Study Area is predominatly plains of sandy yellow earths with some ironstone gravels. Coastal soils are located near the western boundary of the Study Area in proximity to the coastline.

Table 3 Soil units recorded within the Study Area (Bureau of Rural Sciences 2016)

Unit	Description	Study Area	
		Area (ha)[1]	%
AC15	Plains with some incised streams and some flat valleys and spillways subject to local flooding: chief soils are yellow earthy sands with sandy yellow earths, both may contain some ironstone gravels.	2,005.6	69.4
BA10	Dissected sandstone plateau of high, stony, often steep-sided hills; large areas of bare rock outcrop: chief soils are shallow gritty and stony sands. Other soils may occur.	53.7	1.9

Unit	Description	Study Area	
		Area (ha)[1]	%
B34	Coastal dune systems generally consolidated but with many mobile areas; sometimes with a central core of limestone or ancient coral: chief soils are siliceous sands.	544.5	18.8
MY77	Gently sloping terrain: chief soils are neutral red and acid red earths, some of which contain moderate to large amounts of ironstone gravel; some of these gravels are highly manganiferous. Small areas of soils common to unit AC15 occur also.	75.5	2.6
Unmapped		209.5	7.3

1. Areas are considered approximate due to broadscale nature of the mapping, which does not accurately match the coastline.

4.3. Land Systems

Land systems within the NT have been mapped and described by the NT Department of Land Resource Management (Lynch et al. 2012). Seven land systems are recognised in the Study Area as detailed in **Table 4** and the extent of the land systems are shown in **Figure 10**. The land systems support different types of vegetation, and provide important habitat for a broad range of plant and animal species.

Table 4 Land systems within the Study Area (Lynch et al. 2012)

Landform	Indicated Soil Types	Vegetation
Beach ridge plains and chenier plains Land System: Blue Mud	Deep siliceous sands and shelly lithosols	Mid high open woodland (*Acacia auriculiformis, Acacia hemignosta, Melaleuca nervosa* and *Casuarina equisetifolia*)
Sandy colluvial footslopes below elevated quartz sandstone plateaux Land System: Bundah	Siliceous sands and shallow sandy skeletal soils	Tall open woodland of *E. tetrodonta, E. miniata, Callitris intratropica, C. polycarpa* over tropical tall grass (*Heteropogon triticeus, Chrysopogon fallax, Sorghum* spp)
Level to gently undulating alluvial floodplains of dominantly sandy alluvium Land System: Effington	Uniform gradational and texture contrast sandy soils	Mid-high woodland of *Melaleuca viridiflora, C. polycarpa, Melaleuca nervosa, E. bigalerita, C. latifolia* over *Chrysopogon fallax, Pseudopogonatherum spinescens, Eriachne triseta*
Rugged dissected plateaux on quartz sandstone Land System: Groote	Bare rock and shallow lithosols	Mid-high open woodland of *E. tetrodonta, C. ferruginea, E. miniata, C. bleeseri, E. tectifica* over a sparse to mid-dense grass cover (*Heteropogon triticeus, Chrysopogon fallax, Sorghum* spp)

Landform	Indicated Soil Types	Vegetation
Level tidal flats with channels and estuaries and minor dunes Land System: Littoral 1	Saline muds and grey cracking clays	Samphire, sedgeland, or mangrove low closed forest
Gently undulating sandplains Land System: Queue	Deep red earthy sands	Mid-high woodland of *E. tetrodonta, E. miniata, C. bleeseri*, *Callitris intratropica* over tall tropical grass (*Heteropogon triticeus*, *Chrysopogon fallax*, *Sorghum* spp)
Level to gently undulating plains Land System: Yarrawirrie	Red earths and red siliceous sands	Low open woodland of dwarfed *E. tetrodonta* over *Chrysopogon fallax, Setaria apiculata*, *Schizachyrium fragile*

4.4. Hydrology

The Study Area includes the catchment of the Emerald River. The Emerald River and its tributaries drain the majority of the Study Area (**Figure 11**). The Emerald River is primarily spring-fed, maintaining flows all year round. Water quality is generally very good, typical of a pristine environment. The Southern Tributary starts as a defined gully before forming a wide overland floodplain that eventually connects with the main channel of the Emerald River, near the mouth of the river. The Southern Tributary can maintain waterholes in its upper reaches for several months following the end of the wet season, however, it is highly ephemeral in the vicinity of the project site. The western extent of the Study Area comprises the coastline of the island, and includes the mouth of the Emerald River as it flows into the Gulf of Carpentaria.

4.5. Vegetation

The vegetation across the Study Area comprises areas of rehabilitated mine areas, disturbed remnant vegetation and undisturbed remnant vegetation. In the north of the Study Area, rehabilitated vegetation occurs in the vicinity of the existing GEMCO mine. Disturbed remnant vegetation occurs in areas where exploration activities have occurred. The remaining vegetation is remnant.

A range of broad vegetation types occur within the Study Area, including woodlands, open forests, wetlands, estuarine vegetation and coastal strand vegetation. All areas of remnant vegetation are in good condition and are characterised by a high species and structural diversity. The structure of the understorey and the condition of the ground layer has been modified by a very frequent fire regime.

Due to the remnant vegetation status of the majority of the Study Area, and the absence of broad scale vegetation clearing, habitat connectivity in the landscape is excellent. The Study Area provides linkages with remnant vegetation to the north, east and south that can be utilised by fauna species to connect to adjacent areas of habitat. The Study Area provides a range of habitats for fauna species, including watercourses and wetlands, rocky outcrops and extensive areas of woodland and open forest.

The Study Area is regularly burnt by the Traditional Owners, which has resulted in a reduction in the amount of woody debris, and is also likely to have affected the species composition and structure of the vegetation.

Some species are highly sensitive to changes in fire regime, and it is likely that this may have influenced the suite of species that are present within the Study Area.

4.6. Land Uses

The Study Area comprises a matrix of land uses, including active mining areas, exploration areas, access roads/tracks, an outstation, recreational swimming area and natural vegetation. The active mining areas are located in the northern portion of the Study Area and are predominantly cleared, with some areas of mine rehabilitation also present. Exploration activities have been undertaken at numerous locations within the Study Area, including the areas immediately surrounding active mining (ML960), and within ML961 and the Southern Lease (EL2455). The Emerald River Road extends in a north-south direction in the eastern portion of the Study Area and provides access to country for Traditional Owners, as well as access for exploration activities within the Southern Lease. A public access track connects the Emerald River Road to the coastline, via the Yedikba outstation. Numerous informal tracks are present along the coastline. The land within and surrounding the Study Area comprises natural bushland. No farming or agriculture activities are undertaken in the vicinity of the Study Area; however the vegetation is regularly burnt by the Traditional Owners.

Historically, the area was also the site of the former Emerald River Mission and associated Emerald River Cemetery. The mission was established by the Anglican Church Missionary Society and operational between the 1920s-1940s, and was the first settlement on Groote Eylandt (Department of Natural Resources, Environment, the Arts and Sport 2011). Although structures relating to the mission no longer remain, the location is now utilised as an Outstation. The Emerald River Cemetery was associated with the Emerald River Mission, and contains a number of gravestones. The Emerald River Road was also used as an airfield during World War II. Given it hasn't been used for approximately 70 years, the vegetation surrounding the original airfield has regenerated and there is little evidence remaining.

5. Results: Flora

This chapter provides an overview of the flora of the Study Area and surrounds, including information on vegetation communities, general flora species and threatened flora species.

5.1. Vegetation Communities

The vegetation community patterns within the Study Area strongly reflect the geology, soils, topography, and the impacts of frequent fires. Rocky sandstone hills are often sparsely vegetated by woodlands (depending on the depth of soil formed on the sandstone), but also include open forests. Gently undulating, well-drained sand plains are typically forested. On flatter, low relief areas forests give way to woodlands, swamps and sedgelands (depending on drainage). *Callitris intratropica* (Northern Cypress Pine) forms thickets in places and are prevalent where the sand plains meet the rocky hillsides. Riparian forests and woodland occur along permanent and seasonal streams and adjacent floodplains and include seasonal wetlands. Rainforests and vine thickets occur in areas protected from fires and as such are generally found in the lee of sand dunes and in riparian areas where there is permanent seepage. Coastal vegetation varies in structure depending on the degree of coastal exposure.

The most extensive vegetation communities within the Study Area comprise open woodlands to open forests dominated by *Eucalyptus tetrodonta* (Darwin Stringybark), which occur on both gently undulating sandy and lateritic soils, as well as within rocky sandstone areas. Within sandy and lateritic areas, *Eucalyptus miniata* (Darwin Woollybutt) is locally common in some areas and more rarely *Corymbia polycarpa* (Long-fruited Bloodwood) is also co-dominant. Alluvial woodlands also include *Corymbia bella* (Ghost Gum), *Corymbia polycarpa* (Long-fruited Bloodwood) *Eucalyptus bigalerita* (Northern Salmon Gum) and *Erythrophloem chlorostachys* (Cooktown Ironwood). *Eucalyptus miniata* (Darwin Woollybutt) also occurs within rocky sandstone areas, along with *Callitris intratropica* (Northern Cypress Pine), *Corymbia polycarpa* (Long-fruited Bloodwood) and *Corymbia kombolgiensis* (Scarp Gum). *Callitris intratropica* (Northern Cypress Pine) can occur as small stands dominated by the species, or as scattered individuals within *Eucalyptus tetrodonta* (Darwin Stringybark) forests. *Melaleuca*-dominated vegetation occurs within the riparian zones and wetlands within the Study Area, and is often dominated by *Melaleuca viridiflora* (Broad-leaved Paperbark), *Melaleuca leucadendra* (Weeping Paperbark), and/or *Melaleuca cajuputi* (Swamp Tea Tree), with *Pandanus spiralis* (Common Screwpine) being common in the midstorey. A number of permanent and seasonal wetlands occur within the Study Area including sedge wetlands dominated by *Lepironia* spp., *Dapsilanthus* spp. and *Eleocharis* spp., and Paperbark dominated wetlands of *Melaleuca viridiflora* (Broad-leaved Paperbark) and/or *Melaleuca cajuputi* (Swamp Tea Tree). Coastal areas within the Study Area comprise a mix of low and tall mangroves, shrublands, grasslands, sedgelands, monsoon vine thickets and open woodlands in dune swales dominated by a mix of *Melaleuca* species.

Vegetation mapping produced for this assessment utilises vegetation mapping by Cumberland Ecology (2019g, 2020) as a base, with the 2018 version of DENR's vegetation mapping used in any remaining areas of the Study Area. This mapping has identified over 60 individual VMUs or combination VMUs. Combination VMUs are represented by areas where two VMUs are intermingled and therefore are unable to readily split into discrete areas. The first VMU listed in a combination VMU represents the dominant VMU. A detailed list of the individual VMUs or combination VMUs occurring within the Study Area and Disturbance Footprint is provided in **Appendix D**.

Due to the complexity of the vegetation mapping, which has resulted in a high number of VMUs and combination VMUs, the units have been grouped together to form broad vegetation types. These broad vegetation types were grouped based on consultation and endorsement from DENR. For combination VMUs, the assigned broad vegetation type is representative of the dominant VMU. **Table 5** summarises the broad vegetation types within the Study Area. The broad vegetation types for the Study Area are shown in **Figure 12**.

Cumberland Ecology (2015b) developed vegetation profiles containing descriptions and photographs of VMUs. Profiles of the VMUs occurring within the Disturbance Footprint are provided in **Appendix E**.

Table 5 Broad vegetation types within the Study Area

Broad Vegetation Types	Corresponding VMUs	Study Area	
		Area (ha)	%
1: Mangrove	1	96.3	3.3
3: Dry closed forests or thickets (rainforest) on sand or sandstone	2, 62	83.5	2.9
4: Riparian and gully closed forests with mixed canopies (rainforest and Melaleuca spp.)	5, 18	76.2	2.6
5: Eucalypt open forests of lowlands and deeper sandy soils derived from sandstone or deeply weathered parent rocks (lateritic)	10, 10a, 12, 31	941.7	32.6
7: Eucalypt open forests and woodlands of sandstone uplands	10b, 11	276.3	9.6
8: Callitris open forest	15	30.9	1.1
9: Melaleuca open forests on alluvial plains and drainage systems	17, 19	54.5	1.9
10: Melaleuca swamps	22, 23	29.4	1.0
11: Eucalypt woodlands and open woodlands of lowlands with sandy soils	40, 40a, 59	417.5	14.5
12: Eucalypt woodland and open woodlands on shallow soils associated with basement geologies	13, 53	16.4	0.6
13: Eucalypt woodlands on alluvial soils	42, 45, 51, 51a, 51b, 51c	265.4	9.2
15: Callitris woodland and open woodland	41	26.6	0.9
16: Melaleuca woodlands on alluvial soils (wet)	26, 28, 44, 52	138.0	4.8
17: Melaleuca woodlands on sandy soils (dry)	27a, 27b	4.3	0.1
18: Melaleuca open woodlands on alluvial soils (wet)	43	17.9	0.6
20: Eucalypt low open woodland	46	8.6	0.3
21: Shrublands on quaternary sand	72, 82a	18.9	0.7
25: Tussock grasslands on Quaternary sand	82, 82a	23.4	0.8

Broad Vegetation Types	Corresponding VMUs	Study Area	
		Area (ha)	%
26: Sedge wetlands	80, 81b, 84, 88	16.9	0.6
29: Saline tidal flats and shrublands	75, 100	2.0	0.1
30: Strand complex	90	1.8	0.1
33: Cleared/disturbed/regrowth	200, 201, 202	91.1	3.2
34: Water/ocean	500	243.8	8.4
36: Eucalypt and/or Melaleuca open forest/vine thicket complex	20, 21, 30	7.4	0.3
Total[1]		**2,889**	**100**

1. In some cases totals may not equal the appropriate total number due to rounding.

5.2. Threatened Ecological Communities

The EPBC Act PMST did not record any TECs as occurring or potentially occurring within a 20 km radius of the centre of the Study Area (see **Appendix A**). The map of EPBC Act listed TECs in the NT (DSEWPaC 2013) does not show the occurrence of any TECs within the Study Area, or on Groote Eylandt.

Only one ecological community that occurs in the NT is listed as Endangered under the Commonwealth EPBC Act. This is the *Arnhem Plateau Sandstone Shrubland Complex*, however this TEC does not occur on Groote Eylandt.

Considering the above, it is concluded that no TECs occur in the Study Area. TECs are therefore not considered or assessed further in this report.

There is currently no mechanism for listing TECs under NT legislation. Therefore, the TPWC Act does not contain listings for TECs and are therefore not assessed further in this report.

5.3. Flora Species: Overview

Over 190 plant species have been recorded within the Study Area by Cumberland Ecology (2015a, 2016, 2019g, 2020). The data indicated that the floristic assemblage across the Study Area is very similar to the assemblage recorded in the Eastern Leases and Southern Lease and is well represented by Poaceae (grasses), Fabaceae (Acacias and peas), Cyperaceae (sedges) and Myrtaceae (*Eucalyptus spp.* and *Melaleuca spp.*). A list of flora species that have been recorded within the Study Area by Cumberland Ecology is presented in **Appendix F**.

5.3.1. Declared Weeds

Cumberland Ecology (2020) recorded one declared weed within the Study Area, *Hyptis suaveolens* (Hyptis). The records of this species are located in the north eastern portion of the Study Area in an area previously subject to exploration activities and in proximity to an active mining area.

The NR Maps database (DNRM 2020) holds a number of records within the existing GEMCO mine, such as *Jatropha gossypiifolia* (Bellyache) (approximately 8.5 km north of the Study Area) and *Themeda quadrivalvis* (Grader Grass) (approximately 7.5 km north of the Study Area) which are highly mobile. Within the Study Area, the NR Maps database (DNRM 2020) holds records for *Delonix regia* (Poinciana), *Merremia dissecta* (White Convolvulus Creeper), *Passiflora foetida* (Stinking Passionflower), *Tamarindus indica* (Tamarind).

Weeds recorded by Cumberland Ecology (2020) nearby but outside of the Study Area included *Hyptis suaveolens* (Hyptis), *Stachytarpheta cayennensis* (Snakeweed) and *Sida cordifolia* (Flannel Weed). A number of other declared weeds have been also previously been recorded within GEMCO's existing mining tenement, including *Cenchrus echinatus* (Mossman River Grass), *Cenchrus polystachios* (Mission Grass), *Senna obtusifolia* (Sicklepod) and *Sida acuta* (Spinyhead Sida) (URS Australia Pty Ltd 2012). Weeds that are more common in the existing mining tenements include *Hyptis suaveolens*, *Passiflora foetida* (Stinking Passionflower), *Urochloa mosambicensis* (Sabi Grass) and *Stylosanthes* spp. (the Stylos) (Addison 2013).

5.4. Flora Species: Threatened Species

No threatened flora species were recorded within the Study Area during recent terrestrial surveys undertaken by Cumberland Ecology (2015a, 2016, 2019g, 2020).

An analysis of ecological databases was conducted for the locality, including interrogation of the DAWE EPBC PMST (DAWE 2020c) and NR Maps search facility (DNRM 2020) for threatened flora records. The results of the PMST search are presented in **Appendix A**, and the records held within the NR Maps database are shown on **Figure 13**.

Database records did not identify the presence of any threatened flora species within the locality.

6. Results: Fauna

This chapter provides an overview of the fauna of the Study Area and surrounds, including information on fauna habitats, general fauna species and threatened fauna species.

6.1. Fauna Habitats

The Study Area contains extensive areas of remnant vegetation which provide a range of habitats for fauna species. The matrix of fauna habitats within the Study Area occur within the various vegetation communities, topographical formations and water resources (permanent and ephemeral). The habitat features are numerous and provide potential foraging, shelter and breeding opportunities for a suite of fauna species. Key habitats identified within the Study Area include:

- Closed forest (rainforest) habitats;
- Laterite woodland and forest habitats;
- Sandstone woodland and forest habitats;
- Coastal dune/swale complex habitats;
- Riparian/wetland habitats; and
- Estuarine complex habitats.

The extent of these habitats within the Study Area is summarised in **Table 6** and shown in **Figure 14**. Each of these habitats is discussed below.

Table 6 Fauna habitats within the Study Area

Habitat Type	VMUs[1]	Study Area	
		Area (ha)	%
Riparian/wetland habitats	17, 18, 19, 20, 21, 22, 23, 26, 27b (part), 28 (part), 43, 44, 45 (part), 52, 60 (part), 84	305.9	10.6
Laterite woodland and forest habitats	10 (part), 10a (part), 10b (part), 11 (part), 12 (part), 13 (part), 15 (part), 27a, 30 (part), 31, 31a (part), 40 (part), 40a, 41 (part), 42 (part), 45 (part), 46, 51, 51a, 51b, 51c (part), 53, 59	1,872.5	64.8
Sandstone woodland and forest habitats	10 (part), 10a (part), 10b (part), 11 (part), 12 (part), 13 (part), 15 (part), 40 (part), 41 (part), 42 (part), 45 (part), 51c (part), 70	72.0	2.5
Closed forest (rainforest) habitats	2, 5	91.8	3.2
Coastal dune/swale complex habitats	14, 27b (part), 28 (part), 30 (part), 31a (part), 60 (part), 62, 72, 82, 82a, 90	65.9	2.3
Estuarine complex habitats	1, 75, 80, 81b, 88, 100	101.3	3.5
Cleared	200, 201, 202	135.7	4.7

Habitat Type	VMUs[1]	Study Area	
		Area (ha)	%
Water	500, water, ocean	243.8	8.4
Total[2]		**2,889**	**100**

1. VMUs comprising more than one habitat type are labelled as '(part)' (see Section 3.4).

2. In some cases totals may not equal the total number due to rounding

6.1.1. Riparian/Wetland Habitats

Riparian/wetlands habitats cover approximately 11% of the Study Area (**Table 6**). This habitat type is interspersed throughout the Study Area predominantly along the Emerald River and the Emerald River Southern Tributary (**Figure 14**).

This habitat type is associated with the Emerald River and Emerald River Southern Tributary. Of these, the Emerald River is perennial and flows during the dry season. The upper reaches of both of these watercourses are ephemeral. These upper reaches flow during the wet season, however all but the deepest pools dry out during the dry season. This habitat type also includes permanent and seasonal wetlands within the Study Area, the latter of which form in the wet season and dry out over the course of the dry season. Riparian/wetland habitats are typically dominated by *Melaleuca viridiflora* (Broad-leaved Paperbark), *Melaleuca leucadendra* (Weeping Paperbark) and/or *Melaleuca cajuputi* (Cajuput Tree), and often includes a dense shrub layer with sedges also common in the ground layer. Areas of this habitat type are occasionally burnt by the Traditional Owners, with wetter areas being less easily burnt.

The riparian/wetland areas provide numerous habitat features that would be suitable for a suite of fauna species. Habitat features within this habitat type include a diversity of grasses for seed-eating species, a shrubby understorey for birds and taller eucalypt trees. Hollow bearing trees of varying sizes are present in the structurally diverse riparian areas. The tree hollows provide shelter, roosting and nesting habitat for a number of fauna species. The riparian areas contain woody debris, standing trees, macrophytes and fringing vegetation such as reeds and rushes. They are likely to provide suitable habitat for a range of amphibians and waterbirds, including migratory wetland birds. Any freshwater habitats occurring within the Study Area would be restricted mainly to remnant pools isolated by dry river or stream beds. These temporary pools of water would provide a valuable drinking source in hot and dry months. The seasonal wetlands form short-lived seasonal swamps supporting sedges, rushes and grasses.

Fauna species recorded within this habitat type during recent terrestrial surveys by Cumberland Ecology (2016, 2019c) included the Northern Brown Bandicoot (*Isoodon macrourus*), Agile Wallaby (*Macropus agilis*), Grassland Melomys (*Melomys burtoni*), Gilbert's Dragon, Sand Goanna (*Varanus gouldii*), Torresian Crow (*Corvus orru*), Peaceful Dove (*Geopelia striata*) and Buff-banded Rail (*Gallirallus philippensis*).

Features of this habitat type are summarised in **Table 7**. An example of riparian habitat and a seasonal wetland within the Study Area is shown in **Photograph 1** and **Photograph 2**, respectively.

Table 7 Features of riparian/wetland habitats within the Study Area

Feature	Comment
Area	Covers approximately 11% of Study Area
Physiographic location	Along watercourses and low-lying depressions
Soils	Brownish black to dark black sandy clay loams to silty loams
Water	Associated with permanent or seasonally flowing watercourses, and seasonally wet depressions
Fire	Larger, perennial sections of watercourses provide protection against fires, but most smaller seasonal watercourses support riparian vegetation that is regularly burnt
Tree hollows and fallen logs	Large trees with hollows present along larger watercourses
Key microhabitats	- Watercourses/water - Forest canopy, supporting a diversity of tree and shrub types - Riparian and aquatic plants present
Values for wildlife	Water resources plus diversity of plant food resources

Photograph 1 Riparian habitat within the Study Area (April 2019)

Photograph 2 Wetland habitat within the Study Area (October 2018)

6.1.2. Laterite Woodland and Forest Habitats

Laterite woodland and forest habitats cover approximately 65% of the Study Area (**Table 6**). This habitat type is dominant within the Study Area (**Figure 14**).

This habitat type is associated with the undulating laterite plains within the Study Area. This habitat type varies structurally between open woodland and open forest. At some locations, which are likely in areas where the water table is close to the surface, the canopy stratum is expressed as a shrub layer of stunted or regenerating trees. Laterite woodland and forest habitats are typically dominated by a canopy of *Eucalyptus tetrodonta,* with *Eucalyptus miniata* being locally common at some locations. *Corymbia polycarpa* and *Callitris intratropica* also occur within this habitat type. Areas of this habitat type are frequently burnt by the Traditional Owners.

The extensive areas of laterite woodland and forest habitats provide numerous important habitat features that would be suitable for a suite of fauna species, including a number of the threatened fauna known or predicted to occur within the Study Area (see ***Section 6.3***). Habitat features within this habitat type include a diversity of grasses for seed-eating species, a shrubby understorey for birds and taller eucalypt trees. Hollow bearing trees of varying sizes are present in these areas, however these features are largely absent from low open woodlands. The tree hollows and stags within the Study Area provide shelter, roosting and nesting habitat for a number of arboreal fauna species, including microbats and gliders, diurnal birds, owls and some reptiles. Terrestrial features such as fallen logs, debris and leaf litter provide shelter for many of the small to medium sized terrestrial fauna species known from the Study Area (see ***Section 6.2***). However, there is also a paucity of coarse woody debris on the ground due to the frequency of fire.

Fauna species recorded within this habitat type during recent terrestrial surveys by Cumberland Ecology (2016, 2019c) included the Northern Quoll (*Dasyurus hallucatus*), Northern Brown Bandicoot (*Isoodon macrourus*), Delicate Mouse (*Pseudomys delicatulus*), Sand Goanna (*Varanus gouldii*), Gilbert's Dragon (*Lophognathus gilberti*), Frilled Lizard (*Chlamydosaurus kingii*), Torresian Crow (*Corvus orru*) and Australian Owlet-nightjar (*Aegotheles cristatus*). Feral cats (*Felis catus*) have also been recorded within this habitat type.

Features of this habitat type are summarised in **Table 8**. An example of laterite woodland and forest habitat within the Study Area is shown in **Photograph 3**.

Table 8 Features of laterite woodland and forest habitats within the Study Area

Feature	Comment
Area	Covers approximately 65% of Study Area
Physiographic location	Gently undulating lateritic plains
Soils	Dark brown to reddish brown loamy sands (open forests) and brownish black loamy sands to whitish/red sands (open woodland). Some areas with gravel present
Water	Well drained, relatively dry habitats. Some areas of low open woodland may be associated with shallow groundwater or seasonal flooding
Fire	Frequently and extensively burnt (annually or biennially)
Tree hollows and fallen logs	Large trees with hollows and fallen logs typically present
Key microhabitats	Woodland or forest canopy, subcanopy, shrub layer and grassy ground stratum well developed
Values for wildlife	- Diverse array of plant food resources, hollow-bearing trees, fallen logs, termite mounds - Some woodland has well developed grass and sedge areas

Photograph 3 Laterite woodland and forest habitat within the Study Area (October 2019)

6.1.3. Sandstone Woodland and Forest Habitats

Sandstone woodland and forest habitats cover approximately 2% of the Study Area (**Table 6**). This habitat type occurs in the eastern portion of the Study Area (**Figure 14**).

This habitat type is associated with the sandstone plateaus and rocky outcropping within the Study Area. This habitat type is predominantly a woodland and forest structure. Sandstone woodland and forest habitats have a mixed canopy and include *Eucalyptus tetrodonta*, *Eucalyptus kombolgiensis*, *Callitris intratropica* and *Corymbia polycarpa*. *Cycas arnhemica* is also common within this habitat type.

These areas provide high quality habitat for mammals and reptiles (shelter habitat in the form of rocky outcrops, rock slabs, cracks, crevices, and caves). Sandstone woodland and rock outcrops are considered to provide high quality habitat for the Northern Quoll (*Dasyurus hallucatus*), in particular for denning and shelter.

Fauna species recorded within this habitat type during recent terrestrial surveys by Cumberland Ecology (2016, 2019c) included the Northern Quoll (*Dasyurus hallucatus*), Northern Brown Bandicoot (*Isoodon macrourus*), Delicate Mouse (*Pseudomys delicatulus*), Short-eared Rock-wallaby (*Petrogale brachyotis*), Common Rock-rat (*Zyzomys argurus*), Common Sheathtail-bat (*Taphozous georgianus*), Olive Python (*Liasis olivaceus*) Short-beaked Echidna (*Tachyglossus aculeatus*), Black-headed Monitor (*Varanus tristis*) and Australian Owlet-nightjar (*Aegotheles cristatus*). Feral cats (*Felis catus*) were also recorded within this habitat type.

Features of this habitat type are summarised in **Table 9**. An example of the sandstone woodland and forest habitat in the Study Area is shown in **Photograph 4**.

Table 9 Features of sandstone woodland and forest habitats within the Study Area

Feature	Comment
Area	Covers approximately 2% of Study Area
Physiographic location	Sandstone hills, plateaus and rocky outcropping
Soils	Shallow, if non-existent, gravelly and often rocky clayey sand over quartz sandstone with minor Leptic Rudosols
Water	Water is scarce - though may be present amid deeper rock outcrops
Fire	Relatively unburnt
Tree hollows and fallen logs	Few trees with hollows typically present
Key microhabitats	Various shelters amid rocks including crevices, caves and boulder piles
Values for wildlife	Rocky shelters providing refugia from heat and fire, diversity of plant food resources

Photograph 4 Sandstone woodland and forest habitat immediately to the south of the Study Area (August 2018)

6.1.4. Closed Forest (Rainforest) Habitats

True closed forest (rainforest) habitats cover 3% of the Study Area (**Table 6**). This habitat type is present at a number of scattered locations within the Study Area, including within coastal areas and along the Emerald River (**Figure 14**).

The relative rarity of rainforest in the Study Area is, to a large extent, due to the prevalence of fires, which regularly impact most of the island. Closed forest (rainforest) habitats occur in restricted unburnt areas, at the coastal fringe and along some riparian areas. Some other areas of vegetation within the Study Area contain elements of rainforest in the understorey, however these have not been included in the closed forest (rainforest) habitat type as they do not form closed forests. At coastal locations, closed forest (rainforest) habitats occur in sheltered areas just beyond the coastal dune/swale complex habitats. At inland locations, closed forest (rainforest) habitats occur at sheltered locations in proximity to the larger watercourses where the stream flow is perennial and in areas fed by seepage from adjacent wetlands.

Closed forest includes canopy of *Pouteria sericea* (Wild Prune), *Diospyros maritima* (Sea Ebony), *Aglaia brownii* (Coastal Boodyarra), *Drypetes deplanchei* (Yellow Tulipwood), *Celtis philippensis* (Celtis), *Alstonia actinophylla* (Milkwood), *Canarium australianum* (Mango Bark) and *Melaleuca leucadendra* (Weeping Paperbark), some of which form large hollows. As closed forest is associated with moderate to high moisture (or mesic) conditions and reliable water, it is likely to support a different assemblage of fauna to other habitats in the Study Area.

Fauna species recorded within this habitat type during recent terrestrial surveys by Cumberland Ecology (2016, 2019c) included the Northern Brown Bandicoot (*Isoodon macrourus*), Grassland Melomys (*Melomys burtoni*), Agile Wallaby (*Macropus agilis*), Water Rat (*Hydromys chrysogaster*), Orange-footed Scrubfowl (*Megapodius reinwardt*), Emerald Dove (*Chalcophaps indica*), Sand Goanna (*Varanus gouldii*) and Short-beaked Echidna (*Tachyglossus aculeatus*).

Features of this habitat type are summarised in **Table 10**, and a photograph of the closed forest (rainforest) habitat within the Study Area is shown in **Photograph 5**.

Table 10 Features of close forest (rainforest) habitats within the Study Area

Feature	Comment
Area	Covers approximately 3% of Study Area
Physiographic location	Small pockets protected from fires, coastal areas, riparian areas, spring-fed areas, seepage areas
Soils	High proportion of surface rocks and gravel, with organic material and debris on the rock surface
Water	Associated with permanent water, shallow groundwater, spring-fed locations, seepage areas
Fire	Unburnt
Tree hollows and fallen logs	Large trees with hollows typically present

Key microhabitats	Forest canopy, supporting a diversity of tree and liana types (i.e. long-stemmed woody vines that are rooted in the soil at ground level, and which utilise the trees in order to climb up to the canopy)
Values for wildlife	Sheltered, constant microclimate, diversity of plant food resources, hollow-bearing trees

Photograph 5 Closed forest (rainforest) habitat within the Study Area (October 2018)

6.1.5. Coastal Dune/Swale Complex Habitats

Coastal dune/swale complex habitats cover approximately 2% of the Study Area (**Table 6**). This habitat type occurs along the coastline within the Study Area (**Figure 14**).

This habitat type is associated with the coastal sand plains and is characterised by a dune and swale complex. This habitat type is variable in structure, with dunes often comprising grassland and shrubland with bare sand, and swales often comprising *Melaleuca* dominated woodland and forest. Grasslands and shrublands included both hummock and perennial grassland, and a shrub layer of *Acacias*, *Melaleucas*, *Grevillea heliosperma* (Rock Grevillea) and *Terminalia carpentariae* (Wild Peach). Woodlands and forests included a mixed canopy of *Melaleuca dealbata* (Blue-leaved Paperbark), *Melaleuca ferruginea* (Paperbark) and *Melaleuca cajuputi* (Cajuput Tree).

These habitats contain limited terrestrial features such as trees with hollows and hollow logs. Some areas contain significant dieback of trees and shrubs. Ground cover is generally sparse, with bare ground common throughout the habitat type.

Fauna species recorded within this habitat type during recent terrestrial surveys by Cumberland Ecology (2019c) included the Delicate Mouse (*Pseudomys delicatulus*), Northern Quoll (*Dasyurus hallucatus*), Northern Brown Bandicoot (*Isoodon macrourus*), Gilbert's Dragon (*Lophognathus gilberti*), Short-beaked Echidna (*Tachyglossus aculeatus*), Torresian Crow (*Corvus orru*) and Pheasant Coucal (*Centropus phasianinus*). Feral cats (*Felis catus*) were also recorded within this habitat type.

Features of this habitat type are summarised in **Table 11**. An example of the woodland form and shrubland form of the coastal dune/swale complex within the Study Area are shown in **Photograph 6** and **Photograph 7**, respectively.

Table 11 Features of coastal dune/swale complex habitats within the Study Area

Feature	Comment
Area	Covers approximately 2% of Study Area
Physiographic location	Gently undulating coastal sand plains with dunes and swales
Soils	Siliceous sands
Water	Water is generally scarce, although during the wet season will be held in swales
Fire	Grassland vegetation likely to be frequently burnt (annually or biennially). Woodland vegetation less frequently burnt
Tree hollows and fallen logs	Few trees with hollows typically present
Key microhabitats	- Sheltered areas within woodland and forest - Open areas for foraging
Values for wildlife	Array of plant food resources

Photograph 6 Coastal dune/swale complex habitat (woodland) within the Study Area (October 2018)

Photograph 7 Coastal dune/swale complex habitat (grassland) within the Study Area (April 2019)

6.1.6. Estuarine Complex Habitats

Estuarine complex habitat covers approximately 4% of the Study Area (**Table 6**). This habitat type is located near the western boundary of the Study Area (**Figure 14**).

This habitat type is associated with tidal flats with channels and estuaries. It is variable in structure and includes mangroves, tidal flats, grassland, shrubland and sedgeland. Most of this habitat type is subject to tidal influences. Mangroves within the Study Area form low to tall closed forests, whilst the other forms within this habitat type are sparsely vegetated. These include samphire/chenopod shrublands, closed tussock grassland, and sedgelands. The tidal flats within the Study Area include areas of bare ground with occasional emergent trees or chenopod shrubs.

Features of this habitat type are summarised in **Table 12**, and a photograph of the coastal habitats within the Study Area is shown in **Photograph 8**.

Table 12 Features of estuarine complex habitats within the Study Area

Feature	Comment
Area	Covers approximately 4% of Study Area
Physiographic location	Along the coastal strand, up to high tide levels
Soils	Marine and estuarine sediments and soils
Water	Influenced by tidal movements and associated with the mouth of an unnamed watercourse
Fire	Grassland vegetation likely to be frequently burnt (annually or biennially)
Tree hollows and fallen logs	Limited trees and fallen logs
Key microhabitats	- Dense understorey in mangrove areas - Well developed ground layer in grassland areas - Open areas for foraging (saltmarsh, clay pans)
Values for wildlife	Array of plant food resources

Photograph 8 Estuarine complex habitat within the Study Area (April 2019)

6.2. Fauna Species: Overview

In total, 57 fauna species have been recorded from the Study Area by Cumberland Ecology (Cumberland Ecology 2015a, 2016, 2019c), including 28 birds, 12 mammals and 17 reptiles. A discussion of the faunal diversity recorded from the Study Area is presented below. A complete list of all the fauna species that have been recorded from the Study Area is presented in **Appendix G**. A suite of other fauna species have been recorded in the vicinity of the Study Area by Cumberland Ecology (2015a, 2016, 2019c), Heiniger and Gillespie (2017), URS Australia Pty Ltd (2012) and Webb (1992), the results of which are also presented in **Appendix G**.

6.2.1. Amphibians

No amphibians have been recorded from the Study Area, which is considered to be related to the absence of water during surveys undertaken at times suitable for detecting amphibians, and limited targeted surveys.

No threatened amphibians listed under the EPBC Act and/or the TPWC Act have been recorded from the Study Area or from database searches of the locality and none are considered likely to occur within the Study Area.

6.2.2. Birds

A range of habitat features suitable for birds occurs throughout the Study Area and surrounds. A total of 28 bird species were recorded within the Study Area. Due to the broad range of habitats present within these areas, it is anticipated that bird diversity is much higher than recorded.

The vast majority of bird species were common and widespread, typical of woodland environments and expected to also utilise the Study Area. Dominant families recorded include Meliphagidae (honeyeaters and friarbirds) and Columbidae (pigeons and doves). Commonly recorded species include Torresian Crow (*Corvus orru*), Striated Pardalote (*Pardalotus striatus*) and Northern Fantail (*Rhipidura rufiventris*).

One threatened bird, the Masked Owl (northern) (*Tyto novaehollandiae kimberli*), listed under the EPBC Act and the TPWC Act has been recorded in the Study Area. Several migratory birds are also known to occur within the locality. These species are considered further in ***Section 6.3*** and ***Section 6.4***.

6.2.3. Mammals

A total of 12 mammal species were recorded within the Study Area during recent terrestrial field surveys, including seven terrestrial species and five microbats. Due to the broad range of habitats present within these areas, it is anticipated that mammal diversity is much higher than recorded.

The most common and widespread terrestrial mammals observed within the Study Area included the Northern Quoll (*Dasyurus hallucatus*), Agile Wallaby (*Macropus agilis*), Northern Brown Bandicoot (*Isoodon macrourus*), Delicate Mouse (*Pseudomys delicatulus*), Grassland Melomys (*Melomys burtoni*) and Short-beaked Echidna (*Tachyglossus aculeatus*).

Three microbats were positively recorded including the Common Sheathtail-bat (*Taphozous georgianus*), Northern Cave Bat (*Vespadelus caurinus*) and Finlayson's Cave Bat (*Vespadelus finlaysoni*). Ultrasonic call detection results indicated the potential for a further two species of microbats; however these calls could not be positively identified.

Targeted surveys for the Northern Hopping-mouse (see ***Section 3.2***) did not detect any spoils that could be associated with the species within the Disturbance Footprint.

Only one threatened mammal was recorded during recent terrestrial surveys within the Study Area, namely the Northern Quoll (*Dasyurus hallucatus*). This species is considered likely to utilise habitats within the Study Area and Disturbance Footprint. Further discussion of this species is provided in ***Section 6.3***.

6.2.4. Reptiles

A range of habitat features suitable for reptiles occurs throughout the Study Area and surrounds. A total of 17 reptile species were recorded within the Study Area during the recent terrestrial field surveys. Due to the broad range of habitats present within the Study Area, it is anticipated that reptile diversity is much higher than recorded.

The dominant family within the Study Area was Scincidae (skinks), with other families present including Agamidae (dragons) and Varanidae (monitors). Reptiles recorded include Gilbert's Dragon (*Lophognathus gilberti*), Sand Goanna (*Varanus gouldii*), Frilled Lizard (*Chlamydosaurus kingii*) and Weigel's Black Snake (*Pseudechis weigeli*).

No threatened reptiles were recorded within the Study Area during recent terrestrial surveys. Two threatened reptiles, Mertens' Water Monitor (*Varanus mertensi*) and Yellow-spotted Monitor (*Varanus panoptes*), and one migratory reptile, Salt-water Crocodile (*Crocodylus porosus*) are known to occur within the locality. These species are considered further in ***Section 6.3*** and ***Section 6.4***, respectively.

6.2.5. Exotic / Feral Species

Groote Eylandt represents a unique faunal refuge in that exotic and feral species such as feral cattle, horses, donkeys, pigs, goats, Water Buffalo, the Cane Toad and Rusa Deer are not established on the island.

No exotic / feral fauna species were recorded within the Study Area during recent surveys. Domestic dogs/dingoes (*Canis familiaris/lupus*) have been frequently recorded within the Southern Lease, along with a few infrequent sightings of feral cats (*Felis catus*). Heinger et al. (2020) detected feral cats infrequently in the north eastern portion of the Southern Lease, with detections too sparse to estimate density.

Domestic dogs/dingoes and feral cats are likely to occur within the Study Area.

6.3. Fauna Species: Threatened Species

An analysis of ecological databases was conducted for the Study Area and its surrounds, including interrogation of the DAWE EPBC PMST (DAWE 2020c) and NR Maps search facility (DNRM 2020) for threatened fauna records. Database records identified the presence of a number of threatened fauna species or habitat within the locality of the Study Area (defined in this report as a 20 km radius from the centre of the Study Area). Results of the database searches for terrestrial threatened fauna species in the locality listed under the EPBC Act and/or the TPWC Act are summarised in **Table 13**.

As the locality includes some ocean areas, the search yielded numerous marine species including fish, turtles and marine mammals. These are not relevant to an assessment of terrestrial ecology within the Study Area and are not considered further in this report.

The full results of the PMST search is presented in **Appendix A**. The threatened fauna records held within the NR Maps database within the locality and across Groote Eylandt are shown on **Figure 15**.

One threatened fauna species, the Northern Quoll (*Dasyurus hallucatus*), has been recorded within the Study Area during recent studies and the location of records of this species are shown on **Figure 16**. In some instances, there were multiple sightings of this species at a single location, however only one of these records is shown on the figure.

Table 13 Threatened fauna species database records within the locality

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Birds					
Red Knot	*Calidris canutus*	E, M(w)	V	X	X
Curlew Sandpiper	*Calidris ferruginea*	CE, M(w)	V	X	X
Great Knot	*Calidris tenuirostris*	CE, M(w)	V		X
Greater Sand Plover	*Charadrius leschenaultii*	V, M(w)	V		X

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Lesser Sand Plover	*Charadrius mongolus*	E, M(w)	V		X
Red Goshawk	*Erythrotriorchis radiatus*	V	V	X	
Gouldian Finch	*Erythrura gouldiae*	E	V	X	
Bar-tailed Godwit	*Limosa lapponica*	V/CE[3], M(w)	V	X	X
Eastern Curlew	*Numenius madagascariensis*	CE, M(w)	V	X	X
Australian Painted Snipe	*Rostratula australis*	E	V	X	
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	V	V		X
Mammals					
Brush-tailed Rabbit-rat	*Conilurus penicillatus*	V	E	X	X
Northern Quoll	*Dasyurus hallucatus*	E	CE	X	X
Ghost Bat	*Macroderma gigas*	V		X	X
Northern Hopping-mouse	*Notomys aquilo*	V	V	X	X
Pale Field Rat	*Rattus tunneyi*		V		X
Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	V		X	
Water Mouse	*Xeromys myoides*	V		X	
Reptiles					
Plains Death Adder	*Acanthophis hawkei*	V	V	X	
Mertens' Water Monitor	*Varanus mertensi*		V		X
Yellow-spotted Monitor	*Varanus panoptes*		V		X
Species Restricted to Marine Environment					
Blue Whale	*Balaenoptera musculus*	E, M(m)		X	
Loggerhead Turtle	*Caretta caretta*	E, M(m)	V	X	
Green Turtle	*Chelonia mydas*	V, M(m)		X	X
Leatherback Turtle	*Dermochelys coriacea*	E, M(m)	CE	X	
Hawksbill Turtle	*Eretmochelys imbricata*	V, M(m)	V	X	X
Olive Ridley Turtle	*Lepidochelys olivacea*	E, M(m)	V	X	X
Flatback Turtle	*Natator depressus*	V, M(m)		X	X
Great White Shark	*Carcharodon carcharias*	V, M(m)		X	
Scalloped Hammerhead	*Sphyrna lewini*	CD			X
Speartooth Shark	*Glyphis glyphis*	CE	V	X	
Dwarf Sawfish	*Pristis clavata*	V, M(m)		X	
Largetooth Sawfish	*Pristis pristis*	V, M(m)		X	

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Green Sawfish	*Pristis zijsron*	V, M(m)		X	
Whale Shark	*Rhincodon typus*	V, M(m)		X	

1. Conservation Status: CD = Conservation Dependent, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

2. Subcategories for EPBC Act listing of migratory species follow those within the PMST report

3. Subspecies of Limosa lapponica have different listings under the EPBC Act. Limosa lapponica baueri is listed as Vulnerable and Limosa lapponica menzbieri is listed as Critically Endangered.

A likelihood of occurrence assessment was undertaken for the threatened species listed in **Table 13** (excluding marine species) to determine if they have the potential to occur within the Study Area, and more specifically to occur within the Disturbance Footprint. The likelihood of these species occurring was classified using the criteria presented in **Table 2**. The assessment was based on the species known range, number and age of records, and habitat preferences which were evaluated considering site characteristics observed during the field surveys in areas surrounding the Study Area. The full results of this likelihood of occurrence assessment are presented in **Appendix H**. A summary of the threatened species considered and the assessment of likelihood of occurrence is provided in **Table 14**.

Table 14 Summary of the likelihood of occurrence of threatened fauna species

Common Name	Scientific Name	Conservation Status[1]		Species Recorded within the Study Area[3]	Likelihood of Occurrence	
		EPBC Act[2]	TPWC Act		Study Area	Disturbance Footprint
Birds						
Red Knot	*Calidris canutus*	E, M(w)	V		Low	Low
Curlew Sandpiper	*Calidris ferruginea*	CE, M(w)	V		Low	Low
Great Knot	*Calidris tenuirostris*	CE, M(w)	V		Low	Low
Greater Sand Plover	*Charadrius leschenaultii*	V, M(w)	V		Low	Low
Lesser Sand Plover	*Charadrius mongolus*	E, M(w)	V		Low	Low
Red Goshawk	*Erythrotriorchis radiatus*	V	V		Low	Low
Gouldian Finch	*Erythrura gouldiae*	E	V		Low	Low
Bar-tailed Godwit	*Limosa lapponica*	V/CE[4], M(w)	V		Low	Low
Eastern Curlew	*Numenius madagascariensis*	CE, M(w)	V		Low	Low
Australian Painted Snipe	*Rostratula australis*	E	V		Low	Low

Common Name	Scientific Name	Conservation Status[1]		Species Recorded within the Study Area[3]	Likelihood of Occurrence	
		EPBC Act[2]	TPWC Act		Study Area	Disturbance Footprint
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	V	V		Present	High
Mammals						
Brush-tailed Rabbit-rat	*Conilurus penicillatus*	V	E		Low	Low
Northern Quoll	*Dasyurus hallucatus*	E	CE	X	Present	High
Ghost Bat	*Macroderma gigas*	V			High	High
Northern Hopping-mouse	*Notomys aquilo*	V	V		Low[5]	Low
Pale Field Rat	*Rattus tunneyi*		V		Low	Low
Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	V			Low	Low
Water Mouse	*Xeromys myoides*	V			Low	Low
Reptiles						
Plains Death Adder	*Acanthophis hawkei*	V	V		Low	Low
Mertens' Water Monitor	*Varanus mertensi*		V		High	High
Yellow-spotted Monitor	*Varanus panoptes*		V		High	High

1. EPBC Act Status / TPWC Act Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

2. Subcategories for EPBC Act listing of migratory species follow those within the PMST report

3. Includes records from the recent surveys (2014-2019).

4. Subspecies of Limosa lapponica have different listings under the EPBC Act. Limosa lapponica baueri is listed as Vulnerable and Limosa lapponica menzbieri is listed as Critically Endangered.

5. Recent (October 2020) targeted surveys did not detect the presence of spoils that could be associated with this species within the Disturbance Footprint. This species has been assessed as having a low likelihood of occurrence based on these recent findings in conjunction with the findings within Cumberland Ecology (2019c).

The following sections provide details of the threatened fauna species that have been recorded within the Study Area, or which are considered to have a moderate or high likelihood to occur within the Study Area.

6.3.1. EPBC Act Species (Threatened)

Three threatened fauna species listed under the EPBC Act, namely the Masked Owl (northern) (*Tyto novaehollandiae kimberli*), Northern Quoll (*Dasyurus hallucatus*) and Ghost Bat are considered to have a high likelihood of occurring in the Disturbance Footprint. Details on these species, their occurrence, and habitat preferences within the Study Area and Disturbance Footprint are provided below.

A number of other threatened species are considered to have a moderate potential to occur within the coastal and estuarine complex habitats in the western portion of the Study Area (see **Figure 14**). As the habitats for these species represent a small proportion of the habitat within the Study Area, and do not occur within the Disturbance Footprint, these species have not been described in detail below. Summary descriptions of these species are, however, provided in **Appendix H**.

<u>Masked Owl (northern)</u>

EPBC Act Status: Vulnerable

TPWC Act Status: Vulnerable

Species Overview

The Masked Owl (northern) has been recorded from riparian forest, rainforest, open forest, Melaleuca swamps and the edges of mangroves, as well as along the margins of sugar cane fields (DAWE 2020g). The species occurs mainly in tall eucalypt open forests (especially those dominated by *Eucalyptus miniata* (Darwin Woollybutt) and *E. tetrodonta* (Darwin Stringybark) and also forages in more open vegetation types, including grasslands (Woinarski and Ward 2012). Roosting habitat occurs in dense foliage, including within monsoon rainforests, however it more typically roosts and nests in tree hollows (Woinarski and Ward 2012). Critical habitat for this species is not defined due to a lack of records, however this species is considered to be dependent on tree hollows (Woinarski 2004). Mammals that are up to the size of possums form the primary component of the diet of this species (Higgins 1999). The distribution of the Masked Owl (northern) is imperfectly known, with remarkably few records across its broad range (Woinarski 2004). The Masked Owl (northern) has been impacted by broad-scale changes to the environment of northern Australia caused by altered fire regimes, grazing by livestock and feral animals, and the invasion of native woodlands by exotic plants, particularly introduced pasture grasses (DAWE 2020g).

EPBC Act Plans

Conservation Advice

Approved Conservation Advice for the Masked Owl (northern) has been prepared, which identifies conservation and management actions, survey and monitoring priorities and information and research priorities. Identified threats to the Masked Owl (northern) include broad-scale changes to the environment caused by altered fire regimes, grazing by livestock and feral animals, and the invasion of native woodlands by exotic plants (Threatened Species Scientific Committee 2015a).

Recovery Plan

There is no current Recovery Plan for the Masked Owl (northern); however, the DAWE Species Profile and Threats Database acknowledges that a recovery plan is required. A National Multi-species Recovery Plan had previously been in place for several bird species, including the Masked Owl (Northern) (Woinarski 2004); however DAWE has advised that this plan has ceased to be in effect from 1 October 2015 (DAWE 2020g).

Threat Abatement Plan

A Threat Abatement Plan is in place for the Masked Owl (northern) for the threat of five listed grasses.

Referral Guideline

There is no Referral Guideline for the Masked Owl (northern).

Groote Archipelago Threatened Species Management Plan

The Groote Archipelago Threatened Species Management Plan (TSMP) has been developed with support from the NT Government and the Australian Government (DENR and ALC 2019). The plan identifies key actions to reduce threats and support conditions for threatened species recovery, and it includes the Masked Owl (northern). The goal for the Masked Owl (northern) is to acquire a baseline for the population and evaluate status within two years. Very high and high risk threats identified for the species include major habitat loss/alteration, weed invasion and inappropriate fire regimes.

Presence and Habitat within the Study Area and Disturbance Footprint

The Masked Owl was recorded at one location within the study area however has not been recorded within the Development Footprint. This record was an opportunistic sighting during flora surveys in October 2018. The location of this sighting is shown in **Figure 16**. Prior to this, the Masked Owl (northern) was recorded from one location within the Southern Lease by Cumberland Ecology (2016), using call playback and spotlighting. This species was recorded flying over laterite woodland and forest in response to call playback. This location is in close proximity to the Study Area. This species has also been recorded at numerous locations in the Eastern Leases, which is to the east of the Study Area, by Cumberland Ecology (2015a) and EMS (2013), and at one location to the south of the Study Area by Cumberland Ecology (2019c). A photograph of a Masked Owl (northern) recorded within the Eastern Leases is shown in **Photograph 9**.

The majority of the fauna habitat types occurring in the Study Area (as listed in **Table 6**) have the potential to provide habitat resources for this species. This includes:

- Riparian/wetland habitats;
- Laterite woodland and forest habitats;
- Sandstone woodland and forest habitats;
- Closed forest (rainforest) habitats; and
- Coastal dune/swale complex habitats.

Of these habitat types, riparian/wetland habitats and laterite woodland and forest habitats occur within the Disturbance Footprint, providing habitat resources for this species.

Key foraging habitat resources are present and consist of a high density of potential prey species such as small- to medium-sized ground-dwelling mammals, including the Delicate Mouse (*Pseudomys delicatulus*), Northern Brown Bandicoot (*Isoodon macrourus*) and Northern Quoll (*Dasyurus hallucatus*), as well as habitats containing the Sugar Glider (*Petaurus breviceps*). Such foraging habitats are widespread in the Study Area. Roosting and nesting habitat in the Study Area is confined to the denser closed forest (rainforest) habitats containing large emergent trees with hollows, and in other areas containing hollow-bearing trees with medium- to large-sized hollows such as laterite woodland and forest habitats, sandstone woodland and forest habitats, coastal dune/swale habitats and riparian/wetland habitats. The species is not likely to roost or nest in parts of the Study Area which contain shrubland habitat or grassland habitat due to the lack of dense canopy and large hollow-bearing trees. The Masked Owl may, however, forage within the grassland/shrubland habitats.

Within the Disturbance Footprint, roosting and nesting habitat is likely to be confined to laterite woodland and forest habitats, and riparian/wetland habitats, containing large hollow-bearing trees. The presence of large trees could be used as an indicator of potential breeding habitat for the Masked Owl (NT EPA 2020) as large trees would most likely be associated with large hollows. Pre-clearance surveys undertaken by Cumberland Ecology in 2016 and 2019 recorded suitable hollows for the Masked Owl at a number of locations, most commonly within *Eucalyptus tetrodonta* (Darwin Stringybark), including a small number within the Study Area. Recent surveys within the Disturbance Footprint identified a total of 52 large trees. Large trees frequently encountered included *Melaleuca cajuputi* (Cajuput Tree) (16 trees) and *Eucalyptus tetrodonta* (Darwin Stringybark) (14 trees). The highest concentration of large trees occurs in proximity to the Emerald River and Emerald River Southern Tributary, with 33 large trees having been recorded within 100 m of these waterways.

Photograph 9 Masked Owl photographed in open forest in the Eastern Leases

Northern Quoll

EPBC Act Status: Endangered

TPWC Act Status: Critically Endangered

Species Overview

The Northern Quoll occupies a diversity of habitats across its range which includes rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert (DAWE 2020b). Northern Quoll habitat generally encompasses some form of rocky area for denning purposes with surrounding vegetated habitats with high structural diversity used for foraging and dispersal (DAWE 2020b). Rocky areas are considered prime habitat for the Northern Quoll (Hill and Ward 2010). Den sites include rocky outcrops and crevices, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings (Hill and Ward 2010, DAWE 2020b). During the non-breeding season, home ranges are about 35 ha, but this increases to about 100 ha for males in the breeding season (Woinarski and Ward 2012). They are opportunistic omnivores that feed on a broad range of items, including beetles, grasshoppers, spiders, scorpions, centipedes, fruit and nectar, switching dietary resources according to season and availability (Hill and Ward 2010, DAWE 2020b). The current distribution is discontinuous across northern Australia, with core populations in rocky and/or high rainfall areas (Hill and Ward 2010), however there has been a decline across much of this range (Woinarski and Ward 2012). The species is known from a number of offshore islands, including Groote Eylandt (Hill and Ward 2010). Key threats to the Northern Quoll include lethal toxic ingestion caused by Cane Toads, removal, degradation and fragmentation of habitat, inappropriate fire regimes, weeds and feral predators (DAWE 2020b).

EPBC Act Plans

Conservation Advice

There is no Approved Conservation Advice for the Northern Quoll.

Recovery Plan

A National Recovery Plan for the Northern Quoll has been prepared (Hill and Ward 2010). The plan lists a series of objectives and actions to manage existing populations of the species, including the protection of quoll populations on offshore islands from invasion and establishment of cane toads, cats and other potential predators.

Threat Abatement Plan

Threat Abatement Plans are in place for the Northern Quoll for the threat of Cane Toads, feral cats, and five listed grasses.

Referral Guideline

A Referral Guideline exists for the Northern Quoll which outlines likely habitats critical to the survival of the Northern Quoll and populations important for its long term survival (DotE 2016).

Groote Archipelago Threatened Species Management Plan

The TSMP has been developed with support from the NT Government and the Australian Government (DENR and ALC 2019). The plan identifies key actions to reduce threats and support conditions for threatened species recovery, and it includes the Northern Quoll. The goal for the Northern Quoll is to maintain a stable population at 2017 densities or occupancies across the current range. Very high and high risk threats identified for the species includes poisoning by cane toads, weed invasion and inappropriate fire regimes.

Presence and Habitat within the Study Area and Disturbance Footprint

Northern Quolls were recorded within the Study Area at four locations by Cumberland Ecology (2019c) during camera surveys, two locations by Cumberland Ecology (2016) during Elliott trapping and cage trapping, and two locations by Cumberland Ecology (2016) during camera surveys. It was also recorded at a further two locations within the Study Area by Heiniger and Gillespie (2017). The locations of these records are shown on **Figure 16**. A number of these records occur within proximity to the Disturbance Footprint. A photograph of a Northern Quoll photographed during camera surveys is shown in **Photograph 10**.

The Northern Quoll has also been recorded within mine rehabilitation areas of the existing GEMCO mine (Cumberland Ecology 2015a). The Northern Quoll has been recorded numerous times within and in close proximity to the Eastern Leases (Webb 1992, Ward 2006b, Firth 2008, Smith 2009, URS Australia Pty Ltd 2012, Cumberland Ecology 2015a). Records of this species within the Study Area are also held in the NR Maps database (DNRM 2020) (**Figure 15**). Smith (2009) noted that the Northern Quoll appears to be widely distributed across Groote Eylandt.

Due to the range of habitat this species is known to occur in, the majority of the habitat types listed in **Table 6** (which are found within the Study Area) are considered to be able to provide potential suitable habitat for this species for foraging and breeding. This includes:

- Riparian/wetland habitats;
- Laterite woodland and forest habitats;
- Sandstone woodland and forest habitats;
- Closed forest (rainforest) habitats; and
- Coastal dune/swale complex habitats.

Of these habitat types, riparian/wetland habitats and laterite woodland and forest habitats occur within the Disturbance Footprint, providing habitat resources for this species.

Key areas of habitat are located in proximity to rocky habitats in vegetation with high structural diversity, especially sandstone woodland and rock outcrop habitat. Other habitat types such as closed forest (rainforest), laterite woodland and forest and riparian/wetland habitats also provide den habitat in the form of tree hollows, hollow logs and termite mounds, in addition to suitable habitat for prey species such as other small mammals, frogs, reptiles and invertebrates.

Photograph 10 Northern Quoll captured during camera surveys within the Study Area (July 2018)

Ghost Bat

EPBC Act Status: Vulnerable

TPWC Act Status: Not listed

Species Overview

The Ghost Bat occupies habitats ranging from the arid habitats to tropical savanna woodlands and rainforests (Threatened Species Scientific Committee 2016b). During the daytime they roost in caves, rock crevices and old mines (Threatened Species Scientific Committee 2016b). Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23°–28°C and a moderate to high relative humidity of 50–100 percent (Threatened Species Scientific Committee 2016b). Colonies can disperse up to 150 km from permanent roosting sites during the non-breeding season in the cooler months, with caves, rock shelters, overhangs, vertical cracks and mines providing day roost habitat (Hourigan 2011). Most breeding sites appear to require multiple entranced caves (Threatened Species Scientific Committee 2016b). Individuals aggregate in maternity roosts during spring and summer (Hourigan 2011). The Ghost Bat perches in vegetation to ambush passing prey (either on the ground or in the air), and it also gleans surfaces such as the ground while in flight (Threatened Species Scientific Committee 2016b). It feeds on small mammals including other bats, birds, reptiles, frogs and large insects (Threatened Species Scientific Committee 2016b). The current distribution is discontinuous, with geographically disjunct colonies occurring in the Pilbara, Kimberley, northern portion of the NT (including Groote Eylandt), the Gulf of Carpentaria, coastal and near coastal eastern Queensland from Cape York to near Rockhampton, and western Queensland (Threatened Species Scientific Committee 2016b). A photograph of a Ghost Bat is shown in **Photograph 11**.

EPBC Act Plans

Conservation Advice

Approved Conservation Advice for the Ghost Bat has been prepared, which identifies threats and conservation actions for the species. Conservation actions include management actions, survey and monitoring priorities and information and research priorities. The key threat to the Ghost Bat is habitat loss and degradation due to mining activities (Threatened Species Scientific Committee 2016b).

Recovery Plan

There is no Recovery Plan available for the Ghost Bat; however, the DAWE Species Profile and Threats Database and Approved Conservation Advice recommends that a recovery plan is prepared.

Threat Abatement Plan

A Threat Abatement Plan is in place for the Ghost Bat for the threat of the European Red Fox, which does not occur on Groote Eylandt.

Referral Guideline

There is no Referral Guideline for the Ghost Bat.

Groote Archipelago Threatened Species Management Plan

The TSMP has been developed with support from the NT Government and the Australian Government (DENR and ALC 2019). The plan identifies key actions to reduce threats and support conditions for threatened species recovery, and it includes the Ghost Bat. The goal for the Ghost Bat is to acquire a baseline for the population and evaluate status within two years.. There is one very high risk threat identified for the species which is poisoning by cane toads.

Presence and Habitat within the Study Area and Disturbance Footprint

The Ghost Bat was not recorded within the Study Area during recent terrestrial surveys. The Ghost Bat has been previously recorded within dry eucalypt forest within the existing GEMCO mine (URS Australia Pty Ltd 2012), within open woodland in proximity to the existing GEMCO mine (Diete et al. 2015b) and in coastal grass and shrub habitat in the south west peninsular of the island (Diete et al. 2015b). The NR Maps database has records of this species in the central and northern parts of the island (**Figure 15**).

Areas of rocky outcropping and caves occur within the Study Area, which could be utilised by the Ghost Bat for roosting. These areas are mostly likely to comprise transient roosts. No areas of rocky outcropping and caves occur within the Disturbance Footprint. The closest areas of rocky outcropping occur approximately

1 km north east and 1.2 km south east of the eastern end of the construction access track within sandstone woodland and forest habitats (see **Figure 14**).

Foraging by the Ghost Bat would occur in proximity (within 2 km) to roosting habitat and would occur in all of the habitat types recorded within the Study Area, including:

- Riparian/wetland habitat;
- Laterite woodland and forest habitats;
- Sandstone woodland and forest habitats;
- Closed forest (rainforest) habitats;
- Coastal dune/swale complex habitats; and
- Estuarine complex habitats.

Of these habitat types, riparian/wetland habitats and laterite woodland and forest habitats occur within the Disturbance Footprint, providing foraging habitat for this species.

Photograph 11 Ghost Bat (Source: EMS in URS Australia Pty Ltd, 2012)

6.3.2. TPWC Act Species

Two threatened fauna species listed under both the EPBC Act and TPWC Act have been discussed in ***Section 6.3.1***. Other species listed under the TPWC Act which are considered to have a moderate or high likelihood of occurrence within the Disturbance Footprint include the Yellow-spotted Monitor and Mertens' Water Monitor. Details on the occurrence and habitat of the Yellow-spotted Monitor and Mertens' Water Monitor within the Study Area and Disturbance Footprint are provided below. No other TPWC Act listed threatened fauna species are considered to have a moderate or high likelihood of occurrence within the Disturbance Footprint and as such are not assessed further within this report.

<u>Yellow-spotted Monitor</u>

EPBC Act Status: Not listed

TPWC Act Status: Vulnerable

Species Overview

The Yellow-spotted Monitor occupies a variety of habitats, including coastal beaches, floodplains, grasslands and woodlands (Ward et al. 2012). Clutches of eggs are typically laid in the wet season in burrows in the ground (Ward et al. 2012). Recent research has indicated that these species make use of large communal burrows / warrens (Doody, *et al.*, 2014). It feeds mostly on small terrestrial vertebrates and insects, and often digs up prey, especially eggs of marine and freshwater turtles (Ward et al. 2012). The Yellow-spotted Monitor has a broad geographic range across the far North of Australia from the Kimberley to Cape York Peninsula, and southwards through most of Queensland (Ward et al. 2012). In the NT, it has been recorded across most of the Top End and the Gulf Region (Ward et al. 2012). The advance of the Cane Toad across the NT is the most serious threat facing the Yellow-spotted Monitor as it is highly susceptible to the toxins of the Cane Toad (Ward *et al.*, 2012, Doody *et al.* 2009).

Groote Archipelago Threatened Species Management Plan

The TSMP has been developed with support from the NT Government and the Australian Government (DENR and ALC 2019). The plan identifies key actions to reduce threats and support conditions for threatened species recovery, and it includes the Yellow-spotted Monitor. The goal for Yellow-spotted Monitor is to improve viability of populations on Groote Eylandt in five years. There is one very high risk threat identified for the species which is poisoning by cane toads.

Presence and Habitat within the Study Area and Disturbance Footprint

The Yellow-spotted Monitor was not recorded during recent terrestrial surveys; however it was recorded beyond the Study Area in 2014 during surveys of the nearby Eastern Leases in laterite woodland and forest habitat using cage traps and cameras (Cumberland Ecology 2015a). A photograph of the Yellow-spotted Monitor captured during trapping surveys within the Eastern Leases is shown in **Photograph 12**. The Yellow-spotted Monitor was also recorded from mine rehabilitation areas at the existing GEMCO mine (Cumberland Ecology 2015a). URS Australia Pty Ltd (2012) also recorded this species in the existing GEMCO mine.

Due to the range of habitat this species is known to occur in, the majority of vegetation communities within the Study Area are considered potential habitat for this species. This includes:

- Riparian/wetland habitats;
- Laterite woodland and forest habitats;
- Sandstone woodland and forest habitats;
- Closed forest (rainforest) habitats;
- Coastal dune/swale complex habitats; and
- Estuarine complex habitats, excluding mangroves.

Of these habitat types, riparian/wetland habitats and laterite woodland and forest habitats occur within the Disturbance Footprint, providing habitat resources for this species.

The Yellow-spotted Monitor is known to forage on small vertebrates, and several small terrestrial vertebrates were recorded within the Study Area including the Grassland Melomys (*Melomys burtoni*), Delicate Mouse (*Pseudomys delicatulus*) and Common Planigale (*Planigale maculata*) (Cumberland Ecology 2019c). Other small terrestrial vertebrates and insects present within the Study Area would also provide a suitable food source for this species.

Photograph 12 Yellow-spotted Monitor captured during trapping surveys within the Eastern Leases

Mertens' Water Monitor

EPBC Act Status: Not listed

TPWC Act Status: Vulnerable

Species Overview

Mertens' Water Monitor is semi-aquatic and is seldom seen far from water (Ward et al. 2006). It is often observed climbing on rocks or trees near water, often basking on branches overhanging the water or on rocks mid-stream (Ward et al. 2006). It lays eggs in a burrow constructed in the ground, with egg-laying usually in the early dry season (Ward et al. 2006). It feeds mostly on fish, frogs and carrion, and is also known to eat insects and small terrestrial vertebrates (Ward et al. 2006). Mertens' Water Monitor has a broad geographic range, occupying coastal and inland waters across the far north of Australia from the Kimberley to the west side of Cape York Peninsula (Ward et al. 2006). In the NT it has been recorded across most of the Top End and the Gulf Region (Ward et al. 2006). The advance of the Cane Toad across the NT is the most serious threat facing Mertens' Water Monitor as it is known to consume the Cane Toad and die from the ingested toxins (Ward *et al*., 2012, Doody *et al*. 2009).

Groote Archipelago Threatened Species Management Plan

The TSMP has been developed with support from the NT Government and the Australian Government (DENR and ALC 2019). The plan identifies key actions to reduce threats and support conditions for threatened species recovery, and it includes Mertens' Water Monitor. The goal for Mertens' Water Monitor is to acquire a baseline for the population and evaluate status within two years.. There is one very high risk threat identified for the species which is poisoning by cane toads.

Presence and Habitat within the Study Area and Disturbance Footprint

Mertens' Water Monitor was not recorded in the Study Area during recent terrestrial surveys; however it was recorded beyond the Study Area in 2014 during surveys of the nearby Eastern Leases and Southern Lease within laterite woodland and forest habitat, and riparian/wetland habitats adjacent to watercourses using cage traps and incidental observations (Cumberland Ecology 2015a). A photograph of a Mertens' Water Monitor recorded on camera within the Eastern Leases is shown in **Photograph 13**. The Mertens' Water Monitor was also recorded in mine rehabilitation areas at the existing GEMCO mine within laterite woodland and forest habitat (Cumberland Ecology 2015a). URS Australia Pty Ltd (2012) and Webb (1992) also recorded this species within their respective studies.

The watercourses of the Emerald River catchment provide suitable habitat for this species; however the availability of such habitat is reliant on seasonal conditions. Suitable habitat for Mertens' Water Monitor is likely to be more restricted within the dry season when there is less water within the waterways. Habitat types in which this species would occur within the Study Area predominantly comprises riparian/wetland habitats; however it may also occur within laterite woodland and forest habitat and coastal dune/swale complex habitats.

Suitable habitat for this species also occurs in the Disturbance Footprint within areas located in proximity to the major waterways. Suitable prey for this species would include frogs and small fish located within riparian and aquatic habitats.

Photograph 13 Mertens' Water Monitor detected by a camera within the Eastern Leases

6.4. Fauna Species: Migratory Species

An analysis of ecological databases was conducted for the Study Area and its surrounds, including interrogation of the DAWE EPBC PMST (DAWE 2020c) and NR Maps search facility (DNRM 2020) for migratory fauna records. Database records identified the presence of a number of migratory species or habitat within the locality of the Study Area (defined in this report as a 20 km radius from the centre of the Study Area). Results of the database searches for migratory fauna species in the locality listed under the EPBC Act are summarised in **Table 15**. The TPWC Act does not include a separate migratory status.

As the locality includes some ocean areas, the search yielded numerous marine species including fish, turtles and marine mammals. These are not relevant to an assessment of terrestrial ecology within the Study Area and are not considered further in this report.

The full results of the PMST search is presented in **Appendix A**. The migratory fauna records held within the NR Maps database within the locality and across Groote Eylandt are shown on **Figure 17**.

Table 15 Migratory fauna species database records within the locality

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Birds					
Red Knot	*Calidris canutus*	E, M(w)	V	X	X
Curlew Sandpiper	*Calidris ferruginea*	CE, M(w)	V	X	X
Great Knot	*Calidris tenuirostris*	CE, M(w)	V		X
Greater Sand Plover	*Charadrius leschenaultii*	V, M(w)	V		X
Lesser Sand Plover	*Charadrius mongolus*	E, M(w)	V		X
Bar-tailed Godwit	*Limosa lapponica*	V/CE[3], M(w)	V	X	X
Eastern Curlew	*Numenius madagascariensis*	CE, M(w)	V	X	X
Oriental Reed-warbler	*Acrocephalus orientalis*	M(w)		X	
Common Sandpiper	*Actitis hypoleucos*	M(w)		X	X
Common Noddy	*Anous stolidus*	M(m)		X	
Fork-tailed Swift	*Apus pacificus*	M(m)		X	X
Ruddy Turnstone	*Arenaria interpres*	M(w)			X
Sharp-tailed Sandpiper	*Calidris acuminata*	M(w)		X	X
Pectoral Sandpiper	*Calidris melanotos*	M(w)		X	X
Red-necked Stint	*Calidris ruficollis*	M(w)			X
Streaked Shearwater	*Calonectris leucomelas*	M(m)		X	
Red-rumped Swallow	*Cecropis daurica*	M(t)		X	
Little Ringed Plover	*Charadrius dubius*	M(w)			X
Oriental Plover	*Charadrius veredus*	M(w)		X	X
White-winged Black Tern	*Chlidonias leucopterus*	M(m)			X
Oriental Cuckoo	*Cuculus optatus*	M(t)		X	X
Lesser Frigatebird	*Fregata ariel*	M(m)		X	X
Great Frigatebird	*Fregata minor*	M(m)		X	
Swinhoe's Snipe	*Gallinago megala*	M(w)			X
Oriental Pratincole	*Glareola maldivarum*	M(w)		X	X
Barn Swallow	*Hirundo rustica*	M(t)		X	
Caspian Tern	*Hydroprogne caspia*	M(m)			X
Black-tailed Godwit	*Limosa limosa*	M(w)			X
Grey Wagtail	*Motacilla cinerea*	M(t)		X	
Yellow Wagtail	*Motacilla flava*	M(t)		X	
Little Curlew	*Numenius minutus*	M(w)			X

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Whimbrel	*Numenius phaeopus*	M(w)			X
Eastern Osprey	*Pandion cristatus*[4]	M(w)		X	X
Glossy Ibis	*Plegadis falcinellus*	M(w)			X
Pacific Golden Plover	*Pluvialis fulva*	M(w)			X
Grey Plover	*Pluvialis squatarola*	M(w)			X
Rufous Fantail	*Rhipidura rufifrons*	M(t)		X	
Roseate Tern	*Sterna dougallii*	M(m)			X
Common Tern	*Sterna hirundo*	M(m)			X
Black-naped Tern	*Sterna sumatrana*	M(m)			X
Little Tern	*Sternula albifrons*	M(m)			X
Brown Booby	*Sula leucogaster*	M(m)			X
Lesser Crested Tern	*Thalasseus bengalensis*	(M(w)			X
Grey-tailed Tattler	*Tringa brevipes*	M(w)			X
Wood Sandpiper	*Tringa glareola*	M(w)			X
Common Greenshank	*Tringa nebularia*	M(w)		X	X
Marsh Sandpiper	*Tringa stagnatilis*	M(w)			X
Terek Sandpiper	*Xenus cinereus*	M(w)			X
Reptiles					
Salt-water Crocodile	*Crocodylus porosus*	M(m)		X	X
Species Restricted to Marine Environment					
Blue Whale	*Balaenoptera musculus*	E, M(m)		X	
Bryde's Whale	*Balaenoptera edeni*	M(m)		X	
Killer Whale	*Orcinus orca*	M(m)		X	
Dugong	*Dugong dugong*	M(m)		X	X
Loggerhead Turtle	*Caretta caretta*	E, M(m)	V	X	
Green Turtle	*Chelonia mydas*	V, M(m)		X	X
Leatherback Turtle	*Dermochelys coriacea*	E, M(m)	CE	X	
Hawksbill Turtle	*Eretmochelys imbricata*	V, M(m)	V	X	X
Olive Ridley Turtle	*Lepidochelys olivacea*	E, M(m)	V	X	X
Flatback Turtle	*Natator depressus*	V, M(m)		X	X
Reef Manta Ray	*Manta alfredi*	M(m)		X	
Giant Manta Ray	*Manta birostris*	M(m)		X	
Australian Snubfin Dolphin	*Orcaella heinsohni*	M(m)		X	X

Common Name	Scientific Name	Conservation Status[1]		Database Results	
		EPBC Act[2]	TPWC Act	PMST	NR Maps
Indo-Pacific Humpback Dolphin	*Sousa chinensis*	M(m)		X	
Indo-Pacific Bottlenose Dolphin	*Tursiops aduncus*	M(m)			X
Narrow Sawfish	*Anoxypristis cuspidata*	M(m)		X	
Great White Shark	*Carcharodon carcharias*	V, M(m)		X	
Dwarf Sawfish	*Pristis clavata*	V, M(m)		X	
Largetooth Sawfish	*Pristis pristis*	V, M(m)		X	
Green Sawfish	*Pristis zijsron*	V, M(m)		X	
Whale Shark	*Rhincodon typus*	V, M(m)		X	

1. Conservation Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

2. Subcategories for EPBC Act listing of migratory species follow those within the PMST report

3. Subspecies of Limosa lapponica have different listings under the EPBC Act. Limosa lapponica baueri is listed as Vulnerable and Limosa lapponica menzbieri is listed as Critically Endangered.

4. Species listed as Pandion haliaetus in the Protected Matters Search report. Pandion haliaetus cristatus was previously recognised as a subspecies for Australasia and New Caledonia, however it is currently recognised as a species in its own right.

A likelihood of occurrence assessment was undertaken for the migratory species listed in **Table 15** (excluding marine species) to determine their potential to occur within the Study Area, and more specifically to occur within the Disturbance Footprint. The likelihood of these species occurring was classified using the criteria presented in **Table 2**. The assessment was based on the species known range, number and age of records, and habitat preferences which were evaluated considering site characteristics observed during the field surveys. The full results of this likelihood of occurrence assessment are presented in **Appendix H**. A summary of the species and their likelihood of occurrence is provided in **Table 16**.

Table 16 Summary of the likelihood of occurrence of migratory fauna species

Common Name	Scientific Name	Conservation Status[1]		Species Recorded within the Study Area[3]	Likelihood of Occurrence	
		EPBC Act[2]	TPWC Act		Study Area	Disturbance Footprint
Birds						
Red Knot	*Calidris canutus*	E, M(w)	V		Low	Low
Curlew Sandpiper	*Calidris ferruginea*	CE, M(w)	V		Low	Low
Great Knot	*Calidris tenuirostris*	CE, M(w)	V		Low	Low

Common Name	Scientific Name	Conservation Status[1]		Species Recorded within the Study Area[3]	Likelihood of Occurrence	
		EPBC Act[2]	TPWC Act		Study Area	Disturbance Footprint
Greater Sand Plover	*Charadrius leschenaultii*	V, M(w)	V		Low	Low
Lesser Sand Plover	*Charadrius mongolus*	E, M(w)	V		Low	Low
Bar-tailed Godwit	*Limosa lapponica*	V/CE[4], M(w)	V		Low	Low
Eastern Curlew	*Numenius madagascariensis*	CE, M(w)	V		Low	Low
Oriental Reed-warbler	*Acrocephalus orientalis*	M(w)			Low	Low
Common Sandpiper	*Actitis hypoleucos*	M(w)			Moderate	Low
Common Noddy	*Anous stolidus*	M(m)			Low	Low
Fork-tailed Swift	*Apus pacificus*	M(m)			Moderate	Moderate
Ruddy Turnstone	*Arenaria interpres*	M(w)			Low	Low
Sharp-tailed Sandpiper	*Calidris acuminata*	M(w)			Moderate	Low
Pectoral Sandpiper	*Calidris melanotos*	M(w)			Low	Low
Red-necked Stint	*Calidris ruficollis*	M(w)			Low	Low
Streaked Shearwater	*Calonectris leucomelas*	M(m)			Low	Low
Red-rumped Swallow	*Cecropis daurica*	M(t)			Low	Low
Little Ringed Plover	*Charadrius dubius*	M(w)			Low	Low
Oriental Plover	*Charadrius veredus*	M(w)			Low	Low
White-winged Black Tern	*Chlidonias leucopterus*	M(m)			Low	Low
Oriental Cuckoo	*Cuculus optatus*	M(t)			Low	Low
Lesser Frigatebird	*Fregata ariel*	M(m)			Low	Low
Great Frigatebird	*Fregata minor*	M(m)			Low	Low
Swinhoe's Snipe	*Gallinago megala*	M(w)			Low	Low
Oriental Pratincole	*Glareola maldivarum*	M(w)			Low	Low
Barn Swallow	*Hirundo rustica*	M(t)			Low	Low
Caspian Tern	*Hydroprogne caspia*	M(m)			Low	Low
Black-tailed Godwit	*Limosa limosa*	M(w)			Low	Low
Grey Wagtail	*Motacilla cinerea*	M(t)			Low	Low
Yellow Wagtail	*Motacilla flava*	M(t)			Low	Low

Common Name	Scientific Name	Conservation Status[1]		Species Recorded within the Study Area[3]	Likelihood of Occurrence	
		EPBC Act[2]	TPWC Act		Study Area	Disturbance Footprint
Little Curlew	*Numenius minutus*	M(w)			Low	Low
Whimbrel	*Numenius phaeopus*	M(w)			Low	Low
Eastern Osprey	*Pandion cristatus*[5]	M(w)			High	Moderate
Glossy Ibis	*Plegadis falcinellus*	M(w)			Low	Low
Pacific Golden Plover	*Pluvialis fulva*	M(w)			Low	Low
Grey Plover	*Pluvialis squatarola*	M(w)			Low	Low
Rufous Fantail	*Rhipidura rufifrons*	M(t)			Low	Low
Roseate Tern	*Sterna dougallii*	M(m)			Low	Low
Common Tern	*Sterna hirundo*	M(m)			Low	Low
Black-naped Tern	*Sterna sumatrana*	M(m)			Low	Low
Little Tern	*Sternula albifrons*	M(m)			Low	Low
Brown Booby	*Sula leucogaster*	M(m)			Low	Low
Lesser Crested Tern	*Thalasseus bengalensis*	(M(w)			Low	Low
Grey-tailed Tattler	*Tringa brevipes*	M(w)			Low	Low
Wood Sandpiper	*Tringa glareola*	M(w)			Low	Low
Common Greenshank	*Tringa nebularia*	M(w)			Moderate	Low
Marsh Sandpiper	*Tringa stagnatilis*	M(w)			Moderate	Low
Terek Sandpiper	*Xenus cinereus*	M(w)			Low	Low
Reptiles						
Salt-water Crocodile	*Crocodylus porosus*	M(m)		X	High	High

1. Conservation Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

2. Subcategories for EPBC Act listing of migratory species follow those within the PMST report

3. Includes records from the recent surveys (2014-2019

4. Subspecies of Limosa lapponica have different listings under the EPBC Act. Limosa lapponica baueri is listed as Vulnerable and Limosa lapponica menzbieri is listed as Critically Endangered.

5. Species listed as Pandion haliaetus in the Protected Matters Search report. Pandion haliaetus cristatus was previously recognised as a subspecies for Australasia and New Caledonia, however it is currently recognised as a species in its own right.

The following section provides details of the migratory fauna species that have been recorded within the Study Area, or which are considered to have a moderate or high likelihood to occur within the Study Area.

6.4.1. EPBC Act Species (Migratory)

Several species listed as migratory under the EPBC Act are considered to have a moderate or high likelihood of occurrence within the Disturbance Footprint, including the Fork-tailed Swift (*Apus pacificus*) and Eastern Osprey (*Pandion cristatus*). Details on these species and their occurrence and habitat within the Study Area and Disturbance Footprint are provided below. One additional species, the Salt-water Crocodile (*Crocodylus porosus*), was assessed as having a high likelihood of occurrence within the Disturbance Footprint. The assessment of this species is contained within the aquatics report prepared for the project and is not considered further within this report.

A number of other migratory bird species are considered to have a potential to occur within the coastal and estuarine complex habitats located in the western portion of the Study Area (see **Figure 14**). As the habitats for these species represent a small proportion of the habitat within the Study Area, and do not occur within the Disturbance Footprint, these species have been considered as having a low likelihood of occurrence. Summary descriptions of these species are, however, provided in **Appendix H**.

<u>**Fork-tailed Swift**</u>

EPBC Act Status: Migratory (marine)

Species Overview

The Fork-tailed Swift is known to migrate to Australia during its non-breeding season (August to March) (DAWE 2020a). This species is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher, mostly over inland plains but sometimes above foothills or in coastal areas (DAWE 2020a). Foraging occurs anywhere from 1 m to 300 m above the ground, with the known diet comprising small bees, wasps, termites and moths (DAWE 2020a). This species breeds in Siberia (DAWE 2020a). There are no significant threats to the Fork-tailed Swift in Australia; however potential threats may include habitat destruction and predation by feral animals (DAWE 2020a). A photograph of a Fork-tailed Swift is shown in **Photograph 14**.

EPBC Act Plans

Conservation Advice

There is no Approved Conservation Advice for the Fork-tailed Swift.

Recovery Plan

There is no Recovery Plan in place for the Fork-tailed Swift.

Threat Abatement Plan

A Threat Abatement Plan is in place for the Fork-tailed Swift for the threat of feral cats.

Referral Guideline

A draft Referral Guideline exists for 14 migratory birds, which includes the Fork-tailed Swift. The draft guideline includes the most current biological and ecological information on the species, important habitat and estimates of ecologically significant proportions of a population (DotE 2015b).

Presence and Habitat within the Study Area and Disturbance Footprint

The Fork-tailed Swift was not recorded within the Study Area during the recent surveys or in database records. The NR Maps database holds six records of this species within the locality (see **Figure 17**), with the latest record from 2018. Neither of these records were within the Study Area. This species was recorded by URS Australia Pty Ltd (2012) on the western side of Groote Eylandt within Melaleuca/riparian habitat (to the north of the Study Area), however the exact location of the record is unknown.

There is potential fly-over habitat for this species above the vegetation within the Study Area and Disturbance Footprint and it is expected to forage aerially about these areas on occasion. No breeding habitat is present within the Study Area (or Groote Eylandt) as breeding occurs outside of Australia.

Photograph 14 Fork-tailed Swift (Source: K. Nicolson in Atlas of Living Australia, 2018)

Eastern Osprey

EPBC Act Status: Migratory (wetland)

Species Overview

The Eastern Osprey occurs in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands (DAWE 2020d). They are mostly found in coastal areas but occasionally travel inland along major rivers (DAWE 2020d). The Eastern Osprey requires extensive areas of open fresh, brackish or saline water for foraging (DAWE 2020d). This species constructs stick nests in a variety of natural and artificial sites including in dead or partly dead trees or bushes; on cliffs, rocks, rock stacks or islets; on the ground on rocky headlands, coral cays, deserted beaches, sandhills or saltmarshes; and on artificial nest platforms, pylons, jetties, lighthouses, navigation towers, cranes, exposed shipwrecks and offshore drilling rigs (DAWE 2020d). The total breeding and non-breeding range of the Eastern Osprey within Australia extends from Esperance in Western Australia to NSW, where records become scarcer towards the south, and into Victoria and Tasmania, where the species is a rare vagrant (DAWE 2020d). The current main threat to the Eastern Osprey in Australia is habitat loss, degradation or alteration of habitat for urban or tourism development (DAWE 2020d). A photograph of an Eastern Osprey is shown in **Photograph 15**.

EPBC Act Plans

Conservation Advice

There is no Approved Conservation Advice for the Eastern Osprey.

Recovery Plan

There is no Recovery Plan for the Eastern Osprey.

Threat Abatement Plan

There are no Threat Abatement Plans in place for the Eastern Osprey.

Referral Guideline

A draft Referral Guideline exists for 14 migratory birds, which includes the Eastern Osprey. The draft guideline includes the most current biological and ecological information on this species, important habitat and estimates of ecologically significant proportions of a population (DotE 2015b).

Presence and Habitat within the Study Area and Disturbance Footprint

The Eastern Osprey was not recorded within the Study Area during the recent surveys. This species was recorded by URS Australia Pty Ltd (2012) on the western side of Groote Eylandt within coastal strand vegetation, however the exact location of the record is unknown. The NR Maps database holds 45 records of this species within the locality of the Study Area (see **Figure 17**), with the latest record from 2019.

Potential habitat for this species occurs in coastal dune/swale complex habitats and estuarine complex habitats, with some riparian areas along the Emerald River that have extensive areas of permanent water also providing habitat within the Study Area. This species is expected to utilise the Study Area as part of a much larger foraging range, and has the potential to utilise the Study Area as breeding habitat. Suitable habitat for this species occurs in the Disturbance Footprint along the Emerald River as there is extensive permanent water.

Photograph 15 Eastern Osprey (Source: P. Harris in BirdLife International, 2016)

7. Impact Assessment

This section presents an assessment of the likely impacts of the project to the terrestrial ecology occurring or likely to occur within the Disturbance Footprint. The impact assessment focuses on species listed under the EPBC Act and/or the TPWC Act that were recorded during the field surveys or considered to have a high or moderate potential to occur due to the presence of suitable habitat.

The following impacts were considered:

- Direct impacts such as the clearing of vegetation and habitat for the construction of the haul road and associated roads, in particular the impacts that are additional to the extent previously approved for clearing (***Section 7.1***); and
- Indirect impacts such as habitat fragmentation, edge effects, the effects of noise and vibration, vehicle strikes, lighting, dust, erosion and the introduction of invasive species, in particular the increase in threats to threatened species (***Section 7.2***).

The scale and timeframe of impacts for each component has been taken into consideration in the impact assessment, and includes the following:

- Haul road: established during the construction phase, ongoing use during mining and rehabilitated at the cessation of mining, subject to agreement with Traditional Owners;
- Construction access track: established during the construction phase, minimal use (light vehicles) during mining and rehabilitated at the cessation of mining; and
- Realigned public access track: relocation of an existing access track, with ongoing impacts comparable to the existing access track.

This section considers these categories of impacts of the project separately for vegetation communities, flora species and fauna species, and includes an impact assessment for each threatened species considered to have a high or moderate potential to occur within the Disturbance Footprint.

The Disturbance Footprint is shown in **Figure 3**. The layout of the Disturbance Footprint has been designed to avoid areas of high ecological value wherever possible. Clearing activities will be subjected to a number of controls to ensure that impacts are minimised. Mitigation measures for these impacts are described in **Chapter 8**.

7.1. Direct Impacts

7.1.1. Vegetation Clearing

The largest direct impact of the project is the removal of native vegetation that also provides habitat for a wide range of flora and fauna species. The total area of the Disturbance Footprint (i.e. the area of direct impact) is approximately 24 ha and includes clearing for the construction of the J Quarry haul road, construction access track and realigned public access track. As noted in ***Section 1.2***, ML961 includes a haul road access corridor connecting the existing mine to J Quarry. This access corridor is approved to be cleared. The project involves the development of a haul road within an alternate alignment of the access corridor. Taking the currently approved area of clearing into account, the project will result in an additional 14 ha of clearing. **Table 17** summarises the extent of vegetation clearing required for the project taking into account the currently approved area.

Table 17 Additional area of vegetation and habitat clearing resulting from the project

Total Disturbance Footprint (ha)	Currently Approved Footprint (ha)	Additional Project Disturbance Footprint (ha)
24 ha	10 ha	14 ha

Table 18 provides a breakdown of the areas of each broad vegetation type to be cleared by the project, and **Figure 18** shows their distribution within the Disturbance Footprint. A breakdown of VMUs within the Study Area and Disturbance Footprint is provided in **Appendix D**.

The dominant broad vegetation type impacted by the project through clearing is Eucalypt open forests of lowlands and deeper sandy soils derived from sandstone or deeply weathered parent rocks (lateritic) which occupies 56% of the Disturbance Footprint.

Table 18 Broad vegetation types within the Disturbance Footprint

Broad Vegetation Types	Corresponding VMUs	Study Area		Total Disturbance Footprint		Currently Approved Footprint		Additional Project Disturbance Footprint	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
1: Mangrove	1	96.3	3.3	-	-	-	-	-	-
3: Dry closed forests or thickets (rainforest) on sand or sandstone	2, 62	83.5	2.9	-	-	-	-	-	-
4: Riparian and gully closed forests with mixed canopies (rainforest and Melaleuca spp.)	5, 18	76.2	2.6	0.9	3.7	0.5	4.6	0.4	3.1
5: Eucalypt open forests of lowlands and deeper sandy soils derived from sandstone or deeply weathered parent rocks (lateritic)	10, 10a, 12, 31	941.7	32.6	13.5	56.1	6.5	66.6	6.9	48.9
7: Eucalypt open forests and woodlands of sandstone uplands	10b, 11	276.3	9.6	0.1	0.4	-	-	0.1	0.7
8: Callitris open forest	15	30.9	1.1	-	-	-	-	-	-
9: Melaleuca open forests on alluvial plains and drainage systems	17, 19	54.5	1.9	0.6	2.4	0.6	6.4	-0.1	-0.4
10: Melaleuca swamps	22, 23	29.4	1.0	-	-	-	-	-	-
11: Eucalypt woodlands and open woodlands of lowlands with sandy soils	40, 40a, 59	417.5	14.5	4.7	19.6	-	-	4.7	33.1
12: Eucalypt woodland and open woodlands on shallow soils associated with basement geologies	13, 53	16.4	0.6	-	-	-	-	-	-
13: Eucalypt woodlands on alluvial soils	42, 45, 51, 51a, 51b, 51c	265.4	9.2	1.9	7.8	1.1	11.7	0.7	5.1

Broad Vegetation Types	Corresponding VMUs	Study Area		Total Disturbance Footprint		Currently Approved Footprint		Additional Project Disturbance Footprint	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
15: Callitris woodland and open woodland	41	26.6	0.9	-	-	-	-	-	-
16: Melaleuca woodlands on alluvial soils (wet)	26, 28, 44, 52	138.0	4.8	1.1	4.6	0.9	9.4	0.2	1.4
17: Melaleuca woodlands on sandy soils (dry)	27a, 27b	4.3	0.1	-	-	-	-	-	-
18: Melaleuca open woodlands on alluvial soils (wet)	43	17.9	0.6	1.1	4.4	-	-	1.1	7.5
20: Eucalypt low open woodland	46	8.6	0.3	-	-	-	-	-	-
21: Shrublands on quaternary sand	72, 82a	18.9	0.7	-	-	-	-	-	-
25: Tussock grasslands on Quaternary sand	82, 82a	23.4	0.8	-	-	-	-	-	-
26: Sedge wetlands	80, 81b, 84, 88	16.9	0.6	-	-	-	-	-	-
29: Saline tidal flats and shrublands	75, 100	2.0	0.1	-	-	-	-	-	-
30: Strand complex	90	1.8	0.1	-	-	-	-	-	-
33: Cleared/disturbed/regrowth	200, 201, 202	91.1	3.2	<0.1	<0.1	-	-	<0.1	0.1
34: Water/ocean	500	243.8	8.4	0.2	0.9	0.1	1.3	0.1	0.7
36: Eucalypt and/or Melaleuca open forest/vine thicket complex	20, 21, 30	7.4	0.3	-	-	-	-	-	-
Total[1]		**2,889**	**100**	**24**	**100**	**10**	**100**	**14**	**100**

1. In some cases totals may not equal the appropriate total number due to rounding.

7.1.2. Habitat Clearing

The native vegetation throughout the Disturbance Footprint provides habitat for a range of flora and fauna, including some species that are listed as threatened or migratory under the EPBC Act and/or TPWC Act. The VMUs within the Disturbance Footprint support only two habitat types for flora and fauna species, and specific habitat features provide foraging, shelter and breeding opportunities for fauna such as mammals and reptiles.

As noted in ***Section 1.2***, the project includes an alternative alignment for an area of the existing GEMCO mine that was approved for clearing. Taking the previously approved area of clearing into account, the project will result in an additional 14 ha of habitat clearing. **Table 17** summarises the extent of habitat clearing required for the project taking into account the previously approved area.

Two habitat types have been identified within the Disturbance Footprint including laterite woodland and forest and riparian / wetland habitats. A breakdown of the clearance of these broad habitat types within the Disturbance Footprint is provided in **Table 19** and **Figure 19** shows their distribution within the Disturbance Footprint. The most impacted broad habitat type is laterite woodland and forest (20 ha), however it represents only 1% of the laterite woodland and forest habitat present within the Study Area. A range of habitat features are present within each of the broad habitats within the Disturbance Footprint and are discussed further below.

Although the project will result in the removal of areas of habitat, extensive areas of land containing similar habitat occurs both within the Study Area and surrounds. It is anticipated that the types of flora and fauna species utilising the habitat within the Disturbance Footprint will continue to persist in these adjacent areas where suitable habitat is present. The impact of the loss of habitat for individual threatened species is assessed in ***Section 7.3*** and ***Section 7.4***.

Table 19 Fauna habitats within the Disturbance Footprint

Habitat Type	VMUs[1]	Study Area		Total Disturbance Footprint		Currently Approved Footprint		Additional Project Disturbance Footprint	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Riparian/wetland habitats	17, 18, 19, 20, 21, 22, 23, 26, 27b (part), 28 (part), 43, 44, 45 (part), 52, 60 (part), 84	305.9	10.6	3.6	15.1	2.0	20.5	1.6	11.5
Laterite woodland and forest habitats	10 (part), 10a (part), 10b (part), 11 (part), 12 (part), 13 (part), 15 (part), 27a, 30 (part), 31, 31a (part), 40 (part), 40a, 41 (part), 42 (part), 45 (part), 46, 51, 51a, 51b, 51c (part), 53, 59	1,872.5	64.8	20.1	83.9	7.7	78.3	12.5	87.8
Sandstone woodland and forest habitats	10 (part), 10a (part), 10b (part), 11 (part), 12 (part), 13 (part), 15 (part), 40 (part), 41 (part), 42 (part), 45 (part), 51c (part), 70	72.0	2.5	-	-	-	-	-	-
Closed forest (rainforest) habitats	2, 5	91.8	3.2	-	-	-	-	-	-
Coastal dune/swale complex habitats	14, 27b (part), 28 (part), 30 (part), 31a (part), 60 (part), 62, 72, 82, 82a, 90	65.9	2.3	-	-	-	-	-	-
Estuarine complex habitats	1, 75, 80, 81b, 88, 100	101.3	3.5	-	-	-	-	-	-
Cleared	200, 201, 202	135.7	4.7	<0.1	<0.1	-	-	<0.1	0.1
Water	500, water, ocean	243.8	8.4	0.2	0.9	0.1	1.3	0.1	0.7
Total[2]		**2,889**	**100**	**24**	**100**	**10**	**100**	**14**	**100**

1. VMUs comprising more than one habitat type are labelled as '(part)' (see Section 3.4).

2. In some cases totals may not equal the total number due to rounding

The project will remove specific habitat features utilised by fauna species for foraging, sheltering, roosting and breeding within the Disturbance Footprint including:

- Understorey vegetation – shelter and foraging habitat for amphibians, reptiles, small birds and terrestrial mammals;
- Fallen logs, debris and leaf litter – shelter habitat for amphibians, reptiles and terrestrial mammals;
- Hollow-bearing living trees and stags – shelter and breeding habitat for a range of reptiles, birds, arboreal mammals and microbats;
- Nectar-producing trees and shrubs – foraging habitat for insects, blossom-dependent birds, arboreal mammals and megachiropteran bats; and
- Feed trees, shrubs and grasses– food for small birds, cockatoos and herbivorous mammals.

Although the project will result in the removal of the aforementioned habitat features, extensive areas of land containing these features occur both within the Study Area and surrounds. The impact of the loss of habitat features is assessed for individual threatened species is ***Section 7.4.***

7.2. Indirect Impacts

The project has the potential to increase the risk of introducing or accelerating the introduction of a number of key threatening processes. This has the most potential to occur via indirect impacts, such as habitat fragmentation and the introduction of invasive species. Additionally, there are a number of potential indirect impacts arising from the construction and operational activities. These include the potential for increased dust, noise, light and erosion. There is the potential for these indirect effects to impact the remaining vegetation and habitat. Indirect impacts relevant to the project have been considered in the context of the potential increase of these impacts beyond the indirect impacts that were already approved. Indirect impacts are considered in more detail below.

Indirect impacts have been considered within the Assessments of Significance within ***Section 7.7***.

7.2.1. Habitat Fragmentation

A degree of habitat fragmentation is likely to occur as a result of the project, particularly for less mobile ground dwelling species, through the clearing of areas of native vegetation and reduction of habitat connectivity. However, the approved layout of the haul road corridor, which is 60 metres wide, would also cause fragmentation of habitat. The increase in total width of the realigned haul road disturbance footprint, being an increase of up to 80 m in width, will not significantly change or increase the degree of habitat fragmentation that would be caused by the approved haul road. Moreover, for either haul road design, habitat connectivity for ground dwelling species will be maintained within strips of habitat retained along the coastline. Consequently, the movement and dispersal opportunities for fauna including threatened fauna species, are not expected to be significantly worsened by the proposed access corridor.

The impacts to fauna movement and dispersal on threatened species are discussed in ***Section 7.4***.

Whilst some fragmentation of habitat will occur in the vicinity of the construction access track and the realigned public access track, the impacts are considered to be minimal due to the relatively narrow width of the tracks (between 3 – 10 m) and total length (approximately 4 km) . Most of the fauna species potentially impacted by habitat fragmentation, including threatened species such as the Northern Quoll and Yellow-spotted Monitor are likely to be able to cross these narrow tracks.

7.2.2. Edge Effects

The project will result in edge effects where vegetation is cleared within the Disturbance Footprint. Due to edge effects, the indirect impacts of the clearing may extend beyond the areas that are being cleared and into the areas of adjacent habitat that fringe the Disturbance Footprint. Edges effects are considered most likely to occur along the haul road, due to the increased scale of impact (approximately 80 m width increase in comparison to the approved corridor), with the increased width contributing to increased microclimate changes. The project is considered to result in a minor increase in the extent of edge effects along the haul road beyond the impacts that were already approved. Indirect impact that would extend into the areas adjacent to the haul road include noise and vibration, alteration of light levels, dust, and erosion and sedimentation.

Whilst some edge effects will occur in the vicinity of the construction access track and realigned public access track, the impacts are considered to be minimal due to the relatively narrow width and limited use of the tracks. For the realigned public access track, the scale of impact will be commensurate with edge effects along the existing public access track.

7.2.3. Noise and Vibration

The noise created by the construction and operation of the project is likely to affect native species and affect the value of the habitats that remain. Some species are likely to move in response to noise, and therefore the habitat value of the woodlands and forests remaining in the immediate vicinity of the Disturbance Footprint may decrease. This has the effect of increasing the amount of habitat for native species that will be disturbed as a result of the project. However, the construction period will be undertaken in the dry season and take place over a 6-8 month period. It is likely that most animal species will habituate to noise disturbance (AMEC 2005), and that noise and vibration impacts from the project are likely to only cause temporary disturbance to fauna. Cumberland Ecology (2015a) detected a range of fauna species, including the Northern Quoll, in rehabilitation areas located in proximity to active mining operations, and along the Rowell Highway. Furthermore, the impacts from noise emissions are likely to be localised close to the haul road. The project is considered to result in a minor increase in the extent of noise and vibration along the haul road beyond the impacts that were already approved. This minor increase is due to the increased scale of impact.

7.2.4. Vehicle Strike

The project will construct the J Quarry haul road as well as the access tracks, and the vehicles traversing these roads can impact animals that may cross and navigate these roads. Impacts from vehicle strike are most likely to occur along the haul road due to large haul trucks and other large mine vehicles operating on these roads, however vehicle strikes may also occur along the construction access track and public access track.

The project is considered to result in a minor increase in impact of vehicle strike along the haul road beyond the impacts that were already approved. However, a chain wire mesh fence will be constructed on both sides of the haul road from the light vehicle access tunnel and extend 100m to the north and south running parallel with the haul road. This fencing is designed to stop public access to the haul road, however will also prevent wildlife from directly crossing the haul road. Whilst some vehicle strike may occur along the construction access track and realigned public access track, the impacts are considered to be minimal due to the relatively narrow width and limited use of the tracks. For the realigned public access track, the scale of impact will be commensurate with impacts along the existing public access track.

Speed limits along haul roads, appropriate signage and GEMCO's own enforced driving policies will increase the awareness of drivers and decrease the risk of vehicles striking fauna. This will assist to limit the potential for vehicle strike to occur.

7.2.5. Light

The project will include lighting required during construction for night time works, however post construction, there will be limited lighting along the haul road and any required lighting will be designed to minimise potential impacts on the surrounding environments. As such, the impacts from night light pollution are likely to remain close to the light sources, with only limited glare into the surrounding natural vegetation. It is likely that most fauna species would habituate to the levels of light pollution or temporarily move away from areas of night lighting. Light is therefore unlikely to have a significant or long-term impact on any fauna species. The project is considered to result in a minor increase in impact of light pollution along the haul road beyond the impacts that were already approved due to the minor increase in construction activities resulting from the larger width of the access corridor.

7.2.6. Dust

Construction and operational activities have the ability to generate dust, which may impact on the terrestrial ecology within the Study Area in a number of ways. The scale and extent of dust impact will vary between the construction and operational phases of the project. During construction, dust impacts will occur as a result of clearing of vegetation. Ongoing dust impacts will primarily be the result of ongoing use of the haul road. Impacts associated with the construction access track and realigned public access track post construction will be commensurate with dust impacts currently experienced along the existing public access track due to the low frequency of light vehicle movements.

The effect of dust deposition also affects animals that use plants, either as a source of food or habitat. Dust on the foliage and fruit may reduce palatability to animals, and decreased health of trees and changed community structure results in a reduction in the amount of available habitat. Dust pollution can lead to a decrease in habitat quality which has the potential to extend the area of impact beyond the Disturbance Footprint. Increased levels of dust could impact vegetation within woodland communities, reducing the health of some species along the edge of haul roads and access tracks. It could also impact upon potential foraging resources for wildlife in areas immediately adjacent to the Disturbance Footprint. Dust is less likely to be an issue in the wet season, than in the dry season. Standard dust minimisation strategies such as watering haul roads, application of speed limits and general awareness by the GEMCO workforce will be implemented to minimise the creation of dust, particularly during the dry season.

A specific dust investigation was conducted as part of the Eastern Leases Project by Cumberland Ecology (2015a) to establish whether there was evidence that dust was having an impact on native vegetation adjacent to the existing GEMCO mine, particularly vegetation adjacent to an existing haul road. The study found that dust was deposited mainly on vegetation on the western side of the mine/haul road, due to the prevailing winds being from the north east and north west. While bands of dust were clearly discernible on the canopy of forest vegetation as seen from aerial photographs taken during the dry season, the vegetation survey found no evidence that dust was having a significant detrimental impact upon native vegetation. This was shown by:

- No evidence of crown dieback, or dieback of any of the open forest strata;
- No floristic difference between vegetation samples taken from areas exposed to dust and vegetation in control sites in relatively dust-free areas; and
- No evidence of additional weed species in areas where dust is prevalent.

In areas where dust is prevalent due to mining on Groote Eylandt, two factors are likely to naturally mitigate dust impacts on vegetation and fauna habitat: rain and fires. Heavy rains during the wet season wash dust from foliage and settle the dust raised from activities along haul roads and quarries. Fire removes old and dusty foliage and triggers renewed foliage growth, providing new surfaces for photosynthesis, and improves food for herbivores.

Given these factors, and the experience at the existing GEMCO mine, it is considered unlikely that dust impacts will significantly affect the terrestrial ecology of the areas surrounding the Disturbance Footprint. The project is considered to result in a minor increase in the extent of dust impacts along the haul road beyond the impacts that were already approved. This minor increase is due to the increased scale of impact.

Whilst some dust impacts will occur in the vicinity of the construction access track and realigned public access track, the impacts are considered to be minimal due to the relatively narrow width and limited use of the tracks. For the realigned public access track, the scale of impact will be commensurate with dust impacts along the existing public access track.

7.2.7. Erosion and Sedimentation

The project has the potential to increase the amount of erosion occurring in the Study Area through the construction of the haul road and associated roads, and due to vegetation clearance associated with these activities. Water erosion of soil can be classified into four categories, being sheet, rill, gully, and tunnel erosion (Harpstead et al. 2001). Sheet erosion is the uniform removal of soil without the development of visible water channels and is the least apparent of the four erosion types. Rill erosion is soil removal through the cutting of many small, but conspicuous, channels. Gully erosion is the consequence of water that cuts down into the soil along the line of flow and this type of erosion develops more quickly in places like tracks and animal trails. Tunnel erosion may occur in soils with sub-surface layers that have a greater tendency to transport flowing water than does the surface layer.

The project will create new roads and tracks within the Disturbance Footprint, with an associated risk of increase in gully erosion. During wet periods large volumes of rain have the ability to wash away disturbed earth relatively easily, particularly if located on a slope. There is an increased risk of sheet and rill erosion where large areas are cleared. Where there is no obvious existing channel for the water to follow, it will form rills or flow overland.

The project is located in a tropical climate, and heavy rainfall during the wet season can erode and wash away any disturbed earth relatively easily. The haul road may be subject to erosion, potentially leading to runoff with elevated levels of suspended sediment. This may result in sedimentation and increased turbidity of streams and would therefore impact the aquatic environment. However, the haul road is being designed to ensure that is has a compacted laterite sub base and wearing course to reduce erosion and sedimentation. I addition, the cambre, raddi and fall of the haul road is being designed to allow any runoff water to report to sediment basins located along the perimeter of the road. The haul road is also being designed to a flood immunity of 1:2 to 1:5 annual exceedance probability and will be regularly maintained. Erosion and sedimentation impacts are likely to primarily occur during the construction phase of the project, with some ongoing impacts during the operational phase. Whilst erosion and sedimentation would have occurred as part of the previously approved impact, the project is considered to increase the scale of these impacts due to the increase scale and design of the haul road.

During both construction and operational phases, erosion and sedimentation impacts can be minimised through the implementation of mitigation measures. Impacts of erosion and sedimentation are to be mitigated via a number of measures including capture and diversion of runoff, vegetating exposed batters and drains, lining batters and drains. Given these measures, and the experience at the existing GEMCO mine, it is considered unlikely that erosion and sedimentation impacts will significantly affect the terrestrial ecology of the areas surrounding the Disturbance Footprint.

7.2.8. Feral Animals and Weeds

Alterations to habitat conditions often favour introduced and/or hardy native plant and animal species that can proliferate in disturbed conditions. Such species have the potential to impact upon the existing local native plant and animal species. This is especially the case on Groote Eylandt, where the main reason for the conservation significance of the island is thought to be the absence or near absence of key threatening processes (such as feral animals) that occur on the Australian mainland (NRETAS 2009).

GEMCO has a quarantine procedure that provides guidance on how to correctly inspect barges and their cargo coming to the port facilities at Milner Bay. This applies to shipping containers, vehicles and equipment. The procedure is designed to prevent unwanted weeds and pests arriving on Groote Eylandt.

The potential for invasive species to be introduced by the project is discussed in the following sections.

7.2.8.1. Weeds

Weed invasion is identified as a key threat in the TSMP. Weeds have the potential to out-compete native plant species for resources such as nutrients, sunlight and space. Weeds are generally spread via contaminated vehicles and machinery, animals and watercourses (DENR and ALC 2019). Weeds are most likely to occur at disturbed locations where they can be readily spread. The invasion of weeds within native vegetation can alter the diversity and functioning of vegetation communities.

It will be important to ensure that the project is undertaken in a manner that does not give rise to the introduction of weeds. Weed species that are known to occur in the existing mining tenements have the highest potential to establish in the vicinity of the Disturbance Footprint. A number of declared weeds have previously been recorded within GEMCO's existing mining tenement including *Cenchrus echinatus* (Mossman River Grass), *Cenchrus polystachios* (Mission Grass), *Senna obtusifolia* (Sicklepod) and *Sida acuta* (Spinyhead Sida) (URS Australia Pty Ltd 2012). The NT Natural Resource Maps database (NR Maps database) (DNRM 2020) holds a number of records within the existing GEMCO mine, such as *Jatropha gossypiifolia* (Bellyache) and *Themeda quadrivalvis* (Grader Grass) which are highly mobile. Weeds that are more common in the existing mining tenements include *Hyptis suaveolens*, *Passiflora foetida* (Stinking Passionflower), *Urochloa mosambicensis* (Sabi Grass) and *Stylosanthes* spp. (the Stylos) (Addison 2013).

There is potential for weeds to be introduced and become established as construction works take place for the project within the Disturbance Footprint or from movement of haul trucks once the haul road is in use. Weed species known to occur in the existing mine tenements are likely to have the highest potential to be introduced to the Study Area. The project is not considered to result in a significant increase in weed species beyond previously approved impacts.

GEMCO will implement weed control measures for the Study Area (**Chapter 8**). Weed management measures for the project will focus on preventing the introduction of weeds, the identification and reporting of known invasive weeds species, the early detection and eradication of weeds before they establish and employee awareness. With the implementation of these measures, it is unlikely that weeds will have a significant impact on the ecology of the Study Area.

7.2.8.2. Feral Animals

Feral animals can cause problems for native fauna species by preying upon them or by competing with them for food and resources. Feral animals considered likely to occur within the Study Area are the feral dog (*Canis familiaris*) and feral cat (*Felis catus*). Predation by feral cats is identified as a key threat in the TSMP. The feral cat population on Groote Eylandt appears to have a low density, however significant predation may still exist (DENR and ALC 2019). Low numbers of feral cats were observed within the adjacent Southern Lease and surrounds during recent surveys by Cumberland Ecology (2019c). Heiniger et al. (2020) also detected low numbers of cats within the Southern Lease. Feral cats occurred in both disturbed areas (i.e. areas subject to exploration) and areas not subject to disturbances, and it is likely they opportunistically move throughout the landscape to areas with abundant prey.

The project has the potential to increase the numbers of feral dogs and feral cats due to the creation of transport vectors for feral animals such as tracks and haul roads. Given that there are existing tracks within the Study Area which would also facilitate movement, the project is not considered to result in a significant increase in movement of these species beyond previously approved impacts.

Poisoning by the Cane Toad (*Rhinella marina*) is identified as a key threat in the TSMP. The Cane Toad (*Rhinella marina*) is currently absent from Groote Eylandt. In addition to the quarantine procedure described above, GEMCO also has a specific Cane Toad Management Plan which operates across all of the GEMCO leases. This plan will continue to operate and will be applicable for the project. As such, the project is unlikely to exacerbate the risk of the introduction of this species to the island beyond current conditions, given that it will not significantly increase transport vectors for the Cane Toad.

7.3. Impacts to Threatened Flora Species

7.3.1. EPBC Act Species

No threatened flora species listed under the EPBC Act have been encountered within the Disturbance Footprint and none are predicted to occur. As such, no impacts to EPBC Act listed flora species are anticipated.

7.3.2. TPWC Act Species

No threatened flora species listed under the TPWC Act have been encountered within the Disturbance Footprint and none are predicted to occur. As such, no impacts to TPWC Act listed flora species are anticipated.

7.4. Impacts to Threatened Fauna Species

Several threatened species listed under the EPBC Act and/or TPWC Act have the potential to occur within the Disturbance Footprint, given the proximity of recent database records and the presence of suitable habitat for these species. These species include the Masked Owl (northern), Northern Quoll, Ghost Bat, Yellow-spotted Monitor and Mertens' Water Monitor, and two migratory species (Fork-tailed Swift and Eastern Osprey). The potential impacts to the threatened and migratory species with a high to moderate likelihood of being present within the Disturbance Footprint, are discussed below.

An assessment of the significance of impacts to each of the EPBC Act listed species has been undertaken according to the Significant Impact Guidelines and are provided in **Appendix I**. The assessment concluded that the project is not predicted to have a significant impact on all EPBC Act listed species. A range of impact avoidance and mitigation measures have been developed to address potential impacts.

7.4.1. EPBC Act Species (Threatened)

7.4.1.1. Masked Owl (northern)

EPBC Act Status: Vulnerable

TPWC Act Status: Vulnerable

The Masked Owl (northern) is considered to have a high likelihood of occurring within the Disturbance Footprint and it is anticipated that this species would utilise the available habitat for foraging and breeding. Approximately 14 ha of additional habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. Key habitats that will be removed by the project include laterite woodland and forest habitats, and riparian habitats, both of which contain hollow-bearing trees and suitable prey items for the Masked Owl (northern).

Previous surveys within the Eastern Leases identified potential hollows for this species within *Eucalyptus tetrodonta* (Darwin Stringybark), *Eucalyptus miniata* (Darwin Woollybutt) and dead standing trees (EMS 2013, 2014). Although the Masked Owl (northern) requires medium- to large-sized hollows, which are not present in all areas, a high proportion of the tree species to be removed within the Disturbance Footprint comprise these tree types. Recent surveys within the Disturbance Footprint identified a total of 52 large trees, which can be used as an indicator of potential breeding habitat for the Masked Owl as large trees would most likely be associated with large hollows. Large trees frequently encountered included *Melaleuca cajuputi* (Cajuput Tree) (16 trees) and *Eucalyptus tetrodonta* (Darwin Stringybark) (14 trees). The highest concentration of large trees occurs in proximity to the Emerald River and Emerald River Southern Tributary, with 33 large trees having been recorded within 100 m of these waterways.

The removal of approximately 14 ha of additional habitat will reduce the potential area of occupancy for the species. Hollow-bearing trees are considered critical to the survival of this species and the project is likely remove such features. However due to the small and linear nature of the disturbance, the project is unlikely to disrupt the breeding cycle of the population of the Masked Owl (northern) on Groote Eylandt.

The project may also result in indirect impacts to this species, through edge effects and alteration of light and noise levels, however these impacts are only increased slightly beyond impacts that were already approved. Many of these indirect impacts may have consequences on the foraging resources for the Masked Owl (northern), as small- to medium-sized ground-dwelling mammals (i.e. prey for the Masked Owl (northern)) may alter habitat usage in response to these impacts. These indirect impacts are not considered to result in a decline of the Masked Owl (northern) population of Groote Eylandt as they will be localised to the Development Footprint and the species is expected to occupy a range of areas on Groote Eylandt at various times. It is also considered unlikely that the project will increase the potential risk of invasive species becoming established beyond current conditions or introduce disease, which could cause the population of the species to decline.

The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species. This species is considered to be tolerant to some disturbance in their habitat because it is highly mobile and is expected to occupy a range of areas on Groote Eylandt at various times, and therefore is not reliant on the habitat of the Disturbance Footprint. Extensive areas of potential habitat will remain across the island.

An assessment of significance has been conducted for this species according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (DotE 2013b) (see **Appendix I**). This assessment indicates that no significant impact is predicted on the Masked Owl (northern) as a result of the project.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to the Masked Owl (northern), including positioning the proposed access corridor to minimise impacts to riparian environments which provide suitable breeding habitat for the species.

7.4.1.2. Northern Quoll

EPBC Act Status: Endangered

TPWC Act Status: Critically Endangered

The Northern Quoll has been recorded within the Study Area, including in close proximity to the Disturbance Footprint. It is anticipated that this species would forage and breed within the Disturbance Footprint. Critical habitats that will be removed by the project include laterite woodland and forest habitats, and riparian habitats, along with habitat features such as tree hollows, hollow logs and termite mounds.

Approximately 14 ha of additional habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species.

A degree of habitat fragmentation is likely to occur as a result of the project, particularly for less mobile ground dwelling species, through the clearing of areas of native vegetation and reduction of habitat connectivity. However, the approved layout of the haul road corridor, which is 60 metres wide, would also cause fragmentation of habitat. The increase in width of the realigned haul road will not significantly change or increase the degree of habitat fragmentation that would be caused by the approved haul road. Moreover, for either haul road design, habitat connectivity for ground dwelling species will be maintained within strips of habitat retained along the coastline. Consequently, the movement and dispersal opportunities for fauna including threatened fauna species, are not expected to be worsened by the proposed access corridor.

The project may also result in other indirect impacts to this species, through edge effects and alteration of light and noise levels, however these impacts are only increased slightly beyond impacts that were already approved. Vehicle strike is also relevant to the species because individuals may cross the haul road, particularly during the night.

The potential impacts of the project on the Northern Quoll were assessed against the *Northern Quoll Referral Guideline* (DotE 2016). This guideline assists proponents in determining whether an action will potentially have a significant impact on the Northern Quoll. An assessment of significance has been conducted for this species according to the *Northern Quoll Referral Guideline* (DotE 2016) (see **Appendix I**). This assessment indicates that a significant impact is not likely to occur on the Northern Quoll as the project will only result in a minor increase in direct and indirect impacts from that which have already been approved.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to the Northern Quoll. This includes the management of indirect impacts such as light, noise and vibration which will minimise disturbance to foraging habitat for the species, and implementation of Cane Toad management measures, which is a key potential threat to the species.

No offsets are proposed to be provided for this species, because additional habitat loss associated with the project is not materially greater than the impacts of the approved haul road, when considering the nature and extent of habitats occupied by the Northern Quoll on Groote Eylandt.

7.4.1.3. Ghost Bat

EPBC Act Status: Vulnerable

TPWC Act Status: Not listed

The Ghost Bat is considered to have a high likelihood of occurrence within the Disturbance Footprint and it is anticipated that this species would utilise the available habitat for foraging. Approximately 14 ha of additional habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. Key habitats that will be removed by the project include laterite woodland and forest habitats, and riparian habitats, both of which comprise foraging habitat for this species. Breeding habitat comprises areas of rocky outcropping and caves, neither of which occur within the Disturbance Footprint. The closest areas of rocky outcropping occur approximately 1 km north east and 1.2 km south east of the eastern end of the construction access track within sandstone woodland and forest habitats (see **Figure 14**).

The removal of approximately 14 ha of additional habitat will reduce the potential area of occupancy for the species. No critical habitat (comprising roosting or breeding habitat), such as areas of sandstone outcropping, will be removed for the project. Due to the absence of such features within the Disturbance Footprint, or close proximity, the project is unlikely to potentially disrupt the breeding cycle of the Ghost Bat population on Groote Eylandt.

The project may also result in indirect impacts to this species, through edge effects and alteration of light and noise levels, however these impacts are only increased slightly beyond impacts that were already approved. Many of these indirect impacts may have consequences on the foraging patterns of the Ghost Bat and foraging behaviours may change as a result of altered conditions. These indirect impacts are not considered likely to result in a decline of the Ghost Bat population on Groote Eylandt as they will be localised to the Development Footprint and the species is expected to occupy a range of areas on Groote Eylandt at various times. Furthermore the project is located outside of breeding habitat for the species. It is also considered unlikely that the project will increase the potential risk of invasive species becoming established beyond current conditions or introduce disease, which could cause the population of the species to decline.

The loss and modification of potential foraging habitat would result in a net decrease in the amount of suitable habitat available to this species. Due to the small area of impact to the species, the highly-mobile nature of the species enabling continuation of movement patterns, and the presence of extensive areas of habitat across Groote Eylandt it is likely that the species able to tolerate this loss of habitat. Furthermore, the project will not impact directly on breeding habitat as no rocky outcropping or caves occur within the Disturbance Footprint.

An assessment of significance has been conducted for this species according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (DotE 2013b) (see **Appendix I**). This assessment indicates that no significant impact is predicted on the Ghost Bat as a result of the project.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to the Ghost Bat, including the management of indirect impacts such as light, noise and vibration which will minimise disturbance to foraging habitat for the species.

7.4.2. TPWC Act Species

7.4.2.1. Yellow-spotted Monitor

EPBC Act Status: Not listed

TPWC Act Status: Vulnerable

The Yellow-spotted Monitor is considered to have a high likelihood of occurrence within the Disturbance Footprint and it is anticipated that this species would utilise the available habitat for foraging and breeding. Approximately 14 ha of additional habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. Key habitats that will be removed by the project include laterite woodland and forest habitats, and riparian/wetland habitats, which both comprise foraging and breeding habitat for this species. The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species.

The project may also result in indirect impacts to this species, through edge effects and alteration of light and noise levels. These indirect impacts may have consequences on the foraging resources for the Yellow-spotted Monitor as prey species may alter habitat usage in response to these impacts. However, the Yellow-spotted Monitor is known to occur in areas adjacent to main roads and is assumed to have a relatively high tolerance to impacts such as light and noise.

The project will result in an increase in habitat fragmentation due to the additional clearing required for the realigned haul road. However, the additional clearing required is unlikely to significantly increase the fragmentation of habitat beyond that which has already been approved. Habitat connectivity will be maintained along the coastline and the movement and dispersal opportunities for the Yellow-spotted monitor are not expected to be exacerbated beyond that which have already been approved.

The project may also result in other indirect impacts to this species, through edge effects and alteration of light and noise levels, however these impacts are only increased slightly beyond impacts that were already approved. Vehicle strike is also relevant to the species as individuals may cross the haul road, particularly during the night. The direct loss of habitat and fragmentation of habitat is not considered to have a significant impact on this species as the project will only result in a minor increase of these impacts beyond that which have already been approved.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to the Yellow-spotted Monitor, including the management of indirect impacts such as light, noise and vibration which will minimise disturbance to breeding and foraging habitat for the species, and implementation of Cane Toad management measures.

7.4.2.2. Mertens' Water Monitor

EPBC Act Status: Not listed

TPWC Act Status: Vulnerable

Mertens' Water Monitor is considered to have a high likelihood of occurrence within the Disturbance Footprint and it is anticipated that this species would utilise the available habitat for foraging and breeding. Approximately 14 ha of additional habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. Key habitats that will be removed by the project include laterite woodland and forest habitats, and riparian habitats, both of which comprise foraging and breeding habitat for this species. The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species.

The project may also result in indirect impacts to this species, through habitat fragmentation, edge effects and alteration of light and noise levels, however these impacts are only increased slightly beyond impacts that were already approved. Habitat fragmentation will occur as a result of the haul road bisecting the Emerald River Southern Tributary. Edge effects, and alteration of light and noise levels is likely to impact the Mertens' Water Monitor in proximity to the bridge established over the Emerald River as these alterations may deter the species from occupying nearby habitat. Impacts to aquatic habitats, such as erosion and sedimentation may also impact this species, although it is noted that controls will be established to avoid erosion and sedimentation. Additionally, the alteration of movement corridors and hydrological regimes has the potential to impact this species.

The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species. Due to the small area of impact to the species, the persistence of a movement corridor along the Emerald River, and the presence of extensive areas of habitat along waterways across Groote Eylandt, it is likely that the species is able to tolerate the loss of and disturbance to habitat. Therefore, the project is not considered to have a significant impact on this species.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to Mertens' Water Monitor, most notably the avoidance of significant impacts to the Emerald River through the establishment of a bridge allowing continued movement of this species along this waterway.

7.4.3. EPBC Act Species (Migratory)

7.4.3.1. Fork-tailed Swift

EPBC Act Status: Migratory (marine)

The Fork-tailed Swift is considered to have a moderate likelihood of occurrence within the Disturbance Footprint. There is potential fly-over habitat for this species above the vegetation within the Disturbance Footprint and it is expected to forage aerially above these areas on occasion. No breeding habitat is present within the Study Area (or Groote Eylandt) as breeding occurs outside of Australia.

This species is an extremely wide-ranging bird that accesses resources from across a large area and it is unlikely to be dependent on the resources present above the Disturbance Footprint for its survival.

An assessment of significance has been conducted for this species according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (DotE 2013b) (see **Appendix I**). This assessment indicates that no significant impact is predicted on the Fork-tailed Swift as a result of the project.

7.4.3.2. Eastern Osprey

EPBC Act Status: Migratory (wetland)

The Eastern Osprey is considered to have a moderate likelihood of occurrence within the Disturbance Footprint and it is anticipated that this species would utilise the available habitat for foraging and breeding. Approximately 2 ha of additional foraging and breeding habitat will be removed by the project within the Disturbance Footprint, beyond what is already approved to be cleared. Key potential foraging and breeding habitats that will be removed by the project are riparian habitats.

The project may also result in indirect impacts to this species, through the alteration of light and noise levels. The Eastern Osprey potentially nests in treed vegetation along the Emerald River, and the alteration of light and noise levels may deter the species from occupying nearby habitats.

The loss and modification of potential foraging and breeding habitat would result in a net decrease in the amount of suitable habitat available to this species. This species is considered to be tolerant to some disturbance in their habitat as the species is highly-mobile and is widespread across Groote Eylandt in coastal areas (see **Figure 17**), therefore not relying on the habitat of the Disturbance Footprint. Extensive areas of potential habitat will remain across the island.

An assessment of significance has been conducted for this species according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (DotE 2013b) (see **Appendix I**). This assessment indicates that no significant impact is predicted on the Eastern Osprey as a result of the project.

A range of impact avoidance and mitigation measures have been developed for the project and these are presented in **Chapter 8**. A number of these measures are relevant to the Eastern Osprey, including the management of indirect impacts such as light, noise and vibration which will minimise disturbance to breeding and foraging habitat for the species, and implementation of Cane Toad management measures.

7.5. Cumulative Impacts

Cumulative impacts result when many small-scale alterations to the environment combine to cause an overall greater level of impact. In a mining environment, cumulative impacts can arise from the compounding activities of a single operation or multiple mining and processing operations in the same area, as well as the interaction of mining impacts with other past, current and future activities that may not be related to mining (Franks et al. 2008).

Cumulative impacts can arise from either persistent losses of one resource, or the compounding effects of two or more impacts (Lindenmayer and Fischer 2006). Direct and indirect impacts that may be considered insignificant on their own may be significant when considered together with other actions being undertaken as part of the project, or with other similar projects in the locality.

Cumulative impacts are likely to arise on a local scale as a result of the combination of ongoing operations within the existing mining areas, the approved expansion of mining within areas proximate to the Disturbance Footprint. The additional clearing associated with the Project also contributes to these cumulative impacts. Further to this, indirect impacts including lighting within the pit, dust generated by machinery and truck movements, and noise from the workings, blasting and infrastructure facilities may generate impacts on the retained habitat within the Study Area.

8. Impact Mitigation

8.1. Introduction

The purpose of this chapter is to outline the avoidance and mitigation measures proposed to ameliorate the impacts of the project on terrestrial flora and fauna. As demonstrated in previous chapters, the Disturbance Footprint provides habitat for a range of terrestrial flora and fauna, including threatened fauna species listed under the EPBC Act and/or the TPWC Act. As discussed in **Chapter 7**, the project will potentially impact threatened species through the clearing of this habitat and a range of indirect impacts.

The impact reduction measures for the project include the following hierarchy of principles:

- Avoid - to the extent possible, the project has been designed to avoid or minimise ecological impacts;
- Mitigate - where certain impacts are unavoidable through design changes, mitigation measures have been introduced to ameliorate the ecological impacts of the project; and
- Compensate – to provide compensation where any residual impacts remain after all mitigation measures have been adopted.

Section 8.2 summarises the avoidance measures incorporated into the design of the project. ***Section 8.3*** outlines the detailed suite of mitigation measures that will be implemented to reduce the impact of the project on terrestrial flora and fauna. ***Section 8.4*** describes biodiversity offsets that are proposed.

8.2. Measures to Avoid Impacts

The avoidance of impacts has been achieved to the extent possible by modification of the design and location of the haul road.

GEMCO/South32 has investigated several possible alignments for the haul road. Criteria that were looked at to determine the alignment included:

- Environmental – minimising the potential impact on the Emerald River riparian zone and its tributaries, as well as sensitive and significant vegetation, to the extent possible;
- Cultural – avoidance of culturally sensitive areas including along the Emerald River and the Yedikba Outstation;
- Safety Management;
- Approvals; and
- Economics.

One alignment for the haul road was deemed to be suitable as a result of the assessment and is shown in **Figure 3**. Key avoidance and minimisation measures relevant to the selected haul road alignment which relate to environmental criteria, and specifically terrestrial biodiversity values include:

- Avoiding the known occurrences of monsoon vine forests;
- Positioning the proposed access corridor to minimise impacts to the riparian zone of the Emerald River;

- Optimising the haul road crossing location of the Emerald River to minimise impacts on flood behaviour and areas that would be inundated;
- Minimising the width of the proposed roads as far as practicable; and
- Minimising the extent of deviation of the realigned public access track from the existing public access track.

GEMCO/South32 will endeavour to achieve further avoidance of terrestrial biodiversity beyond that described during the construction and operational phases of the project. Such avoidance may include limiting disturbance as much as practicable, within the proposed Disturbance Footprint boundary.

8.3. Measures to Mitigate Impacts

GEMCO/South32 has been mining on Groote Eylandt since the 1960s. A suite of mitigation measures have been progressively developed to minimise impacts on terrestrial flora and fauna. The policies and plans that currently apply to the management of terrestrial biodiversity will also apply to the project and are discussed in the following sections.

8.3.1. Clearing

Clearing will be undertaken in accordance with the proponent's Permit to Clear process. As described below, this process includes specifications designed to limit the impact of the clearing activity itself through staged clearing. Undertaking the clearing in a staged manner will:

- Maximise the potential for mobile species to move to adjacent areas; and
- Provide an opportunity for the collection of seeds for use in rehabilitation. Seeds will be collected and stored in accordance with existing procedures.

The following principles will be implemented as part of the proponent's Permit to Clear process (which includes a procedure and an associated form):

- A preclearing survey will be undertaken which will:
    - Delineate the limits of clearing prior to the commencement of any clearing and marked clearly on plans and on the ground;
    - Identify any noxious weeds so that clearing can be undertaken in a manner that avoids the spread of weeds as far as possible;
    - Identify potential habitat trees that may be suitable for threatened fauna species (i.e. hollow-bearing trees) for controlled felling;
- Clearing will be confined to the smallest practicable area in accordance with the project's feasibility study to safely perform the task;
- Clearing work will be planned in a manner that causes minimum disturbance to natural drainage patterns;
- Vegetation removal will be carried out using appropriate earthmoving equipment; and

- Disturbance of the topsoil will be kept to a minimum to enable reuse in mine rehabilitation works.

8.3.2. Weed Management

Weed management measures will focus on employee awareness, preventing the introduction of weeds, and on the early detection and eradication of weeds before they establish. In particular, weed control and monitoring will be undertaken within the cleared areas in accordance with GEMCO's Weed Management Manual. These documents include measures to ensure that planned activities do not introduce weeds and include inspecting and washing vehicles that enter the designated Disturbance Footprint area. These measures include the following:

- Prior to clearing taking place in the Disturbance Footprint, a pre-clearance survey will be undertaken of the area to be cleared. This survey will include identifying the location of any weeds that exist in the area to be cleared. Any weeds that are identified will be GPS recorded and sprayed or removed prior to any clearing.
- Weeds that are recorded within the Disturbance Footprint, either through pre-clearance surveys or through incidental sighting of weeds will be recorded in the proponent's geographic information system database. The database will also include a record of weed control actions that are required, a record of the actions that have been undertaken, and details of follow up monitoring.
- A risk based approach will be adopted in relation to vehicle washdown and inspection procedures, as follows:
    - Vehicles that are considered a high risk for the introduction of weeds will be subject to washdown and inspection procedures before entering the project site. High risk vehicles are any vehicles that have been operating in areas that are considered a moderate or high risk for weeds (e.g. areas within the existing GEMCO mine that are subject to existing weed infestations, off-road areas). This will apply to all equipment that have been working in these areas, including graders, rubber tyre dozers, light vehicles etc.
    - Haul trucks that travel continually between the mining areas and the Run of Mine stockpile at the existing GEMCO mine are considered to be a lower risk for the introduction of weeds. The trucks will follow a set route and the road verges will be routinely inspected for weeds. Weed control measures will be implemented in the event of weeds being recorded along this route. Haul trucks will not be subject to a washdown procedure, provided they follow this low risk transport route.
- The existing vehicle wash bay facility is located at the mine industrial area adjacent to the Maintenance Workshop. The inspection procedure involves checking the entire piece of equipment for noticeable traces of soil/seeds and plant material. This includes checking the deck area, wheel arches, belly plates, front grill and radiator.
- Prior to commencing work within the Disturbance Footprint, personnel will undertake a daily check for weed seeds on work clothes or boots prior to entering the Disturbance Footprint.

- Contractors and suppliers will be required, as part of the proponent's standard supply contract, to ensure that all plant, vehicles and equipment have been adequately washed down prior to arrival on the island. Prior to arrival on the island, the proponent's nominated representative will be required to inspect all plant and equipment on the Australian mainland to ensure compliance with washdown requirements.
- Weed control will be undertaken in accordance with existing procedures, as required.
- Communication and reporting on weeds will occur as part of the Mining Management Plan prepared under the NT *Mining Management Act*. In addition, site-wide communication briefs will be used to alert workers and the Groote Eylandt community of any new weed threats, and to provide weed identification information.
- As part of the site inductions and pre-start meetings, all staff and contractors will be made aware of their responsibilities regarding weed management.

8.3.3. Cane Toad Management

The proponent has a Cane Toad Management Plan and associated quarantine procedures in place. The prevention of the introduction of the Cane Toad is critical to maintaining populations of small mammals on Groote Eylandt including threatened species such as the Northern Quoll. The management plan includes monitoring, and, in the event of a Cane Toad being found, reporting and disposal procedures. These procedures would apply to the project. Current Cane Toad management activities include:

- Cane Toad awareness programs conducted through:
    - Site inductions;
    - Inductions of airport and barge personnel;
    - Contractor inductions prior to arrival on Groote Eylandt;
    - 'Keep Groote Cane Toad Free' signage at the airport, the main road in Alyangula, throughout the accommodation facilities, mess facilities and at the mine and port operations;
    - Community information posters in Alyangula which include the process to be adopted in the event of a Cane Toad being sighted;
    - Information cards on Cane Toads being provided in airplane seat pockets for all commercial flights to Groote Eylandt, and for the proponent's charter flights;
    - In-flight announcements by flight attendants for all commercial flights to Groote Eylandt, and for the proponent's charter flights; and
    - Sitewide Communication Briefs.
- Barge inspections of every barge coming to Milner Bay are undertaken by barge operators. The proponent's Environment Team and the ALC rangers also undertake periodic inspections of the barges to ensure compliance with quarantine protocols.

- Lockers are provided to fly-in fly-out staff to store work boots and other luggage on the island, as a means of reducing the probability of accidentally transporting toads.
- Cane Toad-proof fencing designed to contain and prevent toad movement surrounds the perimeter of the Shipping Yards in Milner Bay and Darwin. The fences are inspected on a monthly basis, and repairs are undertaken as required, to ensure the integrity of the fencing.

8.3.4. Indirect Impacts

Table 20 provides a summary of management measures that will be adopted in relation to indirect impacts.

Table 20 Management of indirect impacts

Indirect Impact	Management
Vehicle Strike	The project will be subject to internal procedures in relation to speed limits, safe driving practices and the installation of signage.
Light	There is very limited project lighting. However, any lighting will be designed to ensure that lighting is directed away from habitat areas, as far as possible.
Dust	The project will be subject to internal procedures in relation to dust minimisation, particularly watering of the haul road.
Erosion and Sedimentation	An Erosion and Sedimentation Control Plan will be developed for the project to detail specific mitigation measures.
Feral Animals and Weeds	The proponent has existing procedures in relation to weed management (see ***Section 8.3.3***), which will be reviewed and applied to project activities, and to the overall management of the project site. The proponent also has a Cane Toad Management Plan and an associated quarantine procedure (see ***Section 8.3.4***). The management plan includes monitoring, and reporting and disposal procedures in the event of a Cane Toad being found. This plan will be reviewed and revised to ensure that it is applicable to all project activities.

8.4. Biodiversity Offsets

In accordance with the Commonwealth Environmental Offsets Policy (SEWPaC 2012), biodiversity offsets are required to offset any significant, residual impacts. At present, there is no approved offsets policy in place for species listed under the Northern Territory legislation only. The project is not considered to result in any significant impacts to threatened species and as such no biodiversity offsets are required.

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APPENDIX A :

EPBC Act Protected Matters Search Tool Results

Australian Government

Department of the Environment and Energy

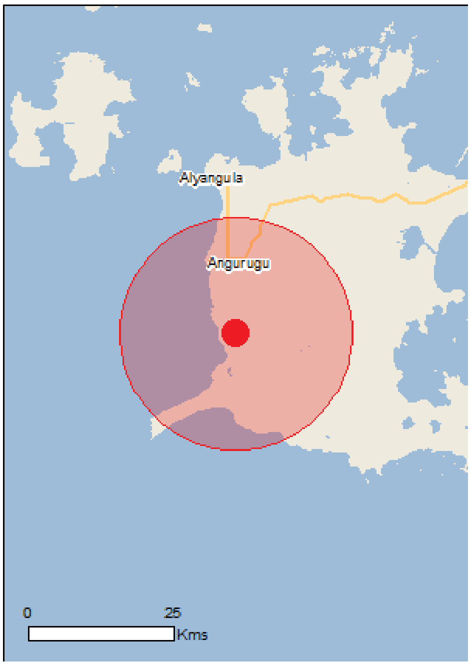
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

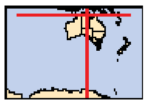
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 21/04/20 13:25:28



Coordinates

Buffer: 20.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	28
Listed Migratory Species:	44

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	75
Whales and Other Cetaceans:	10
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	3
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species

Name	Status	Type of Presence
		habitat may occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Notomys aquilo Northern Hopping-mouse, Woorrentinta [123]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area

Name	Status	Type of Presence
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Anindilyakwa	NT

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Gulf of Carpentaria coastal zone	North

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-14.08526 136.45596

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX B :

Summary of Previous Survey Reports

Table 21 Summary of previous survey reports utilised within this assessment

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Ecological gradients in forest communities on Groote Eylandt, Northern Territory, Australia.	Langkamp, P. J., Ashton, D. H. and Dalling, M. J.	1981	Botanical examination of the natural patterns and ecology of forest and woodland on Western Groote Eylandt, particularly in areas where manganese deposits are located on Western Groote.	Existing GEMCO Mine and Eastern Leases (see Figure 5).	Explains the patterns of forest and woodland floristic and structural variation in relation to soils, topography and drainage.
Flora Survey of the GEMCO Mining Lease on the Western Side of Groote Eylandt, Northern Territory.	Brocklehurst, P. and Cowie, I.	1992	Provide baseline data on the flora and fauna within the GEMCO mineral leases and adjoining areas.	Existing GEMCO Mine and Eastern Leases (see Figure 5).	The document provided information on: - Distribution and descriptions of vegetation communities. - Flora and fauna diversity. - Fauna habitats present.
Flora and Fauna Surveys on the Western Side of Groote Eylandt, N.T. (1991-92).	G. Webb Pty Limited.	1992	Provide baseline data on the flora and fauna within the GEMCO mineral leases and adjoining areas.	Existing GEMCO Mine and Eastern Leases (see Figure 5). Figure 5 shows the study area for Webb (1992).	The document provided information on: - Distribution and descriptions of vegetation communities. - Flora and fauna diversity. - Fauna habitats present. - Occurrence of threatened fauna species (although no maps of occurrence were provided in the Webb report).
Object based land cover mapping for Groote Eylandt: a tool for reconnaissance and land based surveys.	Crase, B. and Hempel, C.	2005	Provide a land cover map by spatial analysis, which integrates remotely sensed imagery with Geographic Information Systems. Intended to be a useful tool for selection of sites for vegetation investigation.	Entire Groote Eylandt.	The document provided a map of broad land cover types.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Northern Hopping Mouse *Notomys aquilo* - ALC Ranger Report April 2006.	Ward, S.	2006	To examine ways to monitor the Northern Hopping-mouse.	Eningkirra and Yanbakwa.	The document provided background information on: - Small terrestrial mammals occurring on Groote Eylandt. - Survey techniques for the Northern Hopping-mouse. This document provided locations of records of potential Northern Hopping-mouse spoils.
Northern Hopping Mouse *Notomys aquilo* - ALC Ranger Report November 2006.	Ward, S.	2006	To examine ways to monitor the Northern Hopping-mouse.	Enungwadena (Kings Crossing) and the road to Dalumba Bay and Yingakwumanja.	The document provided background information on: - Small terrestrial mammals occurring on Groote Eylandt. - Survey techniques for the Northern Hopping-mouse. This document provided locations of records of: - Northern Hopping-mouse. - Potential Northern Hopping-mouse spoils. - Brush-tailed Rabbit-rat.
Northern Hopping Mouse *Notomys aquilo* - ALC Ranger Report April-May 2007.	Ward, S.	2007	To examine ways to monitor the Northern Hopping-mouse.	Amalyikba Creek, Enungwadena (Kings Crossing) and the road to Dalumba Bay, Hempel Bay and tracks joining Umbakumba,	The document provided background information on: - Small terrestrial mammals occurring on Groote Eylandt. - Survey techniques for the Northern Hopping-mouse. This document provided locations of records of:

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
				Mamalingmanja Point (Picnic Beach) and Banyan Tree.	- Northern Hopping-mouse. - Potential Northern Hopping-mouse spoils. - Brush-tailed Rabbit-rat.
Northern Hopping Mouse *Notomys aquilo* - ALC Ranger Report September 2007.	Ward, S.	2007	To examine ways to monitor the Northern Hopping-mouse.	Tracks joining Umbakumba, Mamalingmanja Point (Picnic Beach) and Banyan Tree, north east of Umbakumba and Enungwadena (Kings Crossing) and the road to Dalumba Bay.	The document provided background information on survey techniques for the Northern Hopping-mouse. This document provided locations of records of potential Northern Hopping-mouse spoils.
Surveys for the Threatened Northern Hopping-mouse, Northern Quoll & Brush-tailed Rabbit-rat on GEMCO Eastern Exploration Leases (Groote Eylandt).	Firth, R.	2008	Undertake targeted surveys for the Northern Hopping-mouse, Northern Quoll and Brush-tailed Rabbit-rat.	Eastern Leases (see Figure 5).	This document provided locations of records of: - Potential Northern Hopping-mouse spoils. - Brush-tailed Rabbit-rat.
F3 Quarry Area Expansion, GEMCO, Groote Eylandt. Terrestrial Fauna Assessment.	Ecological Management Services Pty Ltd.	2008	Assess the terrestrial vertebrate fauna species present within the proposed F3 Quarry expansion area and an additional area to the west.	F3 Quarry and adjacent area to west (see Figure 5).	The document provided background information on fauna assemblages within the GEMCO mineral leases. This document provided locations of records of potential Northern Hopping-mouse spoils.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Seasonal detectability of Northern Hopping Mouse spoil heaps on Groote Eylandt.	Smith, D. J.	2009	Collect additional information about the seasonal visibility of Northern Hopping- mouse spoil heaps.	Eastern Leases (see Figure 5).	This document provided locations of records of potential Northern Hopping-mouse spoils.
Surveys for Northern Hopping-mouse, Northern Quoll and Brush-tailed Rabbit-rat across Groote Eylandt.	Smith, D. J.	2009	Undertake targeted surveys for the Northern Hopping-mouse, Northern Quoll and Brush-tailed Rabbit-rat.	Various locations across Groote Eylandt.	The document provided background information on small terrestrial mammals occurring on Groote Eylandt. This document provided locations of records of: - Potential Northern Hopping-mouse spoils. - Northern Quoll. - Brush-tailed Rabbit-rat.
Eastern Leases Pre-clearance Survey for Groote Eylandt Mining Company.	Coffey Environments Pty Ltd.	2010	Pre-clearance surveys for Northern Hopping-mouse and collection of population characteristics through the excavation of spoil heaps, and targeted surveys for the Northern Hopping-mouse.	Eastern Leases (pre-clearing) and Quarries F3, G and D (targeted surveys) (see Figure 5).	The document provided background information on the suitability of using spoils to record the presence of the Northern Hopping-mouse. This document provided locations of records of: - Northern Hopping-mouse. - Potential Northern Hopping-mouse spoils.
Survey for Signs of Northern Hopping-mice on the GEMCO Eastern Leases.	Rankmore, D. B.	2011	Targeted survey for signs of the Northern Hopping-mouse.	Eastern Leases (see Figure 5).	The document provided background information on surveys for the Northern Hopping-mouse.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Flora and Fauna Surveys of Western Groote Eylandt.	URS Australia Pty Ltd.	2012	Provide a comprehensive flora and fauna assessment across the GEMCO mineral leases.	Existing GEMCO Mine Figure 5 shows the study area for URS (2012).	The document provided information on: - Distribution and descriptions of vegetation communities. - Flora and fauna diversity. - Fauna habitats present. - Occurrence of threatened fauna species mentioned but not mapped by URS. - Faunal assemblages within mine rehabilitation areas.
Assessment of Northern Hopping Mouse (***Notomys aquilo***) Habitat Issues, A-South Expansion Area.	Ecological Management Services Pty Ltd.	2012	Provide a preliminary assessment of the potential for a proposed expansion area to support populations of the Northern Hopping-mouse.	West of the A South Quarry (see Figure 5).	The document provided information on mammal species known within the GEMCO mineral leases. This document provided locations of records of potential Northern Hopping-mouse spoils.
Eastern Leases ELR28161/ELR28162 Exploration Drilling Program: Northern Masked Owl/Northern Hopping Mouse Habitat Assessment June – July 2013.	Ecological Management Services Pty Ltd.	2013	Conduct surveys within the footprint of the proposed exploration drilling lines and pads within the Eastern Leases, targeting Masked Owl (northern) individuals and habitat and Northern Hopping-mouse burrows.	Eastern Leases (see Figure 5).	The document provided background information on nesting/roosting habitat features available for use by the Masked Owl (northern). This document provided locations of records of: - Potential Northern Hopping-mouse spoils. - Brush-tailed Rabbit-rat. - Masked Owl (northern).
Eastern Leases ELR28161/ELR28162 Exploration Drilling	Ecological Management	2014	Re-survey uncleared exploration drilling lines and pads in the Eastern Leases and identify Masked Owl	Eastern Leases (see Figure 5).	The document provided background information on nesting/roosting habitat

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Program: Northern Masked Owl/ Northern Hopping Mouse Habitat Assessment. August 2014.	Services Pty Ltd.		(northern) roost/nest trees and Northern Hopping-mouse spoils.		features available for use by the Masked Owl (northern). This document provided locations of records of potential Northern Hopping-mouse spoils.
Eastern Leases Project – Terrestrial Ecology Assessment Report	Cumberland Ecology Pty Ltd.	2015	To document the findings of a terrestrial ecological assessment of the Eastern Leases Project, to support an Environmental Impact Statement.	Eastern Leases (see Figure 5).	The document provided information on: - Distribution and descriptions of vegetation communities. - Flora and fauna diversity. - Fauna habitats present. - Occurrence of threatened species. The document also provides information on faunal assemblages within mine rehabilitation areas of the existing GEMCO mine.
Southern Lease Area – Ecological Pre-clearance Survey Report for the FY17 Gridded Drill Area	Hansen Bailey.	2016	To describe the ecological pre-clearance survey undertaken for the proposed FY17 gridded drill areas in the Southern Lease Area.	Area within the northern portion of the Southern Lease (see Figure 5).	The document provided information on: - Fauna habitat features present.
Southern Lease Project – Baseline Terrestrial Ecology Report	Cumberland Ecology Pty Ltd.	2016	To document the findings of a baseline terrestrial ecology assessment of the Ecological Survey Area, an area of land in the northern portion of the Southern Lease.	Southern Lease (see Figure 5).	The document provided information on: - Distribution and descriptions of vegetation communities. - Flora and fauna diversity. - Fauna habitats present. - Occurrence of threatened species.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
					- Occurrence of introduced and invasive species.
Interim Report on Threatened Small Mammal and Feral Cat Surveys on Groote Eylandt	Heiniger, J. and Gillespie, G.	2017	To document the findings of an island wide survey in lowland eucalypt woodland which was undertaken to understand the current distribution and status of threatened mammal species and feral cats on Groote Eylandt to improve knowledge of their current status, and determine the environmental and landscape correlates of their distributions.	Various locations across Groote Eylandt.	The document provided information on: - Fauna diversity. - Occurrence of threatened fauna species. - Occurrence of introduced fauna species. This document provided locations of records of: - Brush-tailed Rabbit-rat. - Northern Quoll. - Northern Hopping-mouse.
GEMCO/South32 Southern Lease Small Mammal Research Project	Cumberland Ecology Pty Ltd.	2019	To document the findings of a small mammal research project, targeting threatened species, within the Southern Lease and surrounds.	Southern Lease and surrounds (see Figure 5).	The document provided information on: - Habitat types. - Fauna diversity. - Occurrence of threatened species. - Occurrence of introduced and invasive fauna species. - Fire history. This document provided locations of records of: - Masked Owl (northern). - Northern Quoll. - Northern Hopping-mouse.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
Northern Hopping-mouse Surveys: Final Report to Territory NRM July 2019	Anindilyakwa Land & Sea Rangers	2019	To document the findings of targeted Northern Hopping-mouse surveys across Groote Eylandt.	Various locations across Groote Eylandt.	This document provided details of staged targeted surveys for the Northern Hopping-mouse. This document also provided locations of records of Northern Hopping-mouse spoils and individuals.
Eastern Leases Project. Main Haul Road Corridor Ecological Pre-clearance Survey Report	Cumberland Ecology Pty Ltd.	2019	To document the findings of a pre-clearance assessment completed within the Eastern Leases haul road corridor.	Area in the vicinity of the Eastern Leases haul road corridor (see Figure 5).	The document provided information on: - Fauna habitat features present. This document provided locations of records of: - Northern Hopping-mouse.
Eastern Leases Project. Main Haul Road Corridor - Realigned Road. Ecological Pre-clearance Survey Report	Cumberland Ecology Pty Ltd.	2019	To document the findings of a pre-clearance assessment completed within the Eastern Leases haul road corridor.	Area in the vicinity of the Eastern Leases haul road corridor (see Figure 5).	The document provided information on: - Fauna habitat features present. This document provided locations of records of: - Northern Hopping-mouse.
GEMCO Western Leases and Surrounds. Vegetation Mapping Report. DRAFT	Cumberland Ecology Pty Ltd.	2020	To document the findings of a baseline vegetation survey and confirm the presence of vegetation communities within the existing GEMCO mine and surrounds.	Existing GEMCO mine and surrounds (see Figure 5).	The document provided information on: - Vegetation communities present - Broad habitat types present
Status of mammals on Groote Eylandt	Heiniger, J., Davies, H. and Gillespie, G.	2020	To document the findings of an island wide survey in lowland eucalypt woodland which was undertaken to understand the current distribution and status of	Various locations across Groote Eylandt.	The document provided information on: - Fauna diversity. - Occurrence of threatened fauna species. - Occurrence of introduced fauna species.

Document Title	Author	Date	Purpose	Location	Information Utilised within this Report
			threatened mammal species and feral cats on Groote Eylandt to improve knowledge of their current status, and determine the environmental and landscape correlates of their distributions.		This document provided locations of records of: - Brush-tailed Rabbit-rat. - Northern Quoll. - Northern Hopping-mouse.

APPENDIX C :
Summary of Previous Survey Methods

C.1. Introduction

Numerous ecological studies have been undertaken on Groote Eylandt, and in particular the western portion surrounding the existing GEMCO mine and exploration leases. Most recently, detailed flora and fauna studies have been undertaken by both Cumberland Ecology and DENR in the immediate vicinity of the project site. The methods utilised by these studies are summarised below.

C.2. Cumberland Ecology (2015a)

Cumberland Ecology undertook a terrestrial ecology assessment of the Eastern Leases (**Figure 5**). The field surveys were undertaken between May-June 2014 and in October 2014. The field surveys were designed to comply with relevant NT and Commonwealth guidelines. Survey design was also informed by studies by URS (2012) and Webb (1992) of the areas located to the west of the study area.

The terrestrial flora survey included:

- Vegetation mapping, undertaken in the following stages:
  - Development of a preliminary vegetation map based on a desktop review of available datasets and studies, using aerial photograph interpretation techniques and GIS software;
  - Collection of detailed site data during field surveys to validate the preliminary mapping and to inform final mapping outputs, including 33 primary plots, 23 secondary plots and 544 track notes; and
  - Review and refinement of the preliminary vegetation map based on field datasets.
- Threatened flora searches.

Vegetation communities were classified in accordance with the vegetation communities that were described in Webb (1992). Webb classified the vegetation communities he studied on Groote Eylandt into 28 "Map Units". These map units were based on the floristic and structural characteristics of the dominant vegetation type within each community. Map units that were not previously described by Webb (1992) were classified to Level III of the National Vegetation Information Systems framework.

The terrestrial fauna survey included:

- Trapping at 18 fauna survey sites within a 50 x 50 m quadrat for a period of three nights, with each site including 20 Elliott traps, four cage traps, four pitfall traps and associated drift fencing, and four funnel traps. Elliot traps were utilised to target small to medium sized mammals, cage traps were utilised to capture medium-large sized mammals, and pitfall traps and funnel traps were utilised to capture reptiles and frogs;
- Bird census at four fauna survey sites within a 100 x 100 m quadrat, including eight diurnal bird counts and two nocturnal bird counts. Nocturnal bird counts included spotlighting, as well as the use of call playback for the Masked Owl (northern) (*Tyto novaehollandiae kimberli*).

- Active searches at four fauna survey sites within a 50 x 50 m quadrat, including three searches during the day and two searches at night using spotlights. Active searches targeted reptiles, amphibians and mammals.
- Ultrasonic call detection surveys for microchiropteran bats (microbats) undertaken at four fauna survey sites and two additional locations for a period of one to three nights;
- Harp trapping for microbats at three locations for a period of two nights;
- Spotlighting along major tracks from a slow-moving vehicle targeting birds, mammals and reptiles;
- Motion-sensor cameras at six long-term locations (approximately five months). Cameras targeted small, trap shy ground-dwelling fauna;
- Incidental observations throughout the study area; and
- Habitat assessments at four fauna survey sites within a 100 x 100 m quadrat.

C.3. Cumberland Ecology (2016)

Cumberland Ecology undertook a baseline terrestrial ecology assessment of the western part of the Southern Lease area of Groote Eylandt in 2016 (**Figure 5**). The field survey was undertaken in May 2016, and comprised both a terrestrial flora survey and terrestrial fauna survey. The field surveys were designed to comply with relevant NT and Commonwealth guidelines. Survey design was also informed by studies by Cumberland Ecology (2015a), URS (2012) and Webb (1992) of the areas located to the north and north-east of the study area.

The terrestrial flora survey included:

- Vegetation mapping, undertaken in the following stages:
    - Development of a preliminary vegetation map based on a desktop review of available datasets and studies, using aerial photograph interpretation techniques and GIS software;
    - Collection of detailed site data during field surveys to validate the preliminary mapping and to inform final mapping outputs, including 21 primary plots and 766 track notes; and
    - Review and refinement of the preliminary vegetation map based on field datasets.
- Threatened flora searches.

Vegetation communities were classified in accordance with the vegetation communities that were described in Webb (1992). Webb classified the vegetation communities he studied on Groote Eylandt into 28 "Map Units". These map units were based on the floristic and structural characteristics of the dominant vegetation type within each community. Map units that were not previously described by Webb (1992) were classified to Level III of the National Vegetation Information Systems framework.

The terrestrial fauna survey included:

- Trapping at four fauna survey sites within a 50 x 50 m quadrat for a period of three nights, with each site including 20 Elliott traps, four cage traps, four pitfall traps and associated drift fencing, and four funnel traps. Elliot traps were utilised to target small to medium sized mammals, cage traps were utilised to capture medium-large sized mammals, and pitfall traps and funnel traps were utilised to capture reptiles and frogs;
- Bird census at four fauna survey sites within a 100 x 100 m quadrat, including eight diurnal bird counts and two nocturnal bird counts. Nocturnal bird counts included spotlighting, as well as the use of call playback for the Masked Owl (northern) (*Tyto novaehollandiae kimberli*). An additional two locations were surveyed for the Masked Owl (northern) (*Tyto novaehollandiae kimberli*) using spotlighting and call playback;
- Active searches at four fauna survey sites within a 50 x 50 m quadrat, including three searches during the day and two searches at night using spotlights. Active searches targeted reptiles, amphibians and mammals;
- Ultrasonic call detection surveys for microchiropteran bats (microbats) undertaken at four fauna survey sites and two additional locations for a period of one to three nights;
- Harp trapping for microbats at three locations for a period of two to three nights;
- Spotlighting along major tracks from a slow-moving vehicle targeting birds, mammals and reptiles;
- Motion-sensor cameras at four short-term locations (five nights) and 10 long-term locations (approximately two months). Cameras targeted small, trap shy ground-dwelling fauna;
- Incidental observations throughout the study area; and
- Habitat assessments at four fauna survey sites within a 100 x 100 m quadrat.

C.4. Heiniger and Gillespie (2017)

The NT DENR undertook fieldwork for the Groote Island Biodiversity Initiative, which was funded by the NT and Federal governments, and included research on the distribution of small mammals on Groote Eylandt. DENR's research involved surveying a total of 112 sites, which were situated in lowland eucalypt woodland habitat. The sites were surveyed between April and September 2016.

The survey sites were selected based on a systematic, stratified sampling design, based on two environmental gradients, namely land system and fire history. The survey plan included targeting sites in a total of seven land systems and five fire categories. Six motion-sensor camera traps were placed at each of the 112 sites for a minimum of 35 consecutive nights. Habitat assessments, including collecting data on shrub density, log volume and basal areas, were undertaken at each site.

Photographs recorded on the cameras were analysed and all fauna species identified. Single-season occupancy modelling was subsequently conducted to investigate the environmental correlates of individual species site occupancy.

C.5. Cumberland Ecology (2019c)

Cumberland Ecology undertook a small mammal research project within the Southern Lease and surrounds in 2017 and 2018 (see **Figure 5**). The small mammal research project was undertaken to address the requirements of the *GEMCO Southern Lease Exploration Area Threatened Mammal Risk Assessment Plan* (Gillespie and Heiniger 2017). The small mammal research project was designed to obtain additional information on two threatened species, the Northern Hopping-mouse (*Notomys aquilo*) and the Brush-tailed Rabbit-rat (*Conilurus penicillatus*) to provide a more detailed understanding of the occurrence and habitat preferences of these species within the Southern Lease exploration tenement and surrounds. The design of the study also enabled collection of information on habitat types and a suite of other fauna species.

The small mammal research project included field surveys undertaken at 152 sampling sites, the locations of which were determined based on stratification units. Stratification units were determined by habitat types and time since fire. Habitat types were nominated by DENR based on an initial draft island-wide vegetation map that was prepared by DENR in 2017. Time since fire was determined from data downloaded from the North Australia and Rangelands Fire Information website in July 2017 (Darwin Centre for Bushfire Research 2017).

Seventy-six (76) sites were surveyed between August and November 2017 and the remaining 76 sites were surveyed between May and August 2018. Field surveys included the following at each of the 152 sampling sites:

- Four motion-sensor cameras and bait stations, including two unfenced cameras and bait stations, and two fenced (drift fence) cameras and bait stations, with cameras left to record for a minimum of four weeks (28 days);
- A 50 x 50 m habitat assessment quadrat centred at the sampling site, which included the collection of the following data:
  - Representative site photographs;
  - General vegetation description;
  - Evidence of fire prior to site establishment;
  - Circumferences of trees;
  - Length and circumferences of logs;
  - Ground cover, grass layer, shrub/woody vegetation and mid-storey vegetation; and
  - Soil information at each camera.
- Four 20 x 20 m Northern Hopping-mouse burrow search quadrats located adjacent to each camera, which included collection of the following data where spoil heaps were recorded:
  - Measurement of maximum spoil heap width was recorded, a GPS unit reading taken, and the spoil heap photographed;

- ◦ Where spoil heaps had a maximum width greater than 50 cm, searches were undertaken within 5 m of the spoil heap for the presence of pop holes; and
- ◦ Where pop holes were detected, a measurement of the width of the hole was recorded, a GPS reading taken, and the hole photographed.

An extensive amount of data analysis was undertaken following field surveys, including review of camera images and collation of field survey data. As the Northern Hopping-mouse (*Notomys aquilo*) and the Brush-tailed Rabbit-rat (*Conilurus penicillatus*) were not recorded within the study area utilised by the small mammal research project, no occupancy modelling was undertaken for these threatened species.

C.6. Cumberland Ecology (2019g)

Cumberland Ecology undertook a vegetation assessment within the J and O Quarry areas and surrounds in 2018 and 2019 (see **Figure 5**). Initial ground-truthing surveys of the study area were undertaken between 18 and 19 April 2018 and between 25 and 26 May 2018. A second round of survey was undertaken between 23 and 28 October 2018, and a third round undertaken in April 2019.

The initial surveys comprised driving and walking traverses within the study area and collecting data at Road Note points to assess the July 2017 DENR vegetation community distribution and extent. The second survey comprised driving and walking traverses within previously unsurveyed portions of the study area, and collecting data at RDPs and limited Road Note points to assess the September 2018 DENR vegetation community distribution and extent. The third survey was undertaken in areas not previously subject to surveys in the first two rounds.

Data collection at each Road Note point was undertaken in accordance with the Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping (Brocklehurst et al. 2007). The following information was collected:

- Cover and height estimates for each stratum and for each growth form;
- Identification and recording of two to three dominant species in all strata/sub strata;
- Coordinates of each survey site using a hand-held GPS unit; and
- Sample photograph of the assessed VMU.

At RDPs, data collected was the same data as the Road Note points, except that cover and height estimates were not recorded for growth forms. Road Note points were also used where changes to mapping were significant, such as assignment to a VMU with a different structure to that mapped by DENR. A total of 57 Road Note points and 153 RDPs were surveyed.

Incidental searches of coastal areas, including monsoon vine forests, for threatened flora was also undertaken.

Following completion of each round of field surveys, Cumberland Ecology updated the vegetation mapping of the study area. Vegetation communities were classified in accordance with the vegetation communities identified by DENR (which incorporates the Webb (1992) map units). The proposed updated vegetation maps and field survey results were provided to Dr. Nick Cuff from the NT Herbarium for review, and vegetation mapping was subsequently updated based on recommendations from Dr. Nick Cuff where applicable.

C.7. Cumberland Ecology (2020)

Cumberland Ecology has recently undertaken a vegetation assessment throughout the Western Leases and surrounds in 2019 (see **Figure 5**). Surveys were undertaken between August and October 2019. The surveys comprised driving and walking traverses within the study area and collecting data at RDPs to assess the September 2018 DENR vegetation community distribution and extent. At each RDP, the following information was collected:

- Height and cover estimates for each stratum;
- Identification and recording of three to four dominant species in all strata/sub strata;
- Coordinates using a hand-held GPS unit;
- Sample photograph of the assessed VMU;
- Identified VMU; and
- A short description of outcropping geology, topography, land form, soil type, and drainage.

A total of 476 RDPs were sampled within the study area.

APPENDIX D :

Vegetation Map Units

Table 22 Vegetation map units within the Study Area and Disturbance Footprint

VMU	Name	Study Area (ha)	Disturbance Footprint (ha)
Individual VMUs			
1	Mangrove low closed-forest/closed-forest	96.3	-
2	Dry coastal monsoon vine closed forests/low closed-forests	44.0	-
5	Riparian monsoon vine-forests with *Melaleuca cajuputi* and/or *Melaleuca leucadendra*	27.9	-
10	*Eucalyptus tetrodonta/E. miniata* open-forest to woodland with low shrub or tussock grass understorey	15.5	-
10a	*Eucalyptus tetrodonta/E. miniata* open-forest with low shrub or tussock grass understorey on lowland plains and rises	925.7	13.5
10b	*Eucalyptus tetrodonta/E. miniata* open-forest with low shrub and mixed tussock/hummock grass understorey on upland plateau surfaces, mostly associated with deeply weathered land surfaces	33.9	-
11	*Eucalyptus tetrodonta/E. miniata /Callitris intratropica* open-forest with mixed shrub/tussock grass understorey	222.0	0.1
13	*Eucalyptus tetrodonta/E. kombolgiensis* Woodland with shrubby or open hummock grassland understorey	14.1	-
15	*Callitris intratropica* open-forest; *Acacia* spp. tall shrubland complex on sandstone	30.9	-
17	*Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or Mel*aleuca ferruginea / Eucalyptus polycarpa/Eucalyptus bigalerita* open-forest with *Pandanus spiralis* and Mixed tussock grassland understorey	36.8	0.6
18	*Melaleuca leucadendra* and/or *Melaleuca cajaputi / Dillenia alata +/- Melaleuca viridiflora* open forest with fern/sedge understorey (Swamp Forests - Emerald River) Gullies in sandstone	48.2	0.9
19	*Melaleuca cajuputi* or *Melaleuca ferruginea / M. leucadendra* open forest with fern/bracken understorey. *Corymbia bella* and/or *Eucalyptus bigalerita* woodland occurs on the fringes	6.6	-
20	*Melaleuca cajuputi / Corymbia bella* or *Eucalyptus bigalerita* open forest with shrubby understorey often including monsoon vine forest species	4.3	-

VMU	Name	Study Area (ha)	Disturbance Footprint (ha)
21	Mixed *Melaleuca* open forests/ monsoon vine-forests	1.4	-
22	*Melaleuca cajuputi* low closed-forest / *Dapsilanthus ramosus* sedgeland/closed sedgeland (permanent swamps/sedgelands)	8.2	-
23	*Melaleuca cajuputi / M. viridiflora* low open-forest with *Dapsilanthus elatior* sedgeland understorey	21.3	-
26	Riparian woodland to open-forest of *Melaleuca leucadendra*, *Corymbia polycarpa, Eucalyptus tetrodonta* on ephemeral rivers/streams in drier sub-coastal lowlands	0.4	-
27a	*Melaleuca viridiflora* or *Melaleuca ferruginea* low woodland on plains with shrubby or mixed hummock grass/sedge ground layer on lateritic plains	4.3	-
28	*Melaleuca* spp. (*M. viridiflora/M. cajaputi/M. ferruginea*) woodland to low woodland on alluvial plains with sedge understorey	60.9	0.5
30	*Eucalyptus tetrodonta, Corymbia kombolgiensis, Corymbia polycarpa* woodland with shrubby understorey of monsoon vine thicket woodland on deeply weathered lowlands and stabilised coastal sands in the east	1.6	-
31	*Eucalyptus tertodonta, Corymbia kombolgiensis, Melaleuca viridiflora/leucadendra, Corymbia polycarpa, Corymbia foelscheana* open forest/woodland with shrubby understorey and tussock grasses on lowlands including stabilising sands in the east where transitional into VMU 30.	0.5	-
40	*Eucalyptus tetrodonta/E. miniata / E. polycarpa +/- Callitris intratropica (E. bigalerita*) woodland with low shrub or tussock/hummock grass understorey	158.6	<0.1
40a	*Eucalyptus tetrodonta/E. miniata +/- E. polycarpa* woodland with low shrub and tussock grass dominated understorey on lateritic plains and low rises (generally lowlands).	229.3	4.7
41	*Callitris intratropica / Eucalyptus tetrodonta / E. kombolgiensis* open woodland with hummock grassland understorey	26.6	-
42	*Eucalyptus polycarpa /E. tetrodonta /E. miniata* woodland with sedge spp./ low shrub understorey	119.2	1.0
43	*Melaleuca viridiflora / Eucalyptus polycarpa / Grevillea pteridifolia* open woodland with *Asteromytrus symphyocarpa* and Vetiveria elongata tussock grassland	17.9	1.1

VMU	Name	Study Area (ha)	Disturbance Footprint (ha)
44	*Melaleuca leucadendra* or *Melaleuca cajaputi* woodland with Ischaemum spp. understorey adjacent to the estuarine zone	3.4	-
45	*Eucalyptus polycarpa* open- woodland with sedges, short tussock grass understorey. Also areas of grassland	25.4	0.1
46	*Eucalyptus tetrodonta/E. miniata* low woodland with tussock grass understorey (Regeneration)	8.6	-
51	Alluvial woodland to open-woodland with *Corymbia bella, Corymbia polycarpa* and *Eucalyptus bigalerita* +/- *Corymbia grandifolia, Corymbia foelscheana, Corymbia confertiflora, Eucalyptus tetrodonta, Eucalyptus tectifica, Erythrophleum chlorostachys*	31.9	0.8
51a	*E. bigalerita* woodland	6.4	-
51b	*E.bigalerita/C. bella* open woodland	5.3	-
51c	*E. tectifica* and *E. tetrodonta* +/- *E. jensenii* low open woodland to woodland. May be associated with alluvial plains on sandy areas on sandstone plateaus	41.0	-
52	*Melaleuca viridiflora* and *Pandanus spiralis* +/- *Corymbia bella* and/or *Eucalyptus bigalerita* and/or *Corymbia polysciada* (in north) open-woodland adjacent to estuarine zone. *Chrysopogon elongat*us tussock grassland	5.4	-
53	*Eucalyptus jensenii* and/or *Eucalyptus bigalerita*, *Eucalyptus foelscheana* on basalt	2.3	-
59	*Eucalyptus tetrodonta/Erythrophleum chlorostchys/Corymbia polycarpa* woodland on lateritic lowland plains	29.6	-
62	Open-woodland to scattered trees of monsoon species on sand or cemented sand dunes (*Sterculia quadrifida, Diospyros humilis, Drypetes deplanchei, Santalum, Diospyros maratima, Pouteria sericea, Brachychiton paradoxus, Hakea arborescens*)	19.6	-
72	*Acacia* spp. and/or mixed species shrublands (*Melaleuca* spp., *Terminalia carpentariae, Buchanania obovata, Grevillea* spp., *Banksia dentata, Verticordia cunninghamii*) on coastal sandplains and stabilising dunes with mixed sedge/tussock grass ground layer (*Triodia microstachya, Dapsilanthus spathaceus, Schoenus sparteus*)	18.9	-
80	Eleocharis, Cyperus sedgeland	0.4	-

VMU	Name	Study Area (ha)	Disturbance Footprint (ha)
82	Grassland on stabilised primary dune, rearward cemented dunes and sandplains	0.8	-
82a	Tussock grassland on sandplains and stabilised dunes of *Sorghum plumosum* and *Chrysopogon elongatus*	22.6	-
84	*Lepironia* or *Dapsilanthus ramosus* and *Dapsilanthus elatior* sedgeland fringing permanent waterbodies	14.0	-
88	Brackish water sedge swamp - Schoenoplectus littoralis, Eleocharis spp., Cyperus spp.	2.6	-
90	Strand vegetation varying from Samphire, grassland, and *Casuarina equisetifolia* open woodland	1.8	-
100	Saline Tidal Flats +/- emergent isolated trees and (chenopod) shrubs	1.7	-
200	Disturbed	<0.1	-
201	Regrowth/Rehabilitation	0.7	-
202	Cleared	90.4	<0.1
500	Lacustrine wetlands, water	234.7	0.2
Combination VMUs			
10b/15	*Eucalyptus tetrodonta/E. miniata* open-forest with low shrub and mixed tussock/hummock grass understorey on upland plateau surfaces, mostly associated with deeply weathered land surfaces / *Callitris intratropica* open-forest; *Acacia* spp. tall shrubland complex on sandstone	20.4	-
11/21	*Eucalyptus tetrodonta/E. miniata /Callitris intratropica* open-forest with mixed shrub/tussock grass understorey / Mixed *Melaleuca* open forests/ monsoon vine-forests	19.8	-
17/23	*Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or *Melaleuca ferruginea / Eucalyptus polycarpa/Eucalyptus bigalerita* open-forest *with Pandanus spiralis* and Mixed tussock grassland understorey / *Melaleuca cajuputi / M. viridiflora* low open-forest with *Dapsilanthus elatior* sedgeland understorey	1.2	-
17/26	*Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or *Melaleuca ferruginea / Eucalyptus polycarpa/Eucalyptus bigalerita* open-forest *with Pandanus spiralis* and Mixed tussock grassland understorey /	9.8	-

VMU	Name	Study Area (ha)	Disturbance Footprint (ha)
	Riparian woodland to open-forest of *Melaleuca leucadendra, Corymbia polycarpa, Eucalyptus tetrodonta* on ephemeral rivers/streams in drier sub-coastal lowlands		
26/17	Riparian woodland to open-forest of *Melaleuca leucadendra, Corymbia polycarpa, Eucalyptus tetrodonta* on ephemeral rivers/streams in drier sub-coastal lowlands / *Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or *Melaleuca ferruginea / Eucalyptus polycarpa/Eucalyptus bigalerita* open-forest with *Pandanus spiralis* and Mixed tussock grassland understorey	67.2	0.6
42/12	*Eucalyptus polycarpa /E. tetrodonta /E. miniata* woodland with sedge spp./ low shrub understorey / *Eucalyptus tetrodonta/E. miniata/Callitris* intratropica open forest with *Acacia* spp., *Grevillea pteridifolia* dense mid layer and sedge/tussock grass understorey. Drainage areas in sandstone	20.1	-
42/28	*Eucalyptus polycarpa /E. tetrodonta /E. miniata* woodland with sedge spp./ low shrub understorey / *Melaleuca* spp. (*M. viridiflora/M. cajaputi/M. ferruginea*) woodland to low woodland on alluvial plains with sedge understorey	12.1	-
42/51	*Eucalyptus polycarpa /E. tetrodonta /E. miniata* woodland with sedge spp./ low shrub understorey / Alluvial woodland to open-woodland with *Corymbia bella, Corymbia polycarpa* and *Eucalyptus bigalerita* +/- *Corymbia grandifolia, Corymbia foelscheana, Corymbia confertiflora, Eucalyptus tetrodonta, Eucalyptus tectifica, Erythrophleum chlorostachys*	4.1	-
44/1	*Melaleuca leucadendra* or *Melaleuca cajaputi* woodland with Ischaemum spp. understorey adjacent to the estuarine zone / Mangrove low close-forest/closed-forest	0.8	-
75/1	Samphire (Chenopod) Shublands on intertidal flats / Mangrove low close-forest/closed-forest	0.3	-
Water	Water	9.1	-
Total (nearest hectare)		**2,889**	**24**

APPENDIX E :

Vegetation Map Unit Descriptions

E.1. VMU10a

Name: *Eucalyptus tetrodonta/E. miniata* open forest with low shrub or tussock grass understorey on lowland plains and rises

Location: Widespread throughout on lowland lateritic plains and plateaux

Structure: Open forest to woodland (25-35% canopy cover), mean canopy height 16-19m

Sensitive Vegetation Type: n/a

Dominant Species:

Canopy:	*Eucalyptus tetrodonta, Eucalyptus miniata*
Subcanopy:	*Terminalia carpentariae, Acacia lamprocarpa, Petalostigma pubescens, Erythrophleum chlorostachys, Pandanus spiralis, Eucalyptus tetrodonta*
Shrub Layer:	*Cycas arnhemica, Buchanania obovata, Grevillea heliosperma, Acacia lamprocarpa, Petalostigma pubescens, Erythrophleum chlorostachys, Pandanus spiralis*
Ground Layer:	*Heteropogon triticeus, Chrysopogon sp., Sorghum sp., Eriachne sp., Flemingia parviflora*

Photograph 16 VMU10a within the Study Area

E.2. VMU11

Name: *Eucalyptus tetrodonta/E. miniata /Callitris intratropica* open-forest with mixed shrub/tussock grass understorey

Location: Lowland sand plains and fringing sandstone outcrops/plateaux

Structure: Open forest (25-50% canopy cover), mean canopy height 14m

Sensitive Vegetation Type: n/a

Dominant Species:

Canopy:	*Eucalyptus tetrodonta, Callitris intratropica, Eucalyptus miniata*
Subcanopy:	*Callitris intratropica, Eucalyptus tetrodonta, Grevillea pteridifolia, Acacia lamprocarpa, Pandanus spiralis, Erythophleum chlorostachys, Banksia dentata, Terminalia carpentariae, Petalostigma banksii*
Upper Shrub Layer:	*Buchanania obovata, Petalostigma pubescens, Exocarpus latifolius, Acacia lamprocarpa, Acacia torolosa, Callitris intratropica Asteromyrtus symphocarpa, Acacia latescens, Petalostigma banksii, Acacia oncinocarpa, Ampelocissus acetosa*
Lower Shrub Layer:	*Bossiaea bossiaeoides, Exocarpus latifolius, Lithomyrtus retusa, Acacia torolosa, Alyxia spicata*
Ground Layer:	*Lomandra tropica, Eriachne schultziana, Schoenus falcatus, Aristida holerantha, Heteropogon triticeus, Sorghum intrans, Thaumastochloa major, Alloteropsis semialata, Schizachyrium pachyarthron,*

Photograph 17 VMU11 within the Study Area

E.3. VMU17

Name: *Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or *Melaleuca ferruginea / Eucalyptus polycarpa/Eucalyptus biglerita* open-forest with Pandanus spiralis and Mixed tussock grassland understorey

Location: Various locations on alluvial plains and coastal wetlands, including fringing some drainage lines

Structure: Open forest to woodland (20-60% canopy cover), mean canopy height 11-15m

Sensitive Vegetation Type: Riparian Vegetation (part), Wetlands (part)

Dominant Species:

Canopy:	*Melaleuca viridiflora, Corymbia polycarpa Melaleuca cajuputi, Corymbia bella, Grevillea pteridifolia, Eucalyptus bigalerita, Melaleuca leucadendra, Lophostemon lactifluus, Melaleuca ferruginea*
Subcanopy:	*Pandanus spiralis,Terminalia carptentariae,Timonis timon, Melaleuca viridiflora, Alphitonia oblata, Banksia dentata*
Shrub Layer:	*Melaleuca viridiflora, Acacia holosericea, Banksia dentata, Gymnanthera oblonga, Pandanus spiralis, Acacia leptocarpa*
Ground Layer:	*Eriachne triseta, Mnesithea rottboellioides, Pseudopogonantherum contortum, Imperata cylindrica, Fimbristylis sp., Eriocaulon sp., Eriachne schultziana, Chrysopogon elongatus*

Photograph 18 VMU17 within the Study Area

E.4. VMU18

Name: *Melaleuca leucadendra* and/or *Melaleuca cajuputi / Dillenia alata* +/- *Melaleuca viridiflora* open forest with fern/sedge understorey (Swamp Forests - Emerald River) Gullies in sandstone

Location: Wetter soils along the Emerald River floodplain, adjacent to drainage lines or riparian monsoon vine forest

Structure: Open forest (35% canopy cover), 18-20m mean canopy height

Sensitive Vegetation Type: Riparian Vegetation

Dominant Species:

Canopy:	
Subcanopy:	*Melaleuca viridiflora, Pandanus spiralis, Dillenia alata, Melaleuca cajuputi, Timonus timon, Alphitonia oblata, Carallia brachiata*
Shrub Layer:	*Melastoma malabathricum, Osbeckia chinensis, Banksia dentata, Pandanus spiralis*
Ground Layer:	*Dapsilianthus elatior, Mnesithea rottboellioides, Blechnum indicum, Philydrum lanuginosum, Lygodium microphyllum, Cyperus* sp.

Photograph 19 VMU18 within the Study Area

E.5. VMU28

VMU: 28

Name: *Melaleuca* spp. (*M. viridiflora/M. cajuputi/M. ferruginea*) woodland to low woodland on alluvial plains with sedge understorey

Location: Various locations on alluvial plains associated with the Emerald River, also coastal wetlands and fringing sedgelands near the coast, and inland wetlands

Structure: Woodland to open woodland (10-25% canopy cover), mean canopy height 11-16m

Sensitive Vegetation Type: Riparian Vegetation (part), Wetlands (part)

Dominant Species:

Canopy:	*Melaleuca viridiflora, Melaleuca cajuputi, Grevillea pteridifolia, Lophostemon lactifluus*
Subcanopy:	*Grevillea pteridifolia, Melaleuca viridiflora, Pandanus spiralis, Banksia dentata, Timonus timon, Melaleuca cajuputi,Terminalia carpentariae*
Shrub Layer:	*Melaleuca viridiflora, Banksia dentata, Alphitonia oblata, Melaleuca cajuputi, Timonus timon, Pandanus spiralis, Acacia leptocarpa,*
Ground Layer:	*Daplisianthus elatior; Fimbristylis* sp., *Eriocaulon* sp., *Xyris complanata, Tricostularia undulata, Eleocharis* sp. *Scleria* sp., *Gonocarpus chinensis, Goodenia pilosa,*

Photograph 20 VMU28 within the Study Area

E.6. VMU40

Name: *Eucalyptus tetrodonta/E. miniata / E. polycarpa +/- Callitris intratropica (E. bigalerita)* woodland with low shrub or tussock/hummock grass understorey

Location: Lowland plains with sandy soils

Structure: Woodland (20-25% canopy cover), mean height 16-17m

Sensitive Vegetation Type: n/a

Dominant Species:

Canopy:	*Eucalyptus tetrodonta, Corymbia polycarpa, Eucalyptus miniata*
Subcanopy:	*Acacia latescens, Acacia lamprocarpa, Pandanus spiralis*
Shrub Layer:	*Persoonia falcata, Petalostigma banksii, Buchanania obovata, Asteromyrtus symphyocarpa*
Ground Layer:	*Eriachne* sp., *Spermacoce* sp., *Eriachne schultziana, Ericachne pallescens*

Photograph 21 VMU40 within the Study Area

E.7. VMU40a

Name: *Eucalyptus tetrodonta/E. miniata +/- E. polycarpa* woodland with low shrub and tussock grass dominated understorey on lateritic plains and low rises (generally lowlands)

Location: Widespread on lateritic plains

Structure: Woodland (20-25% canopy cover), mean canopy height 11-18m

Sensitive Vegetation Type: n/a

Dominant Species:

Canopy:	*Eucalyptus tetrodonta, Corymbia polycarpa, Eucalyptus miniata*
Subcanopy:	*Terminalia carpentariae, Pandanus spiralis, Corymbia confertiflora, Petalostigma pubescens, Erythrophleum chlorostachys*
Shrub Layer:	*Acacia lamprocarpa, Buchanania obovata, Petalostigma pubescens, Cycas arnhemica, Erythrophleum chlorostachys*
Ground Layer:	*Schizachyrium pachyarthron, Thaumastochloa major, Alloteropsis semialata, Mnesithea rottboellioides, Eriachne* sp.

Photograph 22 VMU40a within the Study Area

E.8. VMU42

Name: *Eucalyptus polycarpa /E. tetrodonta /E. miniata* woodland (open woodland) with sedge spp./ low shrub understorey

Location: Occurs in a narrow band between lateritic plains and adjacent alluvial plains, and between coastal wetlands and adjacent alluvial plains

Structure: Woodland (20-25% canopy cover), mean canopy height 14-20m

Sensitive Vegetation Type: Riparian Vegetation (part)

Dominant Species:

Canopy:	*Eucalyptus tetrodonta, Corymbia polycarpa, Eucalyptus miniata*
Subcanopy:	*Pandanus spiralis, Acacia lamprocarpa,, Grevillea pteridifolia, Erythrophleum chlorostachys, Terminalia carpentariae, Eucalyptus tetrodonta*
Upper Shrub Layer:	*Petalostigma pubescens, Banksia dentata, Petalostigma banksii, Melaleuca viridiflora, Buchanania obovata, Pandanus spiralis*
Lower Shrub Layer:	*Buchanania obovata, Asteromyrtus symphocarpa, Alphitonia excelsa, Grevillea pteridifolia*
Ground Layer:	*Mnesithea rottboellioides, Eriachne triseta, Ericachne pallescens, Eriachne* sp. *Schoenus* sp. *Schoenus falcatus, Lomandra tropica*

Photograph 23 VMU42 within the Study Area

E.9. VMU43

Name: *Melaleuca viridiflora / Eucalyptus polycarpa / Grevillea pteridifolia* open woodland with *Asteromyrtus symphyocarpa and Vetiveria elongata* tussock grassland

Location: Fringing wetlands, mostly inland. Typically on sandy soil

Structure: Open woodland to woodland (2-30% canopy cover), mean canopy height 10m

Sensitive Vegetation Type: Wetlands

Dominant Species:

Canopy:	*Corymbia polycarpa, Melaleuca viridiflora, Grevillea pteridifolia, Asteromyrtus symphocarpa*
Subcanopy:	*Pandanus spiralis, Asteromyrtus symphocarpa, Melaleuca viridiflora, Grevillea pteridifolia, Banksia dentata*
Shrub Layer:	*Melaleuca viridiflora, Asteromyrtus symphocarpa, Banksia dentata, Acacia leptocarpa*
Ground Layer:	*Eriachne triseta, Schoenus sparteus Schoenus falcatus, Eriocaulon* sp, *Panicum* sp.

Photograph 24 VMU43 within the Study Area

E.10. VMU45

Name: *Eucalyptus polycarpa* open- woodland with sedges, short tussock grass understorey. Also areas of grassland

Location: Occurs in several patches with shallow lateritic soil, and patches elsewhere on sandstone plateaux

Structure: Open woodland (5-6% canopy cover), mean canopy height 11-12m

Sensitive Vegetation Type: Riparian Vegetation (part)

Dominant Species:

Canopy:	*Corymbia polycarpa, Erythrophleum chlorostachys, Terminalia carpentariae, Eucalyptus tetrodonta*
Shrub Layer:	*Petalostigma banksii, Buchanania obovata, Grevillea pteridifolia, Alphitonia excelsa*
Ground Layer:	*Schizachyrium pachyarthron, Themeda arguens, Heteropogon triticeus, Schoenus* sp.

Photograph 25 VMU45 within the Study Area

E.11. VMU51

Name: Alluvial woodland to open-woodland with Co*rymbia bella*, *Corymbia polycarpa* and *Eucalyptus biglerita* +/- *Corymbia grandifolia*, *Corymbia foelscheana*, *Corymbia confertiflora*, *Eucalyptus tetrodonta*, *Eucalyptus tectifica*, *Erythrophleum chlorostachys*

Location: Alluvial plains adjacent to the Emerald River and tributary

Structure: Woodland (15-30% canopy cover), mean canopy height 13-14m

Sensitive Vegetation Type: Riparian Vegetation (part)

Dominant Species:

Canopy:	*Corymbia polycarpa, Eucalyptus tetrodonta, Erythrophleum chlorostachys, Eucalyptus bigalerita, Corymbia bella*
Subcanopy:	*Erythrophleum chlorostachys, Pandanus spiralis, Terminalia carpentariae, Grevillea pteridifolia, Melaleuca viridiflora*
Upper Shrub Layer:	*Pandanus spiralis, Petalostigma pubescens, Cycas arhnemica*
Lower Shrub Layer:	*Buchanania obovata, Melaleuca viridiflora, Cycas arhnemica*
Ground Layer:	*Mnesithea rottboellioides, Spermacoce* sp., *Eriachne triseta, Eriachne* sp., *Germainia grandiflora, Imperata cylindrica, Panicum* sp.

Photograph 26 VMU51 within the Study Area

E.12. VMU26/17

Name: Riparian woodland to open-forest of *Melaleuca leucadendra*, *Corymbia polycarpa*, *Eucalyptus tetrodonta* on ephemeral rivers/streams in drier sub-coastal lowlands / *Melaleuca viridiflora* or *Melaleuca cajuputi* or *Melaleuca leucadendra* or *Melaleuca ferruginea* / *Eucalyptus polycarpa/Eucalyptus biglerita* open-forest with *Pandanus spiralis* and Mixed tussock grassland understorey

Location: Riparian fringe of the Emerald River and tributary

Structure: Woodland (30% cover), with canopy height 10-16m

Sensitive Vegetation Type: Riparian Vegetation

Dominant Species:

Canopy:	*Corymbia polycarpa, Corymbia bella, Melaleuca leucadendra, Melaleuca viridiflora, Eucalyptus bigalerita, Eucalyptus tetrodonta*
Subcanopy:	*Melaleuca cajuputi, Pandanus spiralis, Terminalia carpentariae, Melaleuca viridiflora, Melaleuca leucadendra, Erythrophloem chlorostacys, Dillenia alata, Carallia brachiata*
Shrub Layer:	*Terminalia carpentariae, Acacia* spp., *Pandanus spiralis, Melaleuca viridiflora, Erythrophloem chlorostachys, Asteromyrtus symphyocarpa*
Ground Layer:	*Flemingia parviflora, Panicum* sp., *Cheilanthes tenuifolia, Goodenia pillosa, Ischaemum fragile, Dapsilanthus elatior*

Photograph 27 VMU26/17 within the Study Area

APPENDIX F :

Flora Species List

Table 23 Flora species list

Family	Scientific Name	Common Name
Acanthaceae	*Acanthus ilicifolius*	Holly-leaved Mangrove
Amaryllidaceae	*Crinum angustifolium*	Crinium Lily
Anacardiaceae	*Buchanania arborescens*	Bush Currant
Anacardiaceae	*Buchanania obovata*	Green Plum
Apocynaceae	*Alstonia actinophylla*	Milkwood
Apocynaceae	*Alyxia spicata*	Chainfruit
Apocynaceae	*Gymnanthera oblonga*	Gymnanthera
Apocynaceae	*Tabernaemontana orientalis*	Iodine Plant
Araceae	*Colocasia esculenta var. aquatica*	
Araliaceae	*Schefflera actinophylla*	Umbrella Tree
Araliaceae	*Trachymene microcephala*	Lace Flower
Arecaceae	*Hydriastele wendlandiana*	Sour Palm
Asparagaceae	*Lomandra longifolia*	piny-headed mat-rush, honey reed
Asparagaceae	*Lomandra tropica*	Mat-Rush
Asteraceae	*Cyanthillium cinereum*	Vernonia
Bixaceae	*Cochlospermum gillivraei*	Kapok Tree
Blechnaceae	*Blechnum indicum*	Swamp Water Fern
Blechnaceae	*Stenochlaena palustris*	Climbing Swamp Fern
Boraginaceae	*Heliotropium ventricosum*	White Heliotrope
Burseraceae	*Canarium australianum*	Mango Bark
Cannabaceae	*Celtis paniculata*	Celtis
Cannabaceae	*Celtis philippensis*	Celtis
Celastraceae	*Denhamia obscura*	Orange Root
Celastraceae	*Stackhousia intermedia*	Wiry Stackhousia
Combretaceae	*Lumnitzera littorea*	Red-flowered Black mangrove
Combretaceae	*Lumnitzera racemosa*	White-flowered Black Mangrove
Combretaceae	*Terminalia canescens*	Winged Nut Tree
Combretaceae	*Terminalia carpentariae*	Wild Peach
Combretaceae	*Terminalia microcarpa*	Damson
Commelinaceae	*Cartonema spicatum*	Cartonema
Convolvulaceae	*Bonamia media*	Grey-vine
Convolvulaceae	*Evolvulus alsinoides*	Blue Periwinkle
Convolvulaceae	*Polymeria ambigua*	Creeping Polymeria

Family	Scientific Name	Common Name
Convolvulaceae	*Xenostegia tridentata*	Morning Vine
Cupressaceae	*Callitris intratropica*	Northern Cypress Pine
Cycadaceae	*Cycas arnhemica*	Cycad
Cyperaceae	*Baumea rubiginosa*	Soft Twig-rush
Cyperaceae	*Cyperus haspan subsp. juncoides*	Small Umbrella Rush
Cyperaceae	*Cyperus sp.*	
Cyperaceae	*Eleocharis sp.*	
Cyperaceae	*Fimbristylis pauciflora*	Fringe-Rush
Cyperaceae	*Fimbristylis sp.*	
Cyperaceae	*Lepironia articulata*	Grey Rush
Cyperaceae	*Rhynchospora longisetis*	Tick Grass
Cyperaceae	*Schoenus sp.*	
Dilleniaceae	*Dillenia alata*	Golden Guinea Tree
Dioscoreaceae	*Dioscorea bulbifera*	Water Yam
Dioscoreaceae	*Dioscorea sp.*	
Ebenaceae	*Diospyros littorea*	Native Ebony
Ebenaceae	*Diospyros maritima*	Sea Ebony
Eriocaulaceae	*Eriocaulon sp.*	
Euphorbiaceae	*Euphorbia sp.*	
Euphorbiaceae	*Exoecaria agallocha*	Milky mangrove
Euphorbiaceae	*Macaranga tanarius*	Tumkullum
Euphorbiaceae	*Microstachys chamaelea*	Striped Seed Plant
Fabaceae	*Acacia difficilis*	River Wattle
Fabaceae	*Acacia holosericea*	Candelabra Wattle
Fabaceae	*Acacia lamprocarpa*	Hickory Wattle
Fabaceae	*Acacia latescens*	Ball Wattle
Fabaceae	*Acacia leptocarpa*	Wattle
Fabaceae	*Acacia multisiliqua*	Small-ball Wattle
Fabaceae	*Acacia torulosa*	Torulosa Wattle
Fabaceae	*Acacia yirrkallensis*	Dwarf Wattle
Fabaceae	*Cajanus geminatus*	Pigeon-pea
Fabaceae	*Crotalaria brevis*	Rattlepod
Fabaceae	*Desmodium sp.*	
Fabaceae	*Erythrophleum chlorostachys*	Northern Ironwood
Fabaceae	*Flemingia parviflora*	Flemingia

Family	Scientific Name	Common Name
Fabaceae	*Galactia tenuiflora*	Poison Pea
Fabaceae	*Gompholobium subulatum*	Wedge-pea
Fabaceae	*Senna sp.*	
Flagellariaceae	*Flagellaria indica*	Supplejack
Gleicheniaceae	*Dicranopteris linearis var. linearis*	Hay Rake Fern
Goodeniaceae	*Goodenia pilosa*	Hairy Goodenia
Haloragaceae	*Gonocarpus sp.*	
Hemerocallidaceae	*Dianella longifolia*	Blueberry Lily
Lamiaceae	*Anisomeles malabarica*	Purple Bush Flower
Lamiaceae	*Hyptis suaveolens**	Hyptis
Lauraceae	*Cassytha filiformis*	Hairy Dodder-laurel
Lecythidaceae	*Planchonia careya*	Cocky Apple
Lindsaeaceae	*Lindsaea ensifolia*	Common Wedgefern
Loganiaceae	*Mitrasacme connata*	Mitre Plant
Loganiaceae	*Strychnos lucida*	Strychnine Tree
Lomariopsidaceae	*Nephrolepis hirsutula*	Fishbone Fern
Lycopodiaceae	*Lycopodiella cernua*	Staghorn Club Moss
Lygodiaceae	*Lygodium microphyllum*	Climbing Maidenhair Fern
Malvaceae	*Brachychiton diversifolius*	Northern Kurrajong
Malvaceae	*Brachychiton paradoxus*	Red-flowering Kurrajong
Malvaceae	*Grewia retusifolia*	Emu Berries
Malvaceae	*Helicteres cana*	Purple Salvia-flowered Plant
Malvaceae	*Hibiscus tiliaceus*	Beach Hibiscus
Malvaceae	*Sterculia quadrifida*	Peanut Tree
Malvaceae	*Waltheria indica*	Waltheria
Melastomataceae	*Melastoma malabathricum*	Melastoma, Native Lasiandra
Melastomataceae	*Melastoma malabathricum subsp. malabathricum*	Native Lasiandra
Melastomataceae	*Osbeckia chinensis var. chinensis*	Osbeckia
Meliaceae	*Aglaia brownii*	Coastal Boodyarra
Meliaceae	*Aglaia sapindina*	Aglaia
Myristicaceae	*Horsfieldia australiana*	Cape Chestnut
Myrtaceae	*Asteromyrtus symphyocarpa*	Liniment Tree
Myrtaceae	*Corymbia bella*	Ghost Gum
Myrtaceae	*Corymbia confertiflora*	Roughleaf Cabbage Gum

Family	Scientific Name	Common Name
Myrtaceae	*Corymbia ferruginea*	Rusty Bloodwood
Myrtaceae	*Corymbia kombolgiensis*	Scarp Gum
Myrtaceae	*Corymbia polycarpa*	Long-fruited Bloodwood
Myrtaceae	*Eucalyptus bigalerita*	Northern Salmon Gum
Myrtaceae	*Eucalyptus miniata*	Darwin Woollybutt
Myrtaceae	*Eucalyptus tetrodonta*	Darwin Stringybark
Myrtaceae	*Melaleuca cajuputi*	Cajuput Tree
Myrtaceae	*Melaleuca ferruginea*	Paperbark
Myrtaceae	*Melaleuca leucadendra*	Weeping Paperbark
Myrtaceae	*Melaleuca viridiflora*	Broad-leaved Paperbark
Myrtaceae	*Syzygium angophoroides*	Yarrabah Satinash
Myrtaceae	*Syzygium nervosum*	Black Apple
Myrtaceae	*Syzygium suborbiculare*	Red Bush Apple
Nymphaeaceae	*Nymphaea violacea*	Blue Waterlily
Oleaceae	*Jasminum molle*	Stiff Jasmine
Pandanaceae	*Pandanus spiralis*	Screw Palm
Philydraceae	*Philydrum lanuginosum*	Woolly Waterlily
Phyllanthaceae	*Breynia cernua*	Breynia
Phyllanthaceae	*Flueggea virosa*	White Currant
Phyllanthaceae	*Glochidion xerocarpum*	Little Cheeses
Phyllanthaceae	*Phyllanthus carpentariae*	Phyllanthus
Phyllanthaceae	*Sauropus stenocladus*	Sauropus
Picrodendraceae	*Petalostigma banksii*	Quinine Bush
Picrodendraceae	*Petalostigma pubescens*	Quinine Tree
Poaceae	*Alloteropsis semialata*	Cockatoo Grass
Poaceae	*Aristida holathera var. holathera*	Erect Kerosene Grass
Poaceae	*Aristida sp.*	
Poaceae	*Chrysopogon elongatus*	Tall Tamil Grass
Poaceae	*Chrysopogon sp.*	
Poaceae	*Cymbopogon bombycinus*	Silky Oilgrass
Poaceae	*Cymbopogon sp.*	
Poaceae	*Ectrosia leporina*	Haresfoot Grass
Poaceae	*Eriachne avenacea*	Wanderrie Grass
Poaceae	*Eriachne melicaeae*	Fire Grass
Poaceae	*Eriachne pallescens*	Wanderrie Grass

Family	Scientific Name	Common Name
Poaceae	*Eriachne schultziana*	Salt-and-Pepper Grass
Poaceae	*Eriachne sp.*	
Poaceae	*Eriachne triseta*	Wanderrie Grass
Poaceae	*Heteropogon contortus*	Black Speargrass
Poaceae	*Heteropogon triticeus*	Giant Speargrass
Poaceae	*Imperata cylindrica*	Blady Grass
Poaceae	*Ischaemum fragile*	Ischaemum
Poaceae	*Ischaemum sp.*	
Poaceae	*Mnesithea formosa*	Red Grass
Poaceae	*Mnesithea rottboellioides*	Northern Canegrass
Poaceae	*Mnesithea sp.*	
Poaceae	*Panicum sp.*	
Poaceae	*Pseudoraphis spinescens*	Spiny Mudgrass
Poaceae	*Schizachyrium pachyarthron*	Fire Grass
Poaceae	*Setaria apiculata*	Pigeon Grass
Poaceae	*Sorghum interjectum*	Sorghum
Poaceae	*Sorghum intrans*	Annual Sorghum
Poaceae	*Thaumastochloa major*	Thaumastochloa
Polygalaceae	*Polygala sp.*	
Primulaceae	*Aegiceras corniculatum*	River Mangrove
Proteaceae	*Banksia dentata*	Northern Banksia
Proteaceae	*Grevillea heliosperma*	Rock Grevillea
Proteaceae	*Grevillea pteridifolia*	Fern-leaved Grevillea
Proteaceae	*Hakea arborescens*	Yellow Hakea
Proteaceae	*Persoonia falcata*	Milky Plum
Pteridaceae	*Acrostichum speciosum*	Mangrove Fern
Pteridaceae	*Cheilanthes tenuifolia*	Rock Fern
Putranjivaceae	*Drypetes deplanchei*	Yellow Tulipwood
Restionaceae	*Dapsilanthus elatior*	Rush
Restionaceae	*Dapsilanthus ramosus*	Rush
Restionaceae	*Dapsilanthus spathaceus*	Rush
Rhamnaceae	*Alphitonia excelsa*	Red Ash
Rhamnaceae	*Alphitonia oblata*	Hairy Sarsaparilla
Rhizophoraceae	*Bruguiera exaristata*	Red Mangrove
Rhizophoraceae	*Bruguiera gymnorhiza*	Orange Mangrove

Family	Scientific Name	Common Name
Rhizophoraceae	*Carallia brachiata*	Billabong Tree
Rhizophoraceae	*Ceriops tagal*	Orange Mangrove
Rhizophoraceae	*Rhizophora stylosa*	Stilt Mangrove
Rubiaceae	*Gardenia megasperma*	Native Gardenia
Rubiaceae	*Kailarsenia suffruticosa*	Native Gardenia
Rubiaceae	*Nauclea orientalis*	Leichhardt Tree
Rubiaceae	*Psychotria nesophila*	Gabu
Rubiaceae	*Psydrax odorata subsp. arnhemica*	Shiny-leaved Canthium
Rubiaceae	*Spermacoce elaiosoma*	Buttonweed
Rubiaceae	*Spermacoce sp.*	
Rubiaceae	*Timonius timon*	Swizzle Bush
Rutaceae	*Boronia lanuginosa*	Star Boronia
Rutaceae	*Melicope elleryana*	Pink Evodia
Rutaceae	*Micromelum minutum*	Lime Berry
Santalaceae	*Exocarpos latifolius*	Native Cherry
Sapindaceae	*Cupaniopsis anacardioides*	Tuckeroo
Sapotaceae	*Pouteria arnhemica*	Yellow Boxwood
Sapotaceae	*Pouteria sericea*	Wild Prune
Smilacaceae	*Smilax australis*	Austral Smilax
Thelypteridaceae	*Cyclosorus interruptus*	Creeping Swamp Fern
Thymelaeaceae	*Thecanthes concreta*	Thecanthes
Thymelaeaceae	*Thecanthes punicea*	Red Wax Plant
Violaceae	*Hybanchus enneaspermus*	Spade Flower
Vitaceae	*Ampelocissus acetosa*	Wild Grape
Xyridaceae	*Xyris complanata*	Hatpins
Xyridaceae	*Xyris sp.*	

** denotes exotic species*

APPENDIX G :

Fauna Species List

Table 24 Fauna species list

Order	Family	Scientific Name	Common Name	EPBC Act Status	TPWC Act Status	Webb (1992)	URS (2012)	Cumberland Ecology (2015a)			Cumberland Ecology (2016)		Heiniger and Gillespie (2017)		Cumberland Ecology (2019c)	
						Survey Location										
						Eastern Leases & existing mine	Existing mine	Eastern Leases	Rehab areas of existing mine	Within Study Area	Project Area#	Within Study Area	Project Area#	Within Study Area	Project Area#	Within Study Area
AMPHIBIANS																
ANURA	HYLIDAE	*Litoria bicolor*	Northern Dwarf Tree Frog	-	-	X	X	X								
ANURA	HYLIDAE	*Litoria caerulea*	Green Tree Frog	-	-	X	X									
ANURA	HYLIDAE	*Litoria microbelos*	Javelin Frog	-	-		X									
ANURA	HYLIDAE	*Litoria nasuta*	Rocket Frog	-	-	X	X	X								
ANURA	HYLIDAE	*Litoria pallida*	Pale Frog	-	-			X								
ANURA	HYLIDAE	*Litoria rothii*	Roth's Tree Frog	-	-	X	X	X								
ANURA	HYLIDAE	*Litoria rubella*	Desert Tree Frog	-	-	X	X									
ANURA	HYLIDAE	*Litoria tornieri*	Tornier's Frog	-	-		X									
ANURA	HYLIDAE	*Litoria watjulumensis*	Wotjulum Frog	-	-		X									
ANURA	MYOBATRACHIDAE	*Crinia remota*	Remote Froglet	-	-	X	X	X								
ANURA	MYOBATRACHIDAE	*Limnodynastes convexiusculus*	Marbled Frog	-	-	X	X									
ANURA	MYOBATRACHIDAE	*Platyplectrum ornatum*	Ornate Burrowing Frog	-	-	X	X									
ANURA	MYOBATRACHIDAE	*Uperoleia inundata*	Floodplain Toadlet	-	-	X	X	X								
ANURA	MYOBATRACHIDAE	*Uperoleia lithomoda*	Stonemason Toadlet	-	-	X	X									
BIRDS																
ANSERIFORMES	ANATIDAE	*Anas gracilis*	Grey Teal	-	-	X										
ANSERIFORMES	ANATIDAE	*Anas superciliosa*	Pacific Black Duck	-	-	X	X									
ANSERIFORMES	ANATIDAE	*Dendrocygna arcuata*	Wandering Whistling-duck	-	-		X									
ANSERIFORMES	ANATIDAE	*Tadorna tadornoides*	Australian Shelduck	-			X									
APODIFORMES	AEGOTHELIDAE	*Aegotheles cristatus*	Australian Owlet-nightjar	-	-	X	X	X			X		X	X	X	X
APODIFORMES	APODIDAE	*Apus pacificus*	Fork-tailed Swift	M(m)	-		X									
CAPRIMULGIFORMES	CAPRIMULGIDAE	*Caprimulgus macrurus*	Large-tailed Nightjar	-	-	X	X								X	
CAPRIMULGIFORMES	CAPRIMULGIDAE	*Eurostopodus argus*	Spotted Nightjar	-	-	X									X	
CAPRIMULGIFORMES	PODARGIDAE	*Podargus strigoides*	Tawny Frogmouth	-	-	X	X	X			X				X	X
CHARADRIIFORMES	BURHINIDAE	*Burhinus grallarius*	Bush Stone-curlew	-	-	X	X	X			X				X	
CHARADRIIFORMES	BURHINIDAE	*Esacus magnirostris*	Beach Stone-curlew	-	-		X									
CHARADRIIFORMES	CHARADRIIDAE	*Charadrius leschenaultii*	Greater Sand Plover	V, M(w)	-		X									
CHARADRIIFORMES	CHARADRIIDAE	*Charadrius mongolus*	Lesser Sand Plover	E, M(w)	-		X									
CHARADRIIFORMES	CHARADRIIDAE	*Charadrius ruficapillus*	Red-capped Plover	-	-		X									
CHARADRIIFORMES	CHARADRIIDAE	*Pluvialis fulva*	Pacific Golden Plover	M(w)	-	X										
CHARADRIIFORMES	CHARADRIIDAE	*Vanellus miles*	Masked Lapwing	-	-	X	X				X					
CHARADRIIFORMES	JACANIDAE	*Irediparra gallinacea*	Comb-crested Jacana	-	-		X									
CHARADRIIFORMES	LARIDAE	*Chroicocephalus novaehollandiae*	Silver Gull	-	-		X									
CHARADRIIFORMES	LARIDAE	*Gelochelidon nilotica*	Gull-billed Tern	-	-		X									
CHARADRIIFORMES	RECURVIROSTRIDAE	*Himantopus himantopus*	Black-winged Stilt	-	-	X										
CHARADRIIFORMES	SCOLOPACIDAE	*Actitis hypoleucos*	Common Sandpiper	M(w)	-	X	X									

Order	Family	Scientific Name	Common Name	EPBC Act Status	TPWC Act Status	Webb (1992)	URS (2012)	Cumberland Ecology (2015a)			Cumberland Ecology (2016)		Heiniger and Gillespie (2017)		Cumberland Ecology (2019c)	
						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
CHARADRIIFORMES	SCOLOPACIDAE	*Calidris acuminata*	Sharp-tailed Sandpiper	M(w)	-	X										
CHARADRIIFORMES	SCOLOPACIDAE	*Calidris ferruginea*	Curlew Sandpiper	CE, M(w)	-	X										
CHARADRIIFORMES	SCOLOPACIDAE	*Tringa brevipes*	Grey-tailed Tattler	M(w)	-		X									
CHARADRIIFORMES	SCOLOPACIDAE	*Tringa nebularia*	Common Greenshank	M(w)	-	X										
CHARADRIIFORMES	SCOLOPACIDAE	*Tringa stagnatilis*	Marsh Sandpiper	M(w)	-		X									
CICONIIFORMES	ARDEIDAE	*Ardea intermedia*	Intermediate Egret	-	-		X									
CICONIIFORMES	ARDEIDAE	*Ardea modesta*	Eastern Great Egret	-	-		X									
CICONIIFORMES	ARDEIDAE	*Butorides striatus*	Striated Heron	-	-		X									
CICONIIFORMES	ARDEIDAE	*Egretta garzetta*	Little Egret	-	-		X									
CICONIIFORMES	ARDEIDAE	*Egretta novaehollandiae*	White-faced Heron	-	-		X	X								
CICONIIFORMES	ARDEIDAE	*Egretta sacra*	Eastern Reef Egret	-	-		X									
CICONIIFORMES	ARDEIDAE	*Nycticorax caledonicus*	Nankeen Night-heron	-	-		X	X			X					
CICONIIFORMES	CICONIIDAE	*Ephippiorhynchus asiaticus*	Black-necked Stork	-	-		X									
COLUMBIFORMES	COLUMBIDAE	*Chalcophaps indica*	Emerald Dove	-	-	X	X	X		X	X		X		X	
COLUMBIFORMES	COLUMBIDAE	*Ducula bicolor*	Pied Imperial-pigeon	-	-		X	X								
COLUMBIFORMES	COLUMBIDAE	*Ducula spilorrhoa*	Torresian Imperial Pigeon	-	-	X										
COLUMBIFORMES	COLUMBIDAE	*Geopelia humeralis*	Bar-shouldered Dove	-	-	X	X	X	X	X	X	X	X		X	
COLUMBIFORMES	COLUMBIDAE	*Geopelia striata*	Peaceful Dove	-	-	X	X	X	X	X	X	X	X		X	
COLUMBIFORMES	COLUMBIDAE	*Phaps chalcoptera*	Common Bronzewing	-	-	X	X	X	X	X	X		X		X	X
COLUMBIFORMES	COLUMBIDAE	*Ptilinopus regina*	Rose-crowned Fruit-dove	-	-	X	X									
CORACIIFORMES	ALCEDINIDAE	*Ceyx azureus*	Azure Kingfisher	-	-		X									
CORACIIFORMES	ALCEDINIDAE	*Dacelo leachii*	Blue-winged Kookaburra	-	-	X	X	X			X		X		X	
CORACIIFORMES	ALCEDINIDAE	*Todiramphus chloris*	Collared Kingfisher	-	-		X								X	
CORACIIFORMES	ALCEDINIDAE	*Todiramphus macleayii*	Forest Kingfisher	-	-	X	X	X		X	X	X	X			
CORACIIFORMES	ALCEDINIDAE	*Todiramphus sanctus*	Sacred Kingfisher	-	-		X								X	
CORACIIFORMES	CORACIIDAE	*Eurystomus orientalis*	Dollarbird	-	-		X									
CORACIIFORMES	MEROPIDAE	*Merops ornatus*	Rainbow Bee-eater	-	-	X	X	X		X	X				X	
CUCULIFORMES	CENTROPODIDAE	*Centropus phasianinus*	Pheasant Coucal	-	-		X	X			X	X	X		X	
CUCULIFORMES	CUCULIDAE	*Cacomantis variolosus*	Brush Cuckoo	-	-	x	X	X								
CUCULIFORMES	CUCULIDAE	*Chrysococcyx minutillus*	Little Bronze Cuckoo	-	-	X	X									
CUCULIFORMES	CUCULIDAE	*Eudynamys orientalis*	Eastern Koel	-	-	X		X								
CUCULIFORMES	CUCULIDAE	*Scythrops novaehollandiae*	Channel-billed Cuckoo	-	-			X								
FALCONIFORMES	ACCIPITRIDAE	*Accipiter cirrocephalus*	Collared Sparrowhawk	-	-		X						X			
FALCONIFORMES	ACCIPITRIDAE	*Accipiter fasciatus*	Brown Goshawk	-	-	X	X	X							X	
FALCONIFORMES	ACCIPITRIDAE	*Aquila audax*	Wedge-tailed Eagle	-	-		X	X			X					
FALCONIFORMES	ACCIPITRIDAE	*Aviceda subcristata*	Pacific Baza	-	-	X										
FALCONIFORMES	ACCIPITRIDAE	*Circus assimilis*	Spotted Harrier	-	-		X									

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						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
FALCONIFORMES	ACCIPITRIDAE	*Haliaeetus leucogaster*	White-bellied Sea-eagle	-	-		X				X				X	
FALCONIFORMES	ACCIPITRIDAE	*Haliastur indus*	Brahminy Kite	-	-		X									
FALCONIFORMES	ACCIPITRIDAE	*Haliastur sphenurus*	Whistling Kite	-	-	X	X	X	X		X		X		X	
FALCONIFORMES	ACCIPITRIDAE	*Pandion cristatus*	Eastern Osprey	M(w)	-		X									
FALCONIFORMES	FALCONIDAE	*Falco berigora*	Brown Falcon	-	-	X	X								X	
GALLIFORMES	MEGAPODIIDAE	*Megapodius reinwardt*	Orange-footed Scrubfowl	-	-	X	X		X		X		X		X	
GALLIFORMES	PHASIANIDAE	*Coturnix ypsilophora*	Brown Quail	-	-		X	X			X	X			X	
GALLIFORMES	PHASIANIDAE	*Excalfactoria chinensis*	King Quail	-	-		X									
GRUIFORMES	GRUIDAE	*Grus rubicunda*	Brolga	-	-		X				X					
GRUIFORMES	RALLIDAE	*Eulabeornis castaneoventris*	Chestnut Rail	-	-		X									
GRUIFORMES	RALLIDAE	*Gallirallus philippensis*	Buff-banded Rail	-	-										X	
PASSERIFORMES	ACANTHIZIDAE	*Gerygone chloronota*	Green-backed Gerygone	-	-	X	X									
PASSERIFORMES	ACANTHIZIDAE	*Gerygone levigaster*	Mangrove Gerygone	-	-		X									
PASSERIFORMES	ACANTHIZIDAE	*Gerygone magnirostris*	Large-billed Gerygone	-	-	X	X									
PASSERIFORMES	ARTAMIDAE	*Artamus leucorynchus*	White-breasted Woodswallow	-	-	X	X									
PASSERIFORMES	ARTAMIDAE	*Artamus minor*	Little Woodswallow	-	-	X	X									
PASSERIFORMES	ARTAMIDAE	*Cracticus nigrogularis*	Pied Butcherbird	-	-	X	X	X	X		X	X	X		X	
PASSERIFORMES	ARTAMIDAE	*Cracticus tibicen*	Australian Magpie	-	-	X	X	X			X	X	X	X	X	
PASSERIFORMES	CAMPEPHAGIDAE	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	-	-	X	X	X			X					
PASSERIFORMES	CAMPEPHAGIDAE	*Coracina papuensis*	White-bellied Cuckoo-shrike	-	-	X	X	X			X					
PASSERIFORMES	CAMPEPHAGIDAE	*Coracina tenuirostris*	Cicadabird	-	-	X	X									
PASSERIFORMES	CAMPEPHAGIDAE	*Lalage leucomela*	Varied Triller	-	-	X	X									
PASSERIFORMES	CAMPEPHAGIDAE	*Lalage sueurii*	White-winged Triller	-	-		X									
PASSERIFORMES	CISTICOLIDAE	*Cisticola exilis*	Golden-headed Cisticola	-	-		X									
PASSERIFORMES	CORVIDAE	*Corvus orru*	Torresian Crow	-	-	X	X	X	X	X	X	X	X		X	X
PASSERIFORMES	DICRURIDAE	*Dicrurus bracteatus*	Spangled Drongo	-	-	X	X	X	X	X	X	X				
PASSERIFORMES	ESTRILDIDAE	*Taeniopygia bichenovii*	Double-barred Finch	-	-	X	X	X	X		X				X	
PASSERIFORMES	HIRUNDINIDAE	*Petrochelidon nigricans*	Tree Martin	-	-		X									
PASSERIFORMES	MALURIDAE	*Malurus melanocephalus*	Red-backed Fairy-wren	-	-	X	X	X			X		X		X	
PASSERIFORMES	MEGALURIDAE	*Megalurus timoriensis*	Tawny Grassbird	-	-		X									
PASSERIFORMES	MELIPHAGIDAE	*Conopophila albogularis*	Rufous-banded Honeyeater	-	-	X	X									
PASSERIFORMES	MELIPHAGIDAE	*Conopophila rufogularis*	Rufous-throated Honeyeater	-	-								X			
PASSERIFORMES	MELIPHAGIDAE	*Lichmera indistincta*	Brown Honeyeater	-	-	X	X	X	X	X	X				X	
PASSERIFORMES	MELIPHAGIDAE	*Melithreptus albogularis*	White-throated Honeyeater	-	-	X	X	X		X	X	X				
PASSERIFORMES	MELIPHAGIDAE	*Myzomela erythrocephala*	Red-headed Honeyeater	-	-		X									
PASSERIFORMES	MELIPHAGIDAE	*Myzomela obscura*	Dusky Honeyeater	-	-			X								

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						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
PASSERIFORMES	MELIPHAGIDAE	*Philemon argenticeps*	Silver-crowned Friarbird	-	-	X	X	X	X	X	X	X			X	
PASSERIFORMES	MELIPHAGIDAE	*Philemon citreogularis*	Little Friarbird	-	-	X	X	X	X		X	X				
PASSERIFORMES	MELIPHAGIDAE	*Philemon sp.*		-	-										X	
PASSERIFORMES	MELIPHAGIDAE	*Ramsayornis fasciatus*	Bar-breasted Honeyeater	-	-	X	X									
PASSERIFORMES	MELIPHAGIDAE	*Stomiopera unicolor*	White-gaped Honeyeater	-	-	X	X	X		X	X	X				
PASSERIFORMES	MONARCHIDAE	*Grallina cyanoleuca*	Magpie-lark	-	-	X									X	
PASSERIFORMES	MONARCHIDAE	*Myiagra alecto*	Shining Flycatcher	-	-	X	X	X			X				X	
PASSERIFORMES	MONARCHIDAE	*Myiagra inquieta*	Restless Flycatcher	-			X									
PASSERIFORMES	MONARCHIDAE	*Myiagra rubecula*	Leaden Flycatcher	-	-	X	X	X	X		X					
PASSERIFORMES	MONARCHIDAE	*Myiagra ruficollis*	Broad-billed Flycatcher	-	-		X	X								
PASSERIFORMES	MONARCHIDAE	*Symposiachrus trivirgatus*	Spectacled Monarch	M(t)	-	X										
PASSERIFORMES	MOTACILLIDAE	*Anthus novaeseelandiae*	Australasian Pipit	-	-	X									X	
PASSERIFORMES	NECTARINIIDAE	*Dicaeum hirundinaceum*	Mistletoebird	-	-	X	X	X								
PASSERIFORMES	ORIOLIDAE	*Oriolus flavocinctus*	Yellow Oriole	-	-	X	X				X					
PASSERIFORMES	ORIOLIDAE	*Oriolus sagittatus*	Olive-backed Oriole	-	-	X	X	X	X							
PASSERIFORMES	ORIOLIDAE	*Sphecotheres vieilloti*	Australasian Figbird	-	-	X	X									
PASSERIFORMES	PACHYCEPHALIDAE	*Colluricincla harmonica*	Grey Shrike-thrush	-	-	X	X	X		X	X				X	
PASSERIFORMES	PACHYCEPHALIDAE	*Colluricincla megarhyncha*	Little Shrike-thrush	-	-	X		X	X							
PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala rufiventris*	Rufous Whistler	-	-	X	X	X	X	X	X	X			X	
PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala simplex*	Grey Whistler	-	-	X	X	X								
PASSERIFORMES	PARDALOTIDAE	*Pardalotus striatus*	Striated Pardalote	-	-	X	X	X		X	X	X	X		X	X
PASSERIFORMES	PETROICIDAE	*Microeca flavigaster*	Lemon-bellied Flycatcher	-	-	X	X	X			X	X			X	
PASSERIFORMES	PITTIDAE	*Pitta iris*	Rainbow Pitta	-	-	X	X						X		X	
PASSERIFORMES	POMATOSTOMIDAE	*Pomatostomus temporalis*	Grey-crowned Babbler	-	-	X	X	X			X		X		X	
PASSERIFORMES	PTILONORHYNCHIDAE	*Ptilonorhynchus nuchalis*	Great Bowerbird	-	-	X	X				X		X		X	
PASSERIFORMES	RHIPIDURIDAE	*Rhipidura dryas*	Arafura Fantail	-	-		X				X				X	
PASSERIFORMES	RHIPIDURIDAE	*Rhipidura leucophrys*	Willie Wagtail								X					
PASSERIFORMES	RHIPIDURIDAE	*Rhipidura rufifrons*	Rufous Fantail	-	-	X										
PASSERIFORMES	RHIPIDURIDAE	*Rhipidura rufiventris*	Northern Fantail	-	-	X	X	X	X	X	X	X			X	X
PASSERIFORMES	TIMALIIDAE	*Zosterops luteus*	Yellow White-eye	-	-	X	X				X					
PELECANIFORMES	ANHINGIDAE	*Anhinga novaehollandiae*	Australasian Darter	-	-		X									
PELECANIFORMES	PHALACROCORACIDAE	*Phalacrocorax sulcirostris*	Little Black Cormorant	-	-	X										
PODICIPEDIFORMES	PODICIPEDIDAE	*Tachybaptus novaehollandiae*	Australasian Grebe	-	-	X	X									
PSITTACIFORMES	CACATUIDAE	*Cacatua galerita*	Sulphur-crested Cockatoo	-	-	X	X	X	X	X	X					
PSITTACIFORMES	CACATUIDAE	*Cacatua sanguinea*	Little Corella	-	-	X	X		X				X			
PSITTACIFORMES	CACATUIDAE	*Calyptorhynchus banksii*	Red-tailed Black-cockatoo	-	-	X										

Order	Family	Scientific Name	Common Name	EPBC Act Status	TPWC Act Status	Webb (1992)	URS (2012)	Cumberland Ecology (2015a)			Cumberland Ecology (2016)		Heiniger and Gillespie (2017)		Cumberland Ecology (2019c)	
						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
PSITTACIFORMES	PSITTACIDAE	*Aprosmictus erythropterus*	Red-winged Parrot	-	-	X	X	X	X		X	X				
PSITTACIFORMES	PSITTACIDAE	*Trichoglossus haematodus*	Rainbow Lorikeet	-	-	X	X	X	X	X	X	X				
STRIGIFORMES	STRIGIDAE	*Ninox novaeseelandiae*	Southern Boobook	-	-	X	X	X			X	X	X			
STRIGIFORMES	TYTONIDAE	*Tyto novaehollandiae kimberli*	Masked Owl (northern)	V	V		X	X			X				X	
TURNICIFORMES	TURNICIDAE	*Turnix castanotus*	Chestnut-backed Button-quail	-	-	X	X	X			X		X		X	
MAMMALS																
CARNIVORA	CANIDAE	*Canis familiaris*	Domestic Dog	-	-	X	X								X	
CARNIVORA	CANIDAE	*Canis familiaris/lupus*	Domestic Dog / Dingo	-	-		X	X	X		X					
CARNIVORA	CANIDAE	*Canis lupus*	Dingo	-	-	X							X		X	
CARNIVORA	FELIDAE	*Felis catus*	Cat	-	-	X	X	X					X		X	
CHIROPTERA	EMBALLONURIDAE	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	-	-		X	X	X		X					
CHIROPTERA	EMBALLONURIDAE	*Taphozous georgianus*	Common Sheathtail-bat	-	-		X	X			X	X				
CHIROPTERA	HIPPOSIDERIDAE	*Hipposideros ater*	Dusky Leafnosed-bat	-	-			X								
CHIROPTERA	MEGADERMATIDAE	*Macroderma gigas*	Ghost Bat	-	-		X									
CHIROPTERA	MOLOSSIDAE	*Chaerephon jobensis*	Northern Freetail-bat	-	-			X^								
CHIROPTERA	MOLOSSIDAE	*Mormopterus beccarii*	Beccari's Freetail-bat	-	-						X^					
CHIROPTERA	PTEROPODIDAE	*Macroglossus minimus*	Northern Blossom-bat	-	-		X		X							
CHIROPTERA	PTEROPODIDAE	*Pteropus alecto*	Black Flying-fox	-	-		X	X								
CHIROPTERA	PTEROPODIDAE	*Pteropus scapulatus*	Little Red Flying-fox	-	-	X	X									
CHIROPTERA	VESPERTILIONIDAE	*Chalinolobus gouldii*	Gould's Wattled Bat	-	-			X^								
CHIROPTERA	VESPERTILIONIDAE	*Chalinolobus nigrogriseus*	Hoary Wattled Bat	-	-		X	X								
CHIROPTERA	VESPERTILIONIDAE	*Chalinolobus nigrogriseus /* [illegible]		-	-			X	X^		X^	X^				
CHIROPTERA	VESPERTILIONIDAE	*Myotis macropus*	Large-footed Myotis	-	-		X	X								
CHIROPTERA	VESPERTILIONIDAE	*Nyctophilus arnhemensis*	Arnhem Long-eared Bat	-	-		X									
CHIROPTERA	VESPERTILIONIDAE	*Nyctophilus sp.*		-	-			X			X^	X^				
CHIROPTERA	VESPERTILIONIDAE	*Nyctophilus walkeri*	Pygmy Long-eared Bat	-	-			X								
CHIROPTERA	VESPERTILIONIDAE	*Vespadelus caurinus*	Northern Cave Bat	-	-	X	X	X			X	X				
CHIROPTERA	VESPERTILIONIDAE	*Vespadelus finlaysoni*	Finlayson's Cave Bat	-	-		X				X	X				
DASYUROMORPHIA	DASYURIDAE	*Dasyurus hallucatus*	Northern Quoll	E	CE	X	X	X	X	X	X	X	X	X	X	X
DASYUROMORPHIA	DASYURIDAE	*Planigale maculata*	Common Planigale	-	-	X	X						X		X	X
DIPROTODONTIA	MACROPODIDAE	*Macropus agilis*	Agile Wallaby	-	-	X	X	X	X		X	X	X	X	X	X
DIPROTODONTIA	MACROPODIDAE	*Petrogale brachyotis*	Short-eared Rock-wallaby	-	-	X		X					X		X	
DIPROTODONTIA	PETAURIDAE	*Petaurus breviceps*	Sugar Glider	-	-	X	X	X			X		X		X	
DIPROTODONTIA	PHALANGERIDAE	*Trichosurus vulpecula arnhemensis*	Common Brushtail Possum (northern)	-	-		X									
DIPROTODONTIA	PSEUDOCHEIRIDAE	*Petropseudes dahli*	Rock Ringtail Possum	-	-	X									X	

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						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
MONOTREMATA	TACHYGLOSSIDAE	*Tachyglossus aculeatus*	Short-beaked Echidna	-	-	X	X	X			X		X	X	X	X
PERAMELEMORPHIA	PERAMELIDAE	*Isoodon macrourus*	Northern Brown Bandicoot	-	-	X	X	X	X		X	X	X	X	X	X
RODENTIA	MURIDAE	*Conilurus penicillatus*	Brush-tailed Rabbit-rat	V	E			X					X			
RODENTIA	MURIDAE	*Hydromys chrysogaster*	Water-rat	-	-		X								X	
RODENTIA	MURIDAE	*Melomys burtoni*	Grassland Melomys	-	-	X	X	X	X		X		X	X	X	X
RODENTIA	MURIDAE	*Mus musculus**	House Mouse	-	-				X							
RODENTIA	MURIDAE	*Notomys aquilo*	Northern Hopping-mouse	V	V			X					X		X	
RODENTIA	MURIDAE	*Pseudomys delicatulus*	Delicate Mouse	-	-	X	X	X	X		X		X	X	X	X
RODENTIA	MURIDAE	*Rattus rattus*	Black Rat*	-	-				X							
RODENTIA	MURIDAE	*Zyzomys argurus*	Common Rock-rat	-	-	X		X							X	
REPTILES	**REPTILES**															
CROCODYLIA	CROCODYLIDAE	*Crocodylus porosus*	Saltwater Crocodile	M(m)	-	X	X	X			X					
SQUAMATA	AGAMIDAE	*Chlamydosaurus kingii*	Frilled Lizard	-	-	X	X	X	X		X		X		X	X
SQUAMATA	AGAMIDAE	*Diporiphora bilineata*	Two-lined Dragon	-	-	X	X	X			X	X	X		X	
SQUAMATA	AGAMIDAE	*Diporiphora magna*	Yellow-sided Two-line Dragon	-	-			X								
SQUAMATA	AGAMIDAE	*Lophognathus gilberti*	Gilbert's Dragon	-	-	X	X						X	X	X	X
SQUAMATA	AGAMIDAE	*Unidentified spp.*		-	-								X		X	
SQUAMATA	BOIDAE	*Antaresia childreni*	Children's Python	-	-	X	X									
SQUAMATA	BOIDAE	*Liasis fuscus*	Water Python	-	-	X	X									
SQUAMATA	BOIDAE	*Liasis olivaceus*	Olive Python	-	-	X		X			X		X		X	
SQUAMATA	BOIDAE	*Morelia spilota*	Diamond Python	-	-			X								
SQUAMATA	COLUBRIDAE	*Boiga irregularis*	Brown Tree Snake	-	-	x	X	X								
SQUAMATA	COLUBRIDAE	*Dendrelaphis punctulatus*	Common Tree Snake	-	-		X									
SQUAMATA	COLUBRIDAE	*Tropidonophis mairii*	Freshwater Snake	-	-	X	X									
SQUAMATA	DIPLODACTYLIDAE	*Amalosia rhombifer*	Zigzag Velvet Gecko	-	-	X	X									
SQUAMATA	DIPLODACTYLIDAE	*Oedura marmorata*	Marbled Velvet Gecko	-	-	X										
SQUAMATA	ELAPIDAE	*Acanthophis praelongus*	Northern Death Adder	-	-		X									
SQUAMATA	ELAPIDAE	*Demansia olivacea*	Olive Whip Snake	-	-										X	
SQUAMATA	ELAPIDAE	*Pseudechis australis*	King Brown Snake	-	-	X										
SQUAMATA	ELAPIDAE	*Pseudechis weigeli*	Weigel's Black Snake	-	-		X						X	X	X	X
SQUAMATA	ELAPIDAE	*Pseudonaja nuchalis*	Western Brown Snake	-	-										X	
SQUAMATA	ELAPIDAE	*Pseudonaja nuchalis*	Northern Brown Snake	-	-		X	X								
SQUAMATA	ELAPIDAE	*Unidentified spp.*		-	-								X		X	
SQUAMATA	GEKKONIDAE	*Gehyra australis*	Northern Dtella	-	-	X	X									
SQUAMATA	GEKKONIDAE	*Gehyra pamela*	Arnhemland Watercourse Dtella	-	-	X										
SQUAMATA	GEKKONIDAE	*Hemidactylus frenatus*	House Gecko	-	-		X				X					
SQUAMATA	GEKKONIDAE	*Heteronotia binoei*	Bynoe's Gecko	-	-	X	X	X	X		X					
SQUAMATA	GEKKONIDAE	*Unidentified spp.*		-	-								X		X	

Order	Family	Scientific Name	Common Name	EPBC Act Status	TPWC Act Status	Webb (1992)	URS (2012)	Cumberland Ecology (2015a)			Cumberland Ecology (2016)		Heiniger and Gillespie (2017)		Cumberland Ecology (2019c)	
						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*
SQUAMATA	HOMALOPSIDAE	*Enhydris polylepis*	Macleay's Water Snake	-	-	X	X									
SQUAMATA	PYGOPODIDAE	*Delma borea*	Rusty-topped Delma	-	-	X	X	X		X	X	X				
SQUAMATA	PYGOPODIDAE	*Lialis burtonis*	Burton's Snake-lizard	-	-	X	X	X	X							
SQUAMATA	SCINCIDAE	*Carlia amax*	Bauxite Rainbow-skink	-	-	X	X	X	X	X						
SQUAMATA	SCINCIDAE	*Carlia longipes*	Closed-litter Rainbow-skink	-	-	X										
SQUAMATA	SCINCIDAE	*Carlia munda*	Shaded-litter Rainbow-skink	-	-	X	X	X			X	X				
SQUAMATA	SCINCIDAE	*Carlia sexdentata*		-	-		X	X								
SQUAMATA	SCINCIDAE	*Cryptoblepharus metallicus*	Metallic Snake-eyed Skink	-	-		X									
SQUAMATA	SCINCIDAE	*Cryptoblepharus plagiocephalus*	Péron's Snake-eyed Skink	-	-	X		X		X						
SQUAMATA	SCINCIDAE	*Ctenotus arnhemensis*	Arnhem Land Ctenotus	-	-			X								
SQUAMATA	SCINCIDAE	*Ctenotus essingtonii*	Port Essington Ctenotus	-	-	X		X								
SQUAMATA	SCINCIDAE	*Ctenotus inornatus*	Bar-shouldered Ctenotus	-	-	X	X				X					
SQUAMATA	SCINCIDAE	*Ctenotus quirinus*		-	-		X		X		X	X				
SQUAMATA	SCINCIDAE	*Ctenotus robustus*	Robust Ctenotus	-	-		X	X	X	X						
SQUAMATA	SCINCIDAE	*Ctenotus spaldingi*	Spalding's Ctenotus	-	-		X	X			X	X				
SQUAMATA	SCINCIDAE	*Eremiascincus isolepis*	Northern Bar-lipped Skink	-	-	X	X	X								
SQUAMATA	SCINCIDAE	*Glaphyromorphus nigricaudis*	Black-tailed Bar-lipped Skink	-	-	X	X									
SQUAMATA	SCINCIDAE	*Lerista carpentariae*	Carpentaria Fine-lined Slider	-	-	X	X	X								
SQUAMATA	SCINCIDAE	*Menetia alanae*	Alana's Menetia	-	-	X	X									
SQUAMATA	SCINCIDAE	*Menetia greyii*	Common Dwarf Skink	-	-			X		X						
SQUAMATA	SCINCIDAE	*Menetia maini*	Northern Dwarf Skink	-	-			X								
SQUAMATA	SCINCIDAE	*Notoscincus ornatus*	Ornate Soil-crevice Skink	-	-	X	X	X								
SQUAMATA	SCINCIDAE	*Proablepharus tenuis*	Northern Soil-crevice Skink	-	-	X	X	X		X	X					
SQUAMATA	SCINCIDAE	*Tiliqua scincoides*	Eastern Blue-tongue	-	-			X								
SQUAMATA	SCINCIDAE	*Tiliqua scincoides intermedia*	Northern Blue-tongue Lizard	-	-	X	X	X					X		X	X
SQUAMATA	SCINCIDAE	*Unidentified spp.*		-	-								X	X	X	
SQUAMATA	TYPHLOPIDAE	*Ramphotyphlops minimus*	Groote Dwarf Blind Snake	-	-			X								
SQUAMATA	TYPHLOPIDAE	*Ramphotyphlops unguirostris*	Claw-snouted Blind Snake	-	-	X										
SQUAMATA	VARANIDAE	*Varanus acanthurus*	Ridge-tailed Monitor	-	-										X	
SQUAMATA	VARANIDAE	*Varanus glebopalma*	Black-palmed Monitor	-	-	X	X								X	
SQUAMATA	VARANIDAE	*Varanus gouldii*	Sand Goanna	-	-								X		X	X
SQUAMATA	VARANIDAE	*Varanus mertensi*	Mertens' Water Monitor	-	V	X	X	X	X							
SQUAMATA	VARANIDAE	*Varanus panoptes*	Yellow-spotted Monitor	-	V		X	X	X							
SQUAMATA	VARANIDAE	*Varanus scalaris*	Spotted Tree Monitor	-	-	X	X	X	X				X		X	X
SQUAMATA	VARANIDAE	*Varanus sp.*		-	-										X	
SQUAMATA	VARANIDAE	*Varanus tristis*	Black-headed Monitor	-	-								X		X	

1. Conservation Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

Order	Family	Scientific Name	Common Name	EPBC Act Status	TPWC Act Status	Webb (1992)	URS (2012)	Cumberland Ecology (2015a)			Cumberland Ecology (2016)		Heiniger and Gillespie (2017)		Cumberland Ecology (2019c)	
						Survey Location										
						Eastern Leases & existing mine	*Existing mine*	*Eastern Leases*	*Rehab areas of existing mine*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*	*Project Area#*	*Within Study Area*

2. Species listed as Pandion haliaetus the Protected Matters Search report. Pandion haliaetus cristatus was previously recognised as a subspecies for Australasia and New Caledonia, however it is currently recognised as a species in its own right.

** Denotes an exotic species*

^Species identification was not possible, as call could not be positively identified.

 # Refers to the area in which the relevant study was undertaken.

APPENDIX H :

Likelihood of Occurrence Assessment

Table 25 Likelihood of occurrence assessment

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
BIRDS									
Red Knot	*Calidris canutus*	E, M(w)	V	X	X	**General habitat requirements/preferences:** The Red Knot mainly inhabits intertidal mudflats, sandflats and sandy beaches of sheltered coasts and sometimes on sandy ocean beaches or shallow pools on exposed rock platforms (Threatened Species Scientific Committeee 2016). They have also been recorded on terrestrial saline wetlands near the coast (Threatened Species Scientific Committeee 2016). **Foraging requirements/preferences:** The species is known to forage near the edge of water on intertidal mudflats and sand flats, as well as sewage ponds, and nearby lakes (Threatened Species Scientific Committeee 2016). **Roosting requirements/preferences:** The species roosts on sandy beaches, spits and islets, and mudflats (Threatened Species Scientific Committeee 2016). The species prefer to roost in open areas far away from potential cover for predators, but close to feeding grounds (Threatened Species Scientific Committeee 2016). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The NR Maps database identifies two occurrences of the species in the locality, with the latest record from 1978. No records exist within the Study Area. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. The estuarine habitat in the Study Area could provide suitable habitat for the Red Knot. However, the species is assessed as having a low likelihood of occurrence, given the lack of records in recent years.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species does not breed in Australia, (Threatened Species Scientific Committeee 2016).			
Curlew Sandpiper	*Calidris ferruginea*	CE, M(w)	V	X	X	**General habitat requirements/preferences:** The Curlew Sandpiper mainly occurs on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms (Threatened Species Scientific Committee 2015b). **Foraging requirements/preferences:** Main requirements for feeding habitats are the presence of mudflats or shallow water up to 60 mm. The Curlew Sandpiper may also forage in low sparse emergent vegetation, such as saltmarsh, and sometimes forage in flooded paddocks or inundated saltflats (Threatened Species Scientific Committee 2015b). **Roosting requirements/preferences:** Roosting occurs in open situations with damp substrate, especially on bare shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Threatened Species Scientific Committee 2015b). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The NR Maps database identifies 20 occurrences of the species in the locality, with the latest record from 2019. No records are located within the Study Area. The species has been recorded previously on the island by Webb (1992), however the exact location is unknown.	Low likelihood of occurrence. The Curlew Sandpiper is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Curlew Sandpiper due to the absence of intertidal mudflats. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species does not breed in Australia (Threatened Species Scientific Committee 2015b).			
Great Knot	*Calidris tenuirostris*	CE, M(w)	V		X	**General habitat requirements/preferences:** The Great Knot inhabits sheltered coastal habitats, including inlets, harbours and estuaries. The species prefers habitats with large intertidal mudflats or sand flats. It has also been recorded on rock platforms, ponds in salt works, swamps near the coast, and salt lakes (DotE 2013a). **Foraging requirements/preferences:** The species is known to forage in areas of mud for invertebrates (OEH 2014). **Roosting requirements/preferences:** Roosting habitat for the Great Knot is mainly shallow water in close proximity to feeding grounds (DotE 2013a). **Breeding requirements/preferences:** The species does not breed in Australia (DotE 2013a).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The NR Maps database identifies 21 occurrences of the species within the Study Area, with the latest record from 2019. No records occur within the Study Area. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. The Great Knot is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Great Knot due to the absence of intertidal mudflats and sandflats. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
Greater Sand Plover	*Charadrius leschenaultii*	V, M(w)	V		X	**General habitat requirements/preferences:** The Greater Sand Plover inhabits coastal littoral and estuarine environments, and is mainly found on sandy or muddy beaches with intertidal mudflats or sandbanks, rock platforms, inshore reefs or sand cays on coral reefs (DotEE 2019h).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has been recorded previously on the island by URS (2012),	Low likelihood of occurrence. The Greater Sand Plover is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Foraging requirements/preferences: The species forages visually over the surface of the substrate or just below the surface. It prefers to forage in areas that have low densities of other foraging shorebirds (DotEE 2019h). **Roosting requirements/preferences:** The Greater Sand Plover usually roosts on banks, sand-spits, beaches, or in tidal lagoons. They are also known to roost on rocky points and in salt marshes (DotEE 2019h). **Breeding requirements/preferences:** This species does not breed in Australia (DotEE 2019h).	however the exact location is unknown. The NR Maps database identifies 31 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area.	for the Greater Sand Plover due to the absence of preferred habitat including sandy or muddy beaches with intertidal mudflats or sandbanks, rock platforms, inshore reefs or sand clays on coral reefs. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	
Lesser Sand Plover	*Charadrius mongolus*	E, M(w)	V		X	**General habitat requirements/preferences:** The Lesser Sand Plover is found in coastal littoral and estuarine environment, with preferred habitats including large intertidal sand flats or mudflats in sheltered bays, harbours and estuaries, and sometimes also sandy ocean beaches, coral reefs, and rock platforms (DotEE 2019i). **Foraging requirements/preferences:** Preferred foraging habitat consists of vast, freshly-exposed intertidal sand flats and mudflats in beaches, estuaries and ponds in salt works. They are also known to feed on coral reef, river margins, and muddy areas around lakes (DotEE 2019i). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has been recorded previously on the island by URS (2012) in coastal and estuarine environments. The NR Maps database identifies 26 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area.	Low likelihood of occurrence. The Lesser Sand Plover is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Lesser Sand Plover due to the absence of preferred habitat including intertidal sandflats and mudflats. The species is assessed as having a low likelihood of occurrence, given the lack	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Roosting habitat is usually near foraging areas, but it is known to roost inland on sandbanks in swamp, grassy margins of ephemeral pools, and inland claypan (DotEE 2019i). **Breeding requirements/preferences:** The Lesser Sand Plover is a migratory bird which breeds in Mongolia and Siberia, and typically overwinters in Australia. It is not known to breed in Australia (DotEE 2019i).		of habitat within the Study Area.	
Red Goshawk	*Erythrotriorchis radiatus*	V	V	X		**General habitat requirements/preferences:** The Red Goshawk prefers woodlands and forests with a mosaic of vegetation types that are open enough for fast manoeuvring flight. These favoured areas contain permanent water and have large populations of birds of other species (DotEE 2019n). **Foraging requirements/preferences:** The Red Goshawk generally avoids very dense or very open habitats, preferring to hunt along their ecotones (DotEE 2019n). **Roosting requirements/preferences:** The species nests in tall trees in open forest and woodland near permanent water bodies. Their nest is usually placed on a horizontal branch against a vertical branch (DotEE 2019n). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. There are no records of this raptor on Groote Eylandt within the NR Maps database. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The EPBC PMST identifies that the species or species habitat is likely to occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat	Low likelihood of occurrence. The vegetation in the Study Area could provide suitable habitat for the Red Goshawk. However, the species has a low potential to occur in the Study Area, given that it has never been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. The vegetation in the Disturbance Footprint could provide suitable habitat for the Red Goshawk. However, the species has a low potential to occur in the Disturbance Footprint, given that it has never been recorded on Groote Eylandt, despite numerous fauna surveys.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding generally occurs from August to November and nesting territories are reused by breeding pairs year after year (DotEE 2019n).	modelling, rather than actual records of the species.		
Gouldian Finch	*Erythrura gouldiae*	E	V	X		**General habitat requirements/preferences:** The main habitat requirements for the Gouldian Finch are the presence of grasses (especially Sorghum), close proximity to permanent water, and open woodlands dominated by Eucalypts (DotE 2014b). **Foraging requirements/preferences:** The species feeds almost exclusively on seeds taken from grasses such as Sorghum, although they also take seeds from grasses in other genera including Alloteropsis, Aristida, Chrysopogon, Digitaria, Echinochloa, Eriachne, Heteropogon, Panicum, Schizachyrium, Sehima, Themeda, Triodia and Xerochloa. The species has also been recorded foraging in areas burnt by fire. (DotE 2014b). **Roosting requirements/preferences:** The Gouldian Finch usually nests in Eucalyptus tree hollows, but is also known to nest in shrubs among grass and in termite mound hollows (DotE 2014b). **Breeding requirements/preferences:** Breeding habitat usually occurs on ridges and rocky foothills. A critical habitat	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The NR Maps database contains a single record of occurrence of this species on Groote Eylandt (although the record is not from within the Study Area or locality). The record is from the year 1924, and there have been no further records of this species since then, despite numerous fauna surveys on the island, in particular, surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius.	Low likelihood of occurrence. The vegetation in the Study Area could provide suitable habitat for the Gouldian Finch. However, the species is not predicted to occur in the Study Area, given a lack of recent records on Groote Eylandt.	Low likelihood of occurrence. The vegetation in the Disturbance Footprint could provide suitable habitat for the Gouldian Finch. However, the species is not predicted to occur in the Disturbance Footprint, given a lack of recent records on Groote Eylandt.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						requirement for breeding is the presence of unburnt hollow-bearing Eucalyptus trees (DotE 2014b).			
Bar-tailed Godwit	*Limosa lapponica*	V/CE[5] M(w)	V	X	X	**General habitat requirements/preferences:** The Bar-tailed Godwit is mainly a coastal species, and inhabits intertidal sand flats, mudflats, estuaries, harbours and coastal lagoons. The species has been recorded in coastal sewage farms and salt lakes and brackish wetlands, sandy ocean beaches, rock platforms, and around beds of seagrass (DotEE 2019t). **Foraging requirements/preferences:** Preferred feeding habitats include shallow water or the edge of water in tidal estuaries, harbours, or soft mud with seagrass beds (DotEE 2019t). **Roosting requirements/preferences:** Main habitat requirements for roosting include sandy beaches and near-coastal salt marshes (DotEE 2019t). **Breeding requirements/preferences:** The Bar-tailed Godwit does not breed in Australia (DotEE 2019t).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 22 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius.	Low likelihood of occurrence. The Bar-tailed Godwit is a coastal species. A small area of potential habitat for this species occurs in the western portion of the Study Area, in the area mapped as estuarine complex habitat. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
Eastern Curlew	*Numenius madagascariensis*	CE, M(w)	V	X	X	**General habitat requirements/preferences:** During the non-breeding season in Australia, the Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent	Low likelihood of occurrence. The Eastern Curlew is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						large intertidal mudflats or sandflats, often with beds of seagrass (DotE 2015a). **Foraging requirements/preferences:** The species mainly forages during the non-breeding season on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on saltflats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DotE 2015a). **Roosting requirements/preferences:** The species roosts during high tide periods on sandy spits, sandbars and islets, especially on beach sand near the high-water mark, and among coastal vegetation including low saltmarsh or mangroves (DotE 2015a). **Breeding requirements/preferences:** The Eastern Curlew does not breed in Australia (DotE 2015a).	to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 56 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area The EPBC PMST identifies that the species or species habitat is known to occur within the 20 km search radius.	western portion of the Study Area is unlikely to provide suitable habitat for the Eastern Curlew due to the absence of preferred habitat including intertidal mudflats and sandflats. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	contain estuarine complex habitats.
Australian Painted Snipe	*Rostratula australis*	E	V	X		**General habitat requirements/preferences:** Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DAWE 2020f). **Foraging requirements/preferences:** Generally remain in dense cover when feeding, although may forage over	This species was not recorded within the Study Area during recent (2014-2019) field surveys. There are no records of this species on Groote Eylandt within the NR Maps database. The species has not been recorded in areas	Low likelihood of occurrence. The Australian Painted Snipe is a coastal / wetland species. A small area of potential habitat for this species occurs within wetland habitats, particularly in the northern portion of the Study Area.	Low likelihood of occurrence. No suitable habitat is present in the Disturbance Footprint and the species is not known to occur on Groote Eylandt.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						nearby mudflats and other open areas such as ploughed land or grassland (DAWE 2020f). **Breeding requirements/preferences:** Breeds in shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby (DAWE 2020f).	adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.	Nevertheless, the species is assessed as having a low likelihood of occurrence, given the lack of records on Groote Eylandt.	
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	V	V		X	**General habitat requirements/preferences:** The northern species of the Masked Owl is known to occur in riparian forest, eucalypt tall open forest, monsoon rainforest, and Melaleuca swamps and the margins of sugar cane fields (DotEE 2019ak). **Foraging requirements/preferences:** The species forages in open woodland on small to medium-sized terrestrial mammals (DotEE 2019ak). **Roosting requirements/preferences:** The species requires large tree hollows for nesting and usually nests in areas of closed forest (DotEE 2019ak). **Breeding requirements/preferences:**	This species was recorded on one occasion within the study area in 2018. This record was an opportunistic sighting. No other records occur within the Study Area during recent (2014-2019) field surveys, however it has been recorded within the Eastern Leases and Southern Lease. The species was recorded within the Southern Lease at one location during recent field surveys (Cumberland Ecology 2016). The species was recorded flying over *Eucalyptus tetrodonta*	Present. An opportunistic sighting was recorded by Cumberland ecology duing flora surveys in October 2018.	High likelihood of occurrence. Suitable habitat is present throughout the Disturbance Footprint as remnant vegetation exists throughout. There is excellent habitat connectivity in the landscape. Hollow-bearing trees which provide suitable roosting habitat may be present in the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Little is known about the life cycle of the species but it is believed to breed between March-October (DotEE 2019ak).	shrubland in response to call playback. The species has been recorded within areas adjacent to the Study Area in the Southern Lease and along the coastline (Cumberland Ecology 2019c). The Masked Owl (northern) was previously recorded within the nearby Eastern Leases at four locations by Cumberland Ecology (2015) and at 10 locations by EMS (2013). URS (2012) recorded this species at four locations in E. tetrodonta open forest and on the margins of Melaleuca and Eucalyptus-dominated forest types. The NR Maps database identifies 10 occurrences of the species in the locality, with the latest record from 2017.		
Oriental Reed-warbler	*Acrocephalus orientalis*	M(w)		X		**General habitat requirements/preferences:** Found in aquatic vegetation along waterways and waterbodies. It has been recorded using Typha sp., in sugar cane plantations, and in mangroves (DotE 2015b).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. There are no records of this species from Groote Eylandt	Low likelihood of occurrence. A small area of potential habitat for this species occurs primarily within the northern portion of the Study Area where aquatic	Low likelihood of occurrence. No suitable habitat is present in the Disturbance Footprint and the species is not

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Foraging requirements/preferences: Little information on the foraging requirements of this species in Australia is currently known. **Roosting requirements/preferences:** Little information on the roosting requirements of this species in Australia is currently known. **Breeding requirements/preferences:** This species does not breed in Australia (DotE 2015b).	on the NR Maps database. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.	vegetation is present (in riparian/wetland habitats). Nevertheless, the species is assessed as having a low likelihood of occurrence, given it has not been recorded on Groote Eylandt, despite numerous fauna surveys.	known to occur on Groote Eylandt.
Common Sandpiper	*Actitis hypoleucos*	M(w)		X	X	**General habitat requirements/preferences:** This species utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats (DotEE 2019a). **Foraging requirements/preferences:** The species feeds for extensive periods in grasslands consuming terrestrial prey, though riverine areas are also utilised (DotEE 2019a). The species eats molluscs such as bivalves, crustaceans such as amphipods and crabs and a variety of insects (DotEE 2019a).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has been recorded in a previous survey by URS (2012) in monsoon/mangrove forest and coastal strand habitats, and Webb (1992) in sewage ponds. The NR Maps database identifies 60 occurrences of the species in the locality,	Moderate likelihood of occurrence. The Common Sandpiper is a coastal / wetland species. A small area of potential habitat for this species occurs within wetland and estuarine complex habitats in the Study Area. This species is considered to have a moderate likelihood of occurring within the area of estuarine complex habitat and wetlands, particularly in the north-	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats or suitable wetland areas.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Roosting requirements/preferences: Roost sites are typically on rocks or in roots or branches of vegetation, especially mangroves (DotEE 2019a). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019a).	with the latest record from 2019. No records exist within the Study Area. The EPBC PMST identifies that the species or species habitat is known to occur within the 20 km search radius.	western portion of the Study Area. However, the majority of the Study Area does not contain suitable habitat.	
Common Noddy	*Anous stolidus*	M(m)		X		**General habitat requirements/preferences:** The species occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand (DotEE 2019b). **Foraging requirements/preferences:** The species feeds mainly on fish, although they are known to also take squid, pelagic molluscs, medusae, aquatic insects and even Pandanus fruit (DotEE 2019b). **Roosting requirements/preferences:** During the non-breeding period, the species occurs in groups throughout the pelagic zone (DotEE 2019b). **Breeding requirements/preferences:** The species breeds in colonies, and only one breeding location is known within the NT (DotEE 2019b).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database has no records of this species in the Study Area or locality. The latest record from Groote Eylandt is from 1980. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius.	Low likelihood of occurrence. The Common Noddy is a coastal / marine species. This species has been assessed as having a low potential to occur, given, the lack of records in recent years and the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain coastal habitat.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
Fork-tailed Swift	*Apus pacificus*	M(m)		X	X	**General habitat requirements/preferences:** The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. The species mostly occurs over inland plains, open habitats, riparian woodland, tea-tree swamps, and occasionally above foothills or in coastal areas. They also occur over settled areas, including towns, urban areas and cities (DotEE 2019c). **Foraging requirements/preferences:** The species forages aerially, often in updraughts, near cliffs (DotEE 2019c). This species prefers foraging above dry and open habitats (DotEE 2019c). **Roosting requirements/preferences:** The species is likely to roost aerially, but are occasionally observed to land (DotEE 2019c). **Breeding requirements/preferences:** The Fork-tailed Swift does not breed in Australia (DotEE 2019c).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has been recorded in previous surveys by URS (2012), however the exact location is unknown. The NR Maps database identifies 6 occurrences of the species in the locality, with the latest record from 2018. No records exist within the Study Area. The EPBC PMST identifies the species or species habitat as being likely to occur within the 20 km search radius.	Moderate likelihood of occurrence. Potential overfly habitat is present in the Study Area, although this species prefers foraging above dry and open habitats rather than in the predominantly wooded forests in the Study Area.	Moderate likelihood of occurrence. Potential overfly habitat is present in the Disturbance Footprint, although this species prefers foraging above dry and open habitats rather than in the predominantly wooded forests in the Disturbance Footprint.
Ruddy Turnstone	*Arenaria interpres*	M(w)			X	**General habitat requirements/preferences:** The species is mainly found on coastal regions with exposed rock coast lines or coral reefs. It also lives near platforms and shelves, often with shallow tidal pools and rocky, shingle or gravel beaches (DotEE 2019d). **Foraging requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by	Low likelihood of occurrence. The Ruddy Turnstone is a coastal species that requires estuarine complex habitats. Although a small portion of estuarine complex habitat is present in the western portion of	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Mainly forages between lower supralittoral and lower littoral zones of foreshores, from strand-line to wave-zone (DotEE 2019d). **Roosting requirements/preferences:** Roosting occurs on beaches, above the tideline, among rocks, shells, beachcast seaweed or other debris (DotEE 2019d). **Breeding requirements/preferences:** The Ruddy Turnstone does not breed in Australia (DotEE 2019d).	Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 14 occurrences of the species in the locality, with the latest record from 2018. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	the Study Area, it does not contain preferred habitat for the Ruddy Turnstone in the form of rock coastlines or coral reefs. The species is assessed as having a low likelihood of occurrence, given the lack of suitable habitat within the Study Area.	
Sharp-tailed Sandpiper	*Calidris acuminata*	M(w)		X	X	**General habitat requirements/preferences:** This species prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation (DotEE 2019e). **Foraging requirements/preferences:** They forage at the edge of the water of wetlands or intertidal mudflats, either on bare wet mud or sand, or in shallow water (DotEE 2019e). **Roosting requirements/preferences:** Roosting occurs at the edges of wetlands, on wet open mud or sand, in shallow water, or in short sparse vegetation, such as grass or saltmarsh (DotEE 2019e).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has been recorded in previous surveys by Webb (1992), however the exact location is unknown. The NR Maps database identifies 34 occurrences of the species in the locality, with the latest record from 2018. No records exist within the Study Area.	Moderate likelihood of occurrence. The Sharp-tailed Sandpiper is a coastal / marine species. A small area of potential habitat for this species occurs within wetland and estuarine complex habitats in the Study Area. This species is considered to have a moderate likelihood of occurring within the area of estuarine complex habitat and wetlands, particularly in the north-western portion of the Study Area. However, the majority of	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats or suitable wetland areas.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding requirements/preferences: The Sharp-tailed Sandpiper does not breed in Australia (DotEE 2019e).	The EPBC PMST identifies the species or species habitat as known to occur within the 20 km search radius.	the Study Area does not contain suitable habitat.	
Pectoral Sandpiper	*Calidris melanotos*	M(w)		X	X	**General habitat requirements/preferences:** The species prefers shallow fresh to saline wetlands (DotEE 2019f). The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DotEE 2019f). **Foraging requirements/preferences:** The species forages in shallow water or soft mud at the edge of wetlands (DotEE 2019f). **Roosting requirements/preferences:** Roosting habitat occurs in proximity to foraging habitat. **Breeding requirements/preferences:** The Pectoral Sandpiper does not breed in Australia (DotEE 2019f).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies one record of this species within the locality from 2014. This record does not occur within the Study Area. The EPBC PMST identifies that the species or species habitat is likely to occur within the 20 km search radius.	Low likelihood of occurrence. The Pectoral Sandpiper is a coastal / wetland species. A small area of potential habitat for this species occurs within wetland and estuarine complex habitats in the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the scarcity of records.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats or suitable wetland areas.
Red-necked Stint	*Calidris ruficollis*	M(w)			X	**General habitat requirements/preferences:**	This species was not recorded within the Study	Low likelihood of occurrence.	Low likelihood of occurrence.

Common Name	Scientific Name	Conservation Status[1] EPBC Act [2]	Conservation Status[1] TPWC Act	Database Records PMST	Database Records NR Maps	Habitat Requirements	Occurrence Summary	Likelihood of Occurrence Study Area	Likelihood of Occurrence Disturbance Footprint
						The species is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores (DotEE 2019g). **Foraging requirements/preferences:** The species mostly forages on bare wet mud on intertidal mudflats or sandflats, or in very shallow water; mostly in areas with a film of surface water and mostly close to the edge of water (DotEE 2019g). **Roosting requirements/preferences:** The species roosts on sheltered beaches, spits, banks or islets, of sand, mud, coral or shingle, sometimes in saltmarsh or other vegetation (DotEE 2019g). **Breeding requirements/preferences:** The Red-necked Stint does not breed in Australia (DotEE 2019g).	Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 45 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	The Red-necked Stint is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Red-necked Stint due to the absence of preferred habitat including intertidal mudflats. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
Streaked Shearwater	*Calonectris leucomelas*	M(m)		X		**General habitat requirements/preferences:** The species has been observed over open ocean and on islands (Takahashi et al. 2008). **Foraging requirements/preferences:** Areas near the continental shelf that have high primary productivity may be suitable foraging habitat (Takahashi et al. 2008). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a,	Low likelihood of occurrence. No suitable habitat for this species occurs in the Study Area, which is located outside of marine areas. Furthermore, this species has not been recorded on Groote Eylandt.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, which is located outside of marine areas. Furthermore, the species is not known to

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species is known to nest in burrows (Takahashi et al. 2008). **Breeding requirements/preferences:** This species does not breed in Australia (Takahashi et al. 2008).	2016, 2019c), URS (2012) and Webb (1992). The NR Maps database does not identify any records of the species within Groote Eylandt. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. However, this result should be viewed in light of the fact that the PMST radius includes coastal areas, not predominantly representative of the Study Area.		occur on Groote Eylandt.
Red-rumped Swallow	*Cecropis daurica*	M(t)		X		**General habitat requirements/preferences:** The species is found at locations with wetlands and open areas, such as golf courses (DotE 2015b). **Foraging requirements/preferences:** Predominately forages over wetlands, for example swamps, rivers, dams, or open areas such as golf courses or cane fields, where insects are taken on the wing (DotE 2015b). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. Wetland habitat within the Study Area provides potential habitat for the Red-rumped Swallow. However the Study Area lacks open areas such as golf courses. This species has been assessed as having a low potential to occur, given it has not been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. The species is not known to Groote Eylandt.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						As with most swallows and martins, Red-rumped Swallows often perch on bare branches or wires (DotE 2015b). **Breeding requirements/preferences:** This species does not breed in Australia (DotE 2015b).	The NR Maps database does not identify any records of the species within the locality. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.		
Little Ringed Plover	*Charadrius dubius*	M(w)			X	**General habitat requirements/preferences:** The Little Ringed Plover is a rare migrant to the coast of the NT and Western Australia. The species is a shorebird that typically breeds at freshwater lake-shores, rivers or man-made freshwater habitats such as water-treatment ponds, sewage farms and gravel pits. It is mainly an inland shorebird that is rarely found breeding in coastal habitats (Hedenström et al. 2013). **Foraging requirements/preferences:** The species forages on both dry and wet surfaces, and also in shallow water. It forages in tidal mudflats, pools, open short grasslands or bare ground (Hedenström et al. 2013). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies two occurrences of the species in the locality, with the latest record from 2018. No records occur within the Study Area.	Low likelihood of occurrence. Some potential habitat is present within the wetland habitat primarily in the northern portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the vagrant status of the species and absence of records in the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint and no records exist within the Study Area.

Common Name	Scientific Name	Conservation Status[1] EPBC Act [2]	Conservation Status[1] TPWC Act	Database Records PMST	Database Records NR Maps	Habitat Requirements	Occurrence Summary	Likelihood of Occurrence: Study Area	Likelihood of Occurrence: Disturbance Footprint
						Little information on the roosting requirements of this species in Australia is currently known. **Breeding requirements/preferences** The species is not known to breed in Australia.	The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.		
Oriental Plover	*Charadrius veredus*	M(w)		X	X	**General habitat requirements/preferences:** The Oriental Plover is known to spend several weeks in coastal areas when first arriving in northern Australia, and then eventually moves further inland. The species prefers flat, open, grasslands with areas of bare ground or areas recently burnt, including dry paddocks or clay pans. The species has also been sighted near terrestrial wetlands and in salt marshes (DotEE 2019j). **Foraging requirements/preferences:** The species is usually found foraging in short grass or on stony bare ground. It is also known to feed on mudflats and on beaches with beach cast seaweed (DotEE 2019j). **Roosting requirements/preferences:** Oriental Plovers roost on wet mud, near the shallow water of beaches, and in salt marshes or paddocks (DotEE 2019j). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies four occurrences of the species in the locality, with the most recent record in 2015. No records exist within the Study Area. The EPBC PMST identifies that the species or species habitat may occur within the	Low likelihood of occurrence. The Oriental Plover is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Oriental Plover due to the absence of preferred habitat such as open grasslands with areas of bare ground. The species is assessed as having a low likelihood of occurrence, given the scarcity of recent records and lack of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species does not breed in Australia (DotEE 2019j).	20 km search radius. However, this result should be viewed in light of the fact that the PMST radius includes coastal areas, not predominantly representative of the Study Area.		
White-winged Black Tern	*Chlidonias leucopterus*	M(m)			X	**General habitat requirements/preferences:** The species mostly inhabits fresh, brackish or saline, and coastal or subcoastal wetlands (DotEE 2019k). They rarely occur on inland wetlands in Australia (DotEE 2019k). **Foraging requirements/preferences:** The species mainly forages aerially, over water or over muddy or sandy edges of wetlands; and also forages over land adjacent to wetlands, especially if inundated, including rice paddies and dry paddocks and grassland (DotEE 2019k). **Roosting requirements/preferences:** The species often roosts or loafs on ground at the edges of wetlands, including sandflats, mudflats, beaches, spits, banks, islets and rocks (DotEE 2019k). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019k).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies eight occurrences of the species in the locality, with the latest record from 2019. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. A small area of potential habitat for this species occurs within wetland habitats in the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the scarcity of records.	Low likelihood of occurrence. None of the broad habitats required by this species are present within the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
Oriental Cuckoo	*Cuculus optatus*	M(t)		X	X	**General habitat requirements/preferences:** The species is found in coastal regions across northern and eastern Australia as well as offshore islands (DotE 2015b). The species uses a range of vegetated habitats such as monsoon rainforest, wet sclerophyll forest, open woodlands and appears quite often along edges of forests, or ecotones between forest types (DotE 2015b). **Foraging requirements/preferences:** This species feeds arborealy, foraging for invertebrates on loose bark on the trunks and branches of trees, and among the foliage, including in mistletoes (DotE 2015b). It will also forage from the ground (DotE 2015b). **Roosting requirements/preferences:** The species requires shrubs or trees from which it sallies and returns to consume prey items (DotE 2015b). **Breeding requirements/preferences:** This species does not breed in Australia (DotE 2015b).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies five occurrences of the species in the locality, with the latest record from 2018. No records exist within the Study Area. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.	Low likelihood of occurrence. Although the vegetation on the Study Area has some potential to provide habitat for the Oriental Cuckoo, this species has been assessed as having a low potential to occur, given the scarcity of records.	Low likelihood of occurrence. Although the vegetation on the Disturbance Footprint has some potential to provide habitat for the Oriental Cuckoo, this species has been assessed as having a low potential to occur, given that it has never been recorded on Groote Eylandt, despite numerous fauna surveys.
Lesser Frigatebird	*Fregata ariel*	M(m)		X	X	**General habitat requirements/preferences:** This species occurs in pelagic habitat (BirdLife International 2018a).	This species was not recorded within the Study Area during recent (2014-2019) field surveys.	Low likelihood of occurrence. No suitable habitat occurs within the Study Area,	Low likelihood of occurrence. No suitable habitat for this species occurs in

Common Name	Scientific Name	Conservation Status[1] EPBC Act [2]	Conservation Status[1] TPWC Act	Database Records PMST	Database Records NR Maps	Habitat Requirements	Occurrence Summary	Likelihood of Occurrence: Study Area	Likelihood of Occurrence: Disturbance Footprint
						Foraging requirements/preferences: It feeds mainly on fish (especially flying-fish) and squid, but also on seabird eggs and chicks, carrion and fish scraps (BirdLife International 2018a). **Roosting requirements/preferences:** This species occurs in pelagic habitat (BirdLife International 2018a). **Breeding requirements/preferences:** Breeds on small, remote tropical and sub-tropical islands, in mangroves or bushes, and even on bare ground (BirdLife International 2018a).	The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies five occurrences of the species in the locality, with the latest record from 2016. No records exist within the Study Area. The EPBC PMST identifies that the species or species habitat is likely to occur within the 20 km search radius.	which is located outside of marine areas. The species is assessed as having a low likelihood of occurrence, given the absence of habitat within the Study Area.	the Disturbance Footprint, as it does not contain pelagic habitats.
Great Frigatebird	*Fregata minor*	M(m)		X		**General habitat requirements/preferences:** This species occurs in pelagic habitat (BirdLife International 2018b). **Foraging requirements/preferences:** The species feed on fish, squid and chicks of other bird species (BirdLife International 2018b). **Roosting requirements/preferences:** This species occurs in pelagic habitat (BirdLife International 2018b). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. No suitable habitat for this species occurs in the Study Area, which is located outside of marine areas, and given it has not been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, which is located outside of marine areas.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species breeds on small, remote tropical and sub-tropical islands, in mangroves or bushes and occasionally on bare ground (BirdLife International 2018b).	The NR Maps database does not identify any records of the species within Groote Eylandt. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. However, this result should be viewed in light of the fact that the PMST radius includes coastal areas, not predominantly representative of the Study Area.		
Swinhoe's Snipe	*Gallinago megala*	M(w)			X	**General habitat requirements/preferences:** The species occurs at the edges of wetlands, such as wet paddy fields, swamps and freshwater streams (DotEE 2019o). **Foraging requirements/preferences:** Habitat specific to Australia includes the dense clumps of grass and rushes round the edges of fresh and brackish wetlands (DotEE 2019o). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019o).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies seven occurrences of the species in the locality,	Low likelihood of occurrence. A small area of potential habitat for this species occurs within wetland habitats in the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the scarcity of records.	Low likelihood of occurrence. None of the broad habitats required by this species are present within the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
							with the latest record from 2018. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.		
Oriental Pratincole	*Glareola maldivarum*	M(w)		X	X	**General habitat requirements/preferences:** The Oriental Pratincole is found in short grassland or on floodplains in close proximity to wetlands and lakes, as well as on beaches and mudflats along the coast. It prefers habitats with extensive bare areas (DotEE 2019p). **Foraging requirements/preferences:** The species usually forages aerially in large flocks, from just above the ground to 300 m. They are seen near cyclonic storms or fires to catch prey. They are also seen foraging on the ground (DotEE 2019p). **Roosting requirements/preferences:** The Oriental Pratincole usually roosts in bare areas that have low vegetation, such as salt marshes, airfields or clay pans (DotEE 2019p). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019p).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 20 occurrences of the species in the locality, with the latest record from 2019. No records exist within the Study Area. The EPBC PMST identifies the species or species habitat may occur within the 20 km search radius.	Low likelihood of occurrence. The Oriental Pratincole is a coastal / wetland species. A small area of potential habitat for this species occurs within the Study in the form of wetlands. However, the remainder of the Study Area does not contain suitable habitat. The species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats or areas of flat, open grasslands and floodplains.

Common Name	Scientific Name	Conservation Status[1] EPBC Act [2]	TPWC Act	Database Records PMST	NR Maps	Habitat Requirements	Occurrence Summary	Likelihood of Occurrence: Study Area	Disturbance Footprint
Barn Swallow	*Hirundo rustica*	M(t)		X		**General habitat requirements/preferences:** The Barn Swallow occurs in open areas in coastal lowlands, in close proximity to water, towns and cities, as well as around freshwater wetlands, paperbark Melaleuca woodland, and tussock grassland. It is often recorded sitting on overhead wires or bare branches (DotEE 2019q). **Foraging requirements/preferences:** The species prefers to feed on insects by aerial pursuit or by skimming plants or water surface. It is occasionally seen feeding on roads, paths and beaches (DotEE 2019q). **Roosting requirements/preferences:** The Barn Swallow nests on small vertical surfaces, such as window-ledges of buildings, typically, two to five metres from the ground (DotEE 2019q). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019q).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). There are no records of this species from Groote Eylandt on the NR Maps database. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.	Low likelihood of occurrence. Some potential habitat for the Barn Swallow is present in the Study Area; however this species prefers more open habitats rather than the predominantly wooded forests found in the Study Area. Although the vegetation in the Study Area has some potential to provide habitat for the Barn Swallow, this species has been assessed as having a low potential to occur, given that it has never been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. Although the vegetation in the Disturbance Footprint has some potential to provide habitat for the Barn Swallow, this species has been assessed as having a low potential to occur, given that it has never been recorded on Groote Eylandt, despite numerous fauna surveys.
Caspian Tern	*Hydroprogne caspia*	M(m)			X	**General habitat requirements/preferences:** The species is mostly found in sheltered coastal embayments and those with sandy or muddy margins are preferred (DotEE 2019r). **Foraging requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent	Low likelihood of occurrence. The Caspian Tern is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species usually forages in open wetlands, including lakes and rivers (DotEE 2019r). **Roosting requirements/preferences:** Generally roosting occurs on bare exposed sand or shell spits, banks or shores of coasts, lakes, estuaries, coastal lagoons and inlets (DotEE 2019r). **Breeding requirements/preferences:** The species breeds on variable types of sites including low islands, cays, spits, banks, ridges, beaches of sand or shell, terrestrial wetlands and stony or rocky islets or banks (DotEE 2019r).	to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 24 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	western portion of the Study Area provides a small area of suitable habitat for Caspian Tern. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	contain estuarine complex habitats.
Black-tailed Godwit	*Limosa limosa*	M(w)			X	**General habitat requirements/preferences:** The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit (DotEE 2019u). **Foraging requirements/preferences:** The species forages on wide intertidal mudflats or sandflats, in soft mud or shallow water and occasionally in shallow estuaries (DotEE 2019u). **Roosting requirements/preferences:** The claypan may be an important roost site for this species at least during the non-breeding season (DotEE 2019u).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 22 occurrences of the species in the locality,	Low likelihood of occurrence. The Black-tailed Godwit a coastal species. A small area of potential habitat for this species occurs in the western portion of the Study Area, in the area mapped as estuarine complex habitat. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding requirements/preferences: The Black-tailed Godwit does not breed in Australia (DotEE 2019u).	with the latest record from 2018. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.		
Grey Wagtail	*Motacilla cinerea*	M(t)		X		**General habitat requirements/preferences:** All confirmed Australian records are associated with water; especially creeks, rivers and waterfalls (DotE 2015b). **Foraging requirements/preferences:** The diet of the Grey Wagtail reflects its habitat with it feeding on a variety of insects as well as other small prey items such as molluscs, crustaceans and occasionally small fish and tadpoles (DotE 2015b). **Roosting requirements/preferences:** Little information on the roosting requirements of this species in Australia is currently known. **Breeding requirements/preferences:** This species does not breed in Australia (DotE 2015b).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). There are no records of this species from Groote Eylandt on the NR Maps database. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat	Low likelihood of occurrence. A small area of potential habitat for this species occurs in the Study Area, in the area mapped as estuarine complex habitat and riparian/wetland habitat. Nevertheless, the species is assessed as having a low likelihood of occurrence, given it has not been recorded on Groote Eylandt, despite numerous fauna surveys, and the limited extent of habitat within the Study Area.	Low likelihood of occurrence. There is a lack of suitable habitat within the Disturbance Footprint. Furthermore, the species is not known to Groote Eylandt.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
							modelling, rather than actual records of the species.		
Yellow Wagtail	*Motacilla flava*	M(t)		X		**General habitat requirements/preferences:** Habitat requirements for the Yellow Wagtail are highly variable, but typically include open grassy flats near water. Habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves (DotE 2015b). **Foraging requirements/preferences:** Little information on the foraging requirements of this species in Australia is currently known. **Roosting requirements/preferences:** This species roosts in mangroves and other dense vegetation (DotE 2015b). **Breeding requirements/preferences:** This species does not breed in Australia (DotE 2015b).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). There are no records of this species from Groote Eylandt on the NR Maps database. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.	Low likelihood of occurrence. This species has been assessed as having a low potential to occur, given there is limited suitable habitat for this species in the Study Area, and given it has not been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. Limited suitable habitat for this species occurs in the Disturbance Footprint. Furthermore, the species is not known to Groote Eylandt.
Little Curlew	*Numenius minutus*	M(w)			X	**General habitat requirements/preferences:** The species congregates around pools, river beds and water-filled tidal channels,	This species was not recorded within the Study Area during recent (2014-2019) field surveys.	Low likelihood of occurrence. A small area of potential habitat for this species occurs in the Study Area,	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						and shallow water at edges of billabongs (DotEE 2019v). **Foraging requirements/preferences:** The species is most often found feeding in short, dry grassland and sedgeland, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools or areas seasonally inundated (DotEE 2019v). **Roosting requirements/preferences:** Birds may rest in grassy, open woodlands and on bare blacksoil plains, or on dry or recently burnt grasslands on floodplains (DotEE 2019v). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019v).	The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). There are 11 records of this species from the locality on the NR Maps database from 2016. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	in the area mapped as estuarine complex habitat Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Footprint, as it does not contain estuarine complex habitats.
Whimbrel	*Numenius phaeopus*	M(w)			X	**General habitat requirements/preferences:** The species is often found on the intertidal mudflats of sheltered coasts (DotEE 2019w). **Foraging requirements/preferences:** The species generally forages on intertidal mudflats, along the muddy banks of estuaries and in coastal lagoons, either in open unvegetated areas or among mangroves (DotEE 2019w). **Roosting requirements/preferences:** The species often roosts in the branches of mangroves around mudflats and in	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 41 occurrences of the species in the locality,	Low likelihood of occurrence. The Whimbrel is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Whimbrel due to the absence of preferred habitat including intertidal mudflats and coastal lagoons.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						estuaries and occasionally in tall coastal trees (DotEE 2019w). **Breeding requirements/preferences:** The Whimbrel does not breed in Australia (DotEE 2019w).	with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	
Eastern Osprey	*Pandion cristatus*[6]	M(w)		X	X	**General habitat requirements/preferences:** The species occurs in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands (DotEE 2019x). They are mostly found in coastal areas but occasionally travel inland along major rivers (DotEE 2019x). **Foraging requirements/preferences:** They require extensive areas of open fresh, brackish or saline water for foraging (DotEE 2019x). **Roosting requirements/preferences:** This species constructs stick nests in a variety of natural and artificial sites including in dead or partly dead trees or bushes; on cliffs, rocks, rock stacks or islets; on the ground on rocky headlands, coral cays, deserted beaches, sandhills or saltmarshes; and on artificial nest platforms, pylons, jetties, lighthouses, navigation towers, cranes, exposed shipwrecks and offshore drilling rigs (DotEE 2019x).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has been recorded in a previous survey by URS (2012) within coastal strand vegetation. The NR Maps database identifies 45 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST identifies the species as having potential to occur within the 20 km search radius.	High likelihood of occurrence. Potential to occur. Suitable habitat occurs within the Study Area along the coastline and along the Emerald River.	Moderate likelihood of occurrence. Only a very small area of potential habitat is available within the Disturbance Footprint along the Emerald River.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding requirements/preferences: Eastern Ospreys typically breed in monogamous pairs from April to February (DotEE 2019x).			
Glossy Ibis	*Plegadis falcinellus*	M(w)			X	**General habitat requirements/preferences:** Within Australia, the largest contiguous areas of prime habitat is inland and northern floodplains (DotEE 2019y). **Foraging requirements/preferences:** The preferred habitat for foraging is freshwater marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation (DotEE 2019y). **Roosting requirements/preferences:** The species roost in trees or shrubs usually near, but sometimes far, from water bodies (DotEE 2019y). **Breeding requirements/preferences:** The preferred habitat for breeding is fresh water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation (DotEE 2019y).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 24 occurrences of the species in the locality from 2019. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. Although the estuarine complex habitats within the Study Area have some potential to provide habitat for the Glossy Ibis, this species has been assessed as having a low potential to occur, given the absence of records within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain marshes adjacent to the Emerald River that would be suitable for use by this species.
Pacific Golden Plover	*Pluvialis fulva*	M(w)			X	**General habitat requirements/preferences:** In Australia this species usually inhabits coastal habitats, though it occasionally	This species was not recorded within the Study Area during recent (2014-2019) field surveys.	Low likelihood of occurrence. The Pacific Golden Plover is a coastal species that requires estuarine complex habitats. The estuarine	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not

Common Name	Scientific Name	Conservation Status[1] EPBC Act [2]	Conservation Status[1] TPWC Act	Database Records PMST	Database Records NR Maps	Habitat Requirements	Occurrence Summary	Likelihood of Occurrence Study Area	Likelihood of Occurrence Disturbance Footprint
						occurs around inland wetlands (DotEE 2019z). **Foraging requirements/preferences:** This species usually forages on sandy or muddy shores (including mudflats and sandflats) or margins of sheltered areas such as estuaries and lagoons, though it also feeds on rocky shores, islands or reefs (DotEE 2019z). **Roosting requirements/preferences:** The species usually roost near foraging areas, on sandy beaches and spits or rocky points, islets or exposed reefs, occasionally among or beneath vegetation including mangroves or low saltmarsh, or among beachcast seaweed (DotEE 2019z). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019z).	This species has been recorded in a previous survey by Webb (1992) within tailings/water storage dams. The NR Maps database identifies 18 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	complex habitat in the western portion of the Study Area provides potential habitat for the species. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	contain estuarine complex habitats.
Grey Plover	*Pluvialis squatarola*	M(w)			X	**General habitat requirements/preferences:** The species occurs almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons (DotEE 2019z). **Foraging requirements/preferences:** The species usually forages on large areas of exposed mudflats and beaches	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. The Grey Plover is a coastal species that requires estuarine complex habitats. The estuarine complex habitat in the western portion of the Study Area is unlikely to provide suitable habitat for the Grey Plover due to the absence of preferred	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						of sheltered coastal shores such as inlets, estuaries and lagoons (DotEE 2019z). **Roosting requirements/preferences:** The species usually roosts in sandy areas, such as on unvegetated sandbanks or sand-spits on sheltered beaches or other sheltered environments such as estuaries or lagoons (DotEE 2019z). **Breeding requirements/preferences:** This species does not breed in Australia (DotEE 2019z).	The NR Maps database identifies 21 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	habitat including mudflats and sandflats. The species is assessed as having a low likelihood of occurrence, given the lack of habitat within the Study Area.	
Rufous Fantail	*Rhipidura rufifrons*	M(t)		X		**General habitat requirements/preferences:** The Rufous Fantail occurs in coastal and near coastal districts of northern and eastern Australia. In north and north-east Australia, they often occur in tropical rainforest and monsoon rainforests, including semi-evergreen mesophyll vine forests, semi-deciduous vine thickets or thickets of Paperbarks (Melaleuca spp.) (DAWE 2020e). **Foraging requirements/preferences:** The Rufous Fantail forages mainly in the low to middle strata of forests, sometimes in or below the canopy or on the ground; in northern Australia they also forage in mangroves. The species mostly forages aerially by sallying, but also glean food items from foliage and occasionally from the ground and fallen debris (DAWE 2020e). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012). The species was recorded in the Western Leases by Webb (1992). The NR Maps database does not contain any records of the species in the locality. The EPBC PMST identifies the species as likely to occur	Low likelihood of occurrence. This species has been assessed as having a low potential to occur, given there is limited suitable habitat for this species in the Study Area, and given the absence of recent records on Groote Eylandt.	Low likelihood of occurrence. Limited suitable habitat for this species occurs in the Disturbance Footprint. Furthermore, the species is not known to Groote Eylandt.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species nests in trees, shrubs or vines, on average 1.6m above the ground. Nests in a wide variety of habitat types (DAWE 2020e). **Breeding requirements/preferences:** The Rufous Fantail breeds from about September to February, with 81% of eggs laid November-December. Eggs are laid in a small cup-shaped nest which is usually made from grass, roots, fine strips of bark, plant-fibre, decayed wood, moss and spider web (DAWE 2020e).	within the 20 km search radius.		
Roseate Tern	*Sterna dougallii*	M(m)			X	**General habitat requirements/preferences:** The species occurs in coastal and marine areas in subtropical and tropical seas (DotEE 2019ab). The species inhabits rocky and sandy beaches, coral reefs, sand cays and offshore islands (DotEE 2019ab). **Foraging requirements/preferences:** The species forages mainly on fish, but also on some crustaceans (DotEE 2019ab). **Roosting requirements/preferences:** The species usually roosts or loafs in the intertidal zone on islands, including on the upper sections of beaches, above the high-water mark on banks, spits and bars, usually of coral or sand (DotEE 2019ab). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies two occurrences of the species in the locality, with the latest record from 2016. No records exist within the Study Area.	Low likelihood of occurrence. The Roseate Tern is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area and the scarcity of previous records.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding mainly occurs off the coasts of Western Australia, the NT and Queensland (DotEE 2019ab). In the NT, some colonies nest between April and June/July, but the majority nest between September and January/February (DotEE 2019ab).	The EPBC PMST identifies the species as having potential to occur within the 20 km search radius.		
Common Tern	*Sterna hirundo*	M(m)			X	**General habitat requirements/preferences:** The species is marine, pelagic and coastal (DotEE 2019ac). **Foraging requirements/preferences:** The species forages in marine environments, often close to the shore, including sheltered embayments and in the surf-zone, but also well out to sea (DotEE 2019ac). **Roosting requirements/preferences:** The species roosts on unvegetated, intertidal sandy ocean beaches, sandy islands, shores of estuaries or lagoons, and sandbars, as well as on rocky shores, rock platforms or rocks protruding above the surface of the water (DotEE 2019ac). **Breeding requirements/preferences:** This species does not breed in Australia (DotEE 2019ac).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 15 occurrences of the species in the locality, with the latest record from 2015. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. The Common Tern is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
Black-naped Tern	*Sterna sumatrana*	M(m)			X	**General habitat requirements/preferences:** The species is mainly associated with small, offshore sand and coral cays, coral reefs and lagoons, and sandy and rocky islands and islets, and in the surrounding seas (DotEE 2019ad). **Foraging requirements/preferences:** The species forages on and around coral reefs, over lagoons, reef-flats, reef-crests and reef-edges as well as rock pools and the open sea beyond the surf-zone along outer reefs (DotEE 2019ad). **Roosting requirements/preferences:** The species usually roost near the edge of the water, on sandy beaches or spits and occasionally on rubble banks or rocks (DotEE 2019ad). **Breeding requirements/preferences:** The species breeds on islands, which are very occasionally close to or attached to the mainland at low tides, and forage in seas surrounding colonies (DotEE 2019ad).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 10 occurrences of the species in the locality, with the latest record from 2016. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. The Black-naped Tern is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
Little Tern	*Sternula albifrons*	M(m)			X	**General habitat requirements/preferences:** The species inhabits sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches (DotEE 2019ae).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by	Low likelihood of occurrence. The Little Tern is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Foraging requirements/preferences: The species forages in shallow waters of estuaries, coastal lagoons and lakes, frequently over channels next to spits and banks or entrances, and often close to breeding colonies (DotEE 2019ae). **Roosting requirements/preferences:** The species roosts on sand-spits, banks and bars within sheltered estuarine or coastal environments, or on the sandy shores of lakes and ocean beaches (DotEE 2019ae). **Breeding requirements/preferences:** The species nest on sand-spits, banks, ridges or islets in sheltered coastal environments, such as coastal lakes, estuaries and inlets, and also on wide and flat or gently sloping sandy ocean beaches, and also, occasionally, in sand-dunes (DotEE 2019ae).	Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 27 occurrences of the species in the locality, with the latest record from 2019. No records occur within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	
Brown Booby	*Sula leucogaster*	M(m)			X	**General habitat requirements/preferences:** The species uses both marine and terrestrial habitat. The species occurs in, but is not restricted to, tropical waters of all major oceans, often staying close to breeding islands (DotEE 2019af). **Foraging requirements/preferences:** The species forages in tropical waters of all major oceans, often staying close to breeding islands (DotEE 2019af). **Roosting requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992).	Low likelihood of occurrence. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area and	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, which is located outside of coastal and marine areas.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species cords on the ground in a variety of sites, from rugged rocky terrain (cliffs, steep slopes) on larger islands, to beaches, sand bards, coral rubble and guano flats on cays, as well as artificial structures (DotEE 2019af). **Breeding requirements/preferences:** The species utilises tropical islands, continental islands, sand cays and atolls for breeding (DotEE 2019af).	The NR Maps database identifies one occurrence of the species in the locality from 2016. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	scarcity of previous records.	
Lesser Crested Tern	*Thalasseus bengalensis*	(M(w)			X	**General habitat requirements/preferences:** The Lesser Crested Tern occurs in coastal bays and inlets, lakes and large rivers. It frequents coastal seas using shores of sandy beaches, coral cays, exposed reefs, and islands. On parts of the coast it uses mudflats of estuaries, and creek channels (Pizzey and Knight 1997). **Foraging requirements/preferences:** Feed primarily in marine environments, diving for fish (Pizzey and Knight 1997). **Roosting requirements/preferences:** The species roosts in closely packed colonies on small offshore islands. Nests are shallow, unlined scrape in the sand (Pizzey and Knight 1997). **Breeding requirements/preferences:** Breeds in closely packed colonies on low sand and coral cays of reefs, offshore islands or sandbars (Pizzey and Knight 1997).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies nine occurrences of the species in the locality, most recently in 2018. No records exist within the Study Area. The EPBC PMST does not identify habitat for this	Low likelihood of occurrence. The Lesser Crested Tern is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
							species within the 20 km search radius.		
Grey-tailed Tattler	*Tringa brevipes*	M(w)			X	**General habitat requirements/preferences:** The species is often found on sheltered coasts with reefs and rock platforms or with intertidal mudflats (DotEE 2019ag). **Foraging requirements/preferences:** The species usually forages in shallow water, on hard intertidal substrates, such as reefs and rock platforms, in rock pools and among rocks and coral rubble, over which water may surge (DotEE 2019ag). **Roosting requirements/preferences:** The species usually roosts in the branches of mangroves or, rarely, in dense stands of other shrubs, or on snags or driftwood (DotEE 2019ag). **Breeding requirements/preferences:** This species does not breed in Australia (DotEE 2019ag).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c) and Webb (1992). URS (2012) recorded this species in the Western Leases The NR Maps database identifies 34 occurrences of the species in the locality, with the latest from 2018. No records exist within the Study Area The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. The Grey-tailed Tattler is a coastal / marine species. A small area of potential habitat for this species occurs within estuarine complex habitats in the western portion of the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
Wood Sandpiper	*Tringa glareola*	M(w)			X	**General habitat requirements/preferences:** The species uses well-vegetated, shallow, freshwater wetlands, such as swamps,	This species was not recorded within the Study Area during recent (2014-2019) field surveys.	Low likelihood of occurrence. The Common Sandpiper is a coastal / wetland species. A small area of	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						billabongs, lakes, pools and waterholes (DotEE 2019ah). **Foraging requirements/preferences:** The species forages on moist or dry mud at the edges of wetlands, either along shores, among open scattered aquatic vegetation, or in clear shallow water (DotEE 2019ah). **Roosting requirements/preferences:** The species has been recorded loafing on a low, grassy hillock in a flooded meadow. It has also been recorded perched low in trees and on fences (DotEE 2019ah). **Breeding requirements/preferences:** The Wood Sandpiper does not breed in Australia (DotEE 2019ah).	The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 17 occurrences of the species in the locality, with the latest from 2018. No records exist within the Study Area The EPBC PMST does not identify habitat for this species within the 20 km search radius.	potential habitat for this species occurs within wetland and estuarine complex habitats in the Study Area. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Footprint, as it does not contain estuarine complex habitats.
Common Greenshank	*Tringa nebularia*	M(w)		X	X	**General habitat requirements/preferences:** Found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity (DotEE 2019ai). It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass (DotEE 2019ai). **Foraging requirements/preferences:** The species is known to forage at edges of wetlands, in soft mud on mudflats, in channels, or in shallows around the edges of water often among	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has been recorded in a previous survey by Webb (1992) at the Angurugu township sewerage ponds. The NR Maps database identifies 72 occurrences of the species in the locality,	Moderate likelihood of occurrence. The Common Greenshank is a coastal / wetland species. The estuarine complex habitat and wetland habitat in the Study Area provides a small area of suitable habitat for the species. This species is considered to have a moderate likelihood of occurring within this area of estuarine complex habitat	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						pneumatophores of mangroves or other sparse, emergent or fringing vegetation, such as sedges or saltmarsh (DotEE 2019ai). It will occasionally feed on exposed seagrass beds (DotEE 2019ai). **Roosting requirements/preferences:** Roosts and loafs around wetlands, in shallow pools and puddles, or slightly elevated on rocks, sandbanks or small muddy islets (DotEE 2019ai). Occasionally the species will perch and roost on stakes (DotEE 2019ai). **Breeding requirements/preferences:** The species does not breed in Australia (DotEE 2019ai).	with the latest from 2019. No records exist within the Study Area. The EPBC PMST identifies the species as likely to occur within the 20 km search radius.	and wetlands, and also given the number of NR Maps database records within the locality. However, the remainder of the Study Area does not contain suitable habitat for this species.	
Marsh Sandpiper	*Tringa stagnatilis*	M(w)			X	**General habitat requirements/preferences:** The species lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks (DotEE 2019aj). **Foraging requirements/preferences:** The species usually forages in shallow water at the edge of wetlands (DotEE 2019aj). **Roosting requirements/preferences:** The species has been recorded roosting or loafing on tidal mudflats, near low saltmarsh, and around inland swamps (DotEE 2019aj).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has been recorded in a previous survey by URS (2012) within rehabilitation. The NR Maps database identifies 28 occurrences of the species in the locality, with the latest from 2018. No records exist within the Study Area.	Moderate likelihood of occurrence. The Marsh Sandpiper is a coastal / wetland species. The estuarine complex habitat and wetland habitat in the Study Area provides a small area of suitable habitat for the species. This species is considered to have a moderate likelihood of occurring within this area of estuarine complex habitat and wetlands, and also given the number of NR Maps database records within the locality. However, the remainder of	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats or suitable wetland area.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Breeding requirements/preferences: The Marsh Sandpiper does not breed in Australia (DotEE 2019aj).	The EPBC PMST does not identify habitat for this species within the 20 km search radius.	the Study Area does not contain suitable habitat for this species.	
Terek Sandpiper	*Xenus cinereus*	M(w)			X	**General habitat requirements/preferences:** The species occurs on mudflats or in sheltered estuaries, embayments, harbours or lagoons. The species has also been recorded on islets, mudbanks, sandbanks and spits, and near mangroves and occasionally in samphire (DotEE 2019al). **Foraging requirements/preferences:** This species mostly forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons (DotEE 2019al). **Roosting requirements/preferences:** The species prefers to roost in or among mangroves (DotEE 2019al). **Breeding requirements/preferences:** This species does not breed in Australia (DotEE 2019al).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys performed by Cumberland Ecology (2015a, 2016, 2019c), URS (2012) and Webb (1992). The NR Maps database identifies 13 occurrences of the species in the locality, with the latest from 2019. No records exist within the Study Area. The EPBC PMST does not identify habitat for this species within the 20 km search radius.	Low likelihood of occurrence. The Terek Sandpiper is a coastal / marine species. The estuarine complex habitat in the Study Area provides a small area of habitat for the species. Nevertheless, the species is assessed as having a low likelihood of occurrence, given the limited extent of habitat within the Study Area.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint, as it does not contain estuarine complex habitats.
MAMMALS									
Brush-tailed Rabbit-rat	*Conilurus penicillatus*	V	E	X	X	**General habitat requirements/preferences:** Most records of this species are from lowland eucalypt forests and woodlands,	This species was not recorded within the Study Area during recent (2014-2019) field surveys.	Low likelihood of occurrence. Two research projects were recently undertaken	Low likelihood of occurrence. The species was not detected during recent

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						particularly those dominated by *Eucalyptus miniata* (Darwin Woollybutt) and/or E. tetrodonta (Darwin Stringybark) (Threatened Species Scientific Committee 2016a). **Foraging requirements/preferences:** The species primarily eats seeds of grass species such as cockatoo grass (Threatened Species Scientific Committee 2016a). Other dietary items include seeds from other grass species, termites, fruits (including fleshy fruits) and foliage (Threatened Species Scientific Committee 2016a). **Requirements/preferences for shelter sites:** Brush-tailed rabbit-rats shelter during the day in tree hollows and hollow logs, and may also occasionally shelter in Pandanus canopies (Threatened Species Scientific Committee 2016a). **Breeding requirements/preferences:** Breeding season occurs from March to October with a litter size of two or three (Threatened Species Scientific Committee 2016a).	Heiniger and Gillespie (2017) detected the species at 19 locations north of the Study Area. It was also recently recorded in the nearby Eastern Leases in 2014 (Cumberland Ecology 2015). This species was recorded on an IR camera within E. tetrodonta/E. miniata open forest (Cumberland Ecology 2015). The Brush-tailed Rabbit-rat has also been recorded previously within the Eastern Leases by Ward (2007a) and EMS (2013). The NR Maps database identifies 23 occurrences of the species in the locality, with the latest from 2014. Nine records exist within the Study Area, however the records are either undated or from 1921-1922. The EPBC PMST identifies that the species or species habitat may occur within the 20 km search radius.	by Cumberland Ecology (2019c) and Heiniger and Gillespie (2017) to determine the distribution and habitat preferences of this species in nearby areas. No records of this species were obtained. The lack of records suggests that the species is not present in the areas sampled. Given the lack of recent records from a comprehensive research project in the vicinity of the Study Area, it is concluded that there is a low probability of occurrence for the species in the Study Area.	surveys by Cumberland Ecology (2019c) and Heiniger and Gillespie (2017) within and in close proximity to the Study Area and in similar habitat types.
Northern Quoll	*Dasyurus hallucatus*	E	CE	X	X	**General habitat requirements/preferences:**	This species was recorded at 98 locations within the	Present.	High likelihood of occurrence.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The broadly described habitats of the Northern Quoll include rocky areas, Eucalypt forests and woodlands, sandy lowlands, grasslands, shrublands, and deserts (DotEE 2019m). **Foraging requirements/preferences:** The species is known to feed on a wide range of prey including mammals, insects, fruit and human refuse (DotEE 2019m). **Requirements/preferences for shelter sites:** Main habitat requirements for denning include rock crevices, hollow logs and termite mounds (DotEE 2019m). **Breeding requirements/preferences:** Breeding habitat for the Northern Quoll occurs within den sites. Breeding occurs in mid-dry season and breeding territory is likely inherited by female offspring (DotEE 2019m).	Southern Lease during recent (2014-2019) field surveys. This species was recorded within a range of habitats. Heiniger and Gillespie (2017) also recently recorded the species at 15 locations within the Southern Lease. Cumberland Ecology (2019c) recorded the species at a number of other locations to the south and west of the Southern Lease. Heiniger and Gillespie (2017) also detected the species extensively to the north of the Southern lease. It has been recorded during previous surveys by Cumberland Ecology (2015), URS (2012) and Webb (1992). This species is known to occur in areas of mine rehabilitation in the existing GEMCO mine as recorded in surveys by Cumberland Ecology (2015), URS (2012). The NR Maps database identifies 1028 occurrences	The species has been recorded at a number of locations within the Study Area by Cumberland Ecology (2015a, 2016, 2019c) and Heiniger and Gillespie (2017). The species has been recorded across multiple habitat types within the Eastern Leases and Southern Lease and is known to utilise the habitat types present within the Study Area.	Although the species has not been recorded within the Disturbance Footprint, it is known to occur within surrounding areas. Suitable habitat is present throughout the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
							of the species in the locality, with the latest from 2014. Twelve of these records occur within the Study Area. This species has been recorded in close proximity to the Disturbance Footprint by Cumberland Ecology (2016), Heiniger and Gillespie (2017) and Cumberland Ecology (2019c) (see **Figure 16**). The EPBC PMST identifies the species or species habitat as being known to occur within the 20 km search radius.		
Ghost Bat	*Macroderma gigas*	V		X	X	**General habitat requirements/preferences:** This species occupies habitats ranging from the arid Pilbara to tropical savanna woodlands and rainforests (Threatened Species Scientific Committee 2016b). **Foraging requirements/preferences:** They are carnivores, with a broad diet comprising small mammals including other bats, birds, reptiles, frogs and large insects (Threatened Species Scientific Committee 2016b). It perches in vegetation to ambush passing prey (either on the ground or in the air), and it also gleans surfaces such as the ground	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has been recorded on the existing GEMCO mine in a previous survey by URS (2012). Diete et al. (2015b) recorded the species within open woodland in proximity to the existing GEMCO mine and in coastal grass and shrub habitat in the south west peninsular of the island.	High likelihood of occurrence. Suitable roosting and foraging habitat for this species occurs in the Study Area in the form of rocky outcropping and open forests, sandstone woodland and riparian habitats.	High likelihood of occurrence. Suitable foraging habitat for this species occurs in the Disturbance Footprint in the form of open forests, and riparian habitats located in proximity (~2 km) to rocky outcropping.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						while in flight (Threatened Species Scientific Committee 2016b). **Roosting requirements/preferences:** During the daytime they roost in caves, rock crevices and old mines (Threatened Species Scientific Committee 2016b). Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23°–28°C and a moderate to high relative humidity of 50–100 percent (Threatened Species Scientific Committee 2016b). **Breeding requirements/preferences:** Most breeding sites appear to require multiple entranced caves (Threatened Species Scientific Committee 2016b). Females breed at an age of two to three years (Threatened Species Scientific Committee 2016b).	The NR Maps database identifies 17 records in the locality, with only one dated (from 2012). None of the records occur within the Study Area. The EPBC PMST identifies that the species or species habitat is likely to occur within the 20 km search radius.		
Northern Hopping-mouse	*Notomys aquilo*	V	V	X	X	**General habitat requirements/preferences:** The Northern Hopping-mouse inhabits coastal dune systems, shrubland, eucalypt woodland, and the margins of coastal rainforest areas. Main habitat requirements are areas with sandy substrates and relatively high rainfall (about 1000-1400 mm per year), preferring areas in close proximity to rocky areas (DotE 2013c). **Foraging requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. Cumberland Ecology (2019c) recorded the species at one location to the east of the existing GEMCO mine. Heiniger and Gillespie (2017) also detected the species at three locations north of the Southern Lease.	Low likelihood of occurrence. Two research projects were recently undertaken by Cumberland Ecology (2019c) and Heiniger and Gillespie (2017) to determine the distribution and habitat preferences for this species in nearby areas, including within the Study Area. No records of this species were obtained within the Study Area. The	Low likelihood of occurrence. The species was not detected during recent surveys by Cumberland Ecology (2019c) within and in close proximity to the Study Area and in similar habitat types.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species feeds mainly on seeds from grasses, herbs and shrubs. It is also known to eat insects (DotE 2013c). **Requirements/preferences for shelter sites:** The Northern Hopping-mouse constructs complex burrows that can be used for sheltering which consist of a spoil mound located 2 m from the burrow entrance. The entrance is a vertical shaft that is dug from below (DotE 2013c). **Breeding requirements/preferences:** All breeding information is based on observations made in captivity. The young are born hairless with one to five young being reared at a time (DotE 2013c).	It was also recently recorded in the nearby Eastern Leases in 2014 during surveys by Cumberland Ecology (2015). It was recorded within E. tetrodonta/E. miniata open forest. This species was not recorded during surveys by URS (2012) and Webb (1992). The NR Maps database identifies 44 occurrences of the species in the locality, with the latest from 2014. Fourteen records exist within the Study Area, however the records are unconfirmed or from spoil observations which have been determined to potentially be from another species (spoil heaps are also created by the Delicate Mouse (*Pseudomys delicatulus*) (Coffey Environments Pty Ltd 2010, Diete et al. 2015a). The EPBC PMST identifies the species or species habitat may occur within the 20 km search radius.	lack of records suggests that the species is not present in the areas sampled. Given the high survey intensity and sample sites in the full range of suitable habitats and fire types, it is considered that there is a low probability of occurrence for the species in the Study Area.	

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
Pale Field Rat	*Rattus tunneyi*		V		X	**General habitat requirements/preferences:** The Pale Field Rat occurs in higher rainfall areas of northern Australia, and inhabits tall grassland, cane fields and other modified habitats supporting its feeding preferences consisting of roots, grass, stems and seeds (Morris et al. 2008). **Foraging requirements/preferences:** This species feeds on roots, grasses, stems and seeds (Northern Territory Government 2012a). **Requirements/preferences for shelter sites:** This nocturnal species uses shallow burrows in loose sandy soil, as shelter during the day (Morris et al. 2008). **Breeding requirements/preferences:** Burrows are utilised for breeding which takes place during the dry season (Northern Territory Government 2012a).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. It has not been recorded in areas adjacent to the Study Area in previous surveys by Cumberland Ecology (2015), URS (2012) and Webb (1992). The NR Maps database identified two records of this species within the Study Area, both records of which are undated.	Low likelihood of occurrence. Limited potential habitat occurs within the Study Area, with no mapped areas of tall grassland occurring.	Low likelihood of occurrence. Limited potential habitat occurs within the Disturbance Footprint, with no mapped areas of tall grassland occurring.
Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	V		X		**General habitat requirements/preferences:** Occurs mostly in lowland areas, typically in a range of woodland, forest and open environments (DotEE 2019aa). **Foraging requirements/preferences:** The species has a fast, direct flight and is likely to forage primarily for aerial insects over the woodland/forest canopy but may fly lower when foraging over open situations (DotEE 2019aa).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species has not been recorded in areas adjacent to the Study Area in previous surveys by Cumberland Ecology (2015), URS (2012) and Webb (1992).	Low likelihood of occurrence. Suitable habitat for this species occurs in the Study Area, within open forests and woodland. However, given the lack of records of this species on Groote Eylandt, it is assessed as having a low likelihood of occurrence.	Low likelihood of occurrence. Suitable habitat for this species occurs in the Disturbance Footprint, within open forests and woodland. However, given the lack of records of this species on Groote Eylandt, it is assessed as having a

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						Roosting requirements/preferences: No studies have been conducted on the roosting ecology of this species and all located roosts are from incidental records (such as, as a result of land clearance) (DotEE 2019aa). In Australia, all confirmed roosting records are from deep tree hollows in the Poplar Gum, Darwin Woollybutt and Darwin Stringybark (DotEE 2019aa). **Breeding requirements/preferences:** There is no information available on the type of breeding system or breeding success in this species (DotEE 2019aa). In Australia all breeding records have been obtained from trees that were felled during land-clearing operations (DotEE 2019aa).	The NR Maps database does not identify occurrences of the species in the locality or on Groote Eylandt. The EPBC PMST identifies the species as having potential to occur within the 20 km search radius.		low likelihood of occurrence.
Water Mouse	*Xeromys myoides*	V		X		**General habitat requirements/preferences:** The broadly described habitats of the Water Mouse include sedgelands, heathlands, clay pans, mangroves and the associated salt marsh, and freshwater wetlands (DotEE 2019am). In the NT, the Water Mouse has been known to use both intertidal and freshwater habitats, including mangroves, sedgelands, clay pans, and freshwater melaleuca wetlands (DotEE 2019am). **Foraging requirements/preferences:** In the NT, the species is known to feed on grapsid crabs (i.e. shore crabs), and	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species has not been recorded during previous surveys by Cumberland Ecology (2015), URS (2012) and Webb (1992). No records of this species on Groote Eylandt are held within the NR Maps database.	Low likelihood of occurrence. Limited suitable habitat occurs within the Study area. This species has been assessed as having a low potential to occur, given it has not been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. None of the broad habitats required by this species are present within the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						plant foods are believed to comprise some of its diet (DotEE 2019am). **Requirements/preferences for shelter sites:** The species is known to make five types of nests which provide refuge from predators at high tide. These are: free-standing, nests or mounds at the base of mangrove trees, mound nests on small elevated 'islands' within the tidal zone, mound nests or holes in supralittoral banks; nests inside hollow tree trunks, and nests in spoil heaps created as a result of human activity (DotEE 2019am). **Breeding requirements/preferences:** Nests created by the species are important for breeding and it is capable of breeding year-round (DotEE 2019am).	The EPBC PMST identifies the species or species habitat may occur within the 20 km search radius.		
REPTILES									
Plains Death Adder	*Acanthopis hawkei*	V	V	X		**General habitat requirements/preferences:** The Plains Death Adder inhabits flat treeless habitats on the cracking soils of riverine floodplains (Northern Territory Government 2012b). **Foraging requirements/preferences:** When young, the species feeds on frogs and lizards, and when they reach larger sizes the species feeds on mammals (Northern Territory Government 2012b). **Requirements/preferences for shelter sites:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. The species was not recorded in areas adjacent to the Study Area during previous surveys by Cumberland Ecology (2015), URS (2012) and Webb (1992).	Low likelihood of occurrence. This species has been assessed as having a low potential to occur, given no suitable habitat for this species occurs in the Study Area, and given it has never been recorded on Groote Eylandt, despite numerous fauna surveys.	Low likelihood of occurrence. No suitable habitat for this species occurs in the Disturbance Footprint.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						During floods, the species floats on debris or emergent vegetation. During the Dry season, it often rests in deep cracks in the soil (Northern Territory Government 2012b). **Breeding requirements/preferences:** The species breeds from October to November and live young are produced between February and March (Threatened Species Scientific Committee 2012).	The NR Maps database results do not identify occurrences of the species on Groote Eylandt. The EPBC PMST identifies the species or species habitat may occur within the 20 km search radius. It should be noted that the PMST results are based on broad scale habitat modelling, rather than actual records of the species.		
Mertens' Water Monitor	*Varanus mertensi*		V		X	**General habitat requirements/preferences:** The semi-aquatic Mertens' Water Monitor is found in the proximity of water sources, inhabiting both coastal and inland waters and riparian areas (Northern Territory Government 2006). **Foraging requirements/preferences:** The species feeds primarily on fish, frogs and carrion, but it will also forage for insects and small terrestrial invertebrates (Northern Territory Government 2006). **Requirements/preferences for shelter sites:** The Mertens' Water Monitor is terrestrial and also has the ability to climb trees (Northern Territory Government 2006). **Breeding requirements/preferences:**	This species was not recorded within the Study Area during recent (2014-2019) field surveys. It was recently recorded in the nearby Eastern Leases and Southern Lease in 2014 by Cumberland Ecology (2015). It was recorded within freshwater streams and in Melaleuca dominated communities. This species has also been recorded during previous surveys by URS (2012) and Webb (1992).	High likelihood of occurrence. Suitable habitat for this species occurs in the Study Area in the form of riparian habitats. Given the presence of records in the locality and records within the Southern Lease and Eastern Leases in similar habitats, this species is considered likely to occur.	High likelihood of occurrence. Suitable habitat for this species occurs in the Disturbance Footprint in the form of riparian habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						The species digs burrows in the ground where it lays its eggs, usually during the early dry season (Northern Territory Government 2006).	The NR Maps database identifies 15 occurrences of the species in the locality, with the latest record from 2014. No records exist within the Study Area.		
Yellow-spotted Monitor	*Varanus panoptes*		V		X	**General habitat requirements/preferences:** The Yellow-spotted Monitor occurs in a variety of habitats including grasslands, woodlands, floodplains, and coastal beaches. Its distribution has been recorded across most of the Top End of the NT (Northern Territory Government 2012c). **Foraging requirements/preferences:** The species forages on primarily small terrestrial insects and vertebrates, including marine and freshwater turtle eggs (Northern Territory Government 2012c). **Requirements/preferences for shelter sites:** The species is known to dig large burrows and take over existing burrows (Atlas of Living Australia 2014). Recent research has indicated that these species make use of large communal burrows / warrens (Doody, et al., 2014). **Breeding requirements/preferences:** The Yellow-spotted Monitor lays its eggs in burrows in the ground, usually during	This species was not recorded within the Study Area during recent (2014-2019) field surveys. It was recently recorded in the nearby Eastern Leases in 2014 (Cumberland Ecology 2015). It was recorded within E. tetrodonta/E. miniata open forest and Melaleuca woodland. It has been recorded during surveys by URS (2012) in Melaleuca/riparian habitat, Eucalypt forest habitat and within areas of mine rehabilitation in the existing GEMCO mine. The NR Maps database identifies 14 occurrences of the species in the locality, with the latest record from 2014. No records exist within the Study Area.	High likelihood of occurrence. Suitable habitat for this species occurs in the Study Area in the form of open forest, woodland/shrubland, riparian and seasonal wetland habitats.	High likelihood of occurrence. Suitable habitat for this species occurs in the Disturbance Footprint in the form of open forest, woodland/shrubland, riparian and seasonal wetland habitats.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
						the wet season (Northern Territory Government 2012c).			
Salt-water Crocodile	*Crocodylus porosus*	M(m)		X	X	**General habitat requirements/preferences:** The Salt-water crocodile inhabits tidal rivers, coastal floodplains and channels, billabongs and swamps. It may be found up to 150 km inland from the coast, in habitats where salinity levels are sufficient (DotEE 2019l). **Foraging requirements/preferences:** Primary food sources for the Salt-water Crocodile are crustaceans, insects and mammals. In high salinity, more crabs are consumed, while in freshwater, more insects are consumed (DotEE 2019l). **Requirements/preferences for shelter sites:** The species is often found exposed in the midday sun, but under cover and shaded during the morning and late evening (DotEE 2019l). **Breeding requirements/preferences:** Preferred nesting habitat for the species include isolated freshwater swamps that do not have tidal fluctuations (DotEE 2019l).	This species was not recorded within the Study Area during recent (2014-2019) field surveys. This species was recorded in the Eastern Leases by Cumberland Ecology (2015a). This species was recorded incidentally in the Southern Lease and surrounds by Cumberland Ecology (2016). C&R (2019) also recently recorded the species within the Southern Lease. It was also recorded in the nearby Eastern Leases within the tributaries of the Amagula River (Cumberland Ecology 2015). This species has also been recorded during previous surveys by URS (2012) and Webb (1992), however the exact location is unknown. The NR Maps database identifies 11 occurrences of	High likelihood of occurrence. Suitable habitat for this species occurs in and directly adjacent to the Study Area along the Emerald River and its tributaries.	High likelihood of occurrence. Some suitable habitat for this species occurs in the Disturbance Footprint along the Emerald River and its tributaries.

Common Name	Scientific Name	Conservation Status[1]		Database Records		Habitat Requirements	Occurrence Summary	Likelihood of Occurrence	
		EPBC Act [2]	TPWC Act	PMST	NR Maps			Study Area	Disturbance Footprint
							the species in the locality, with the latest from 2014. No records exist within the Study Area. The EPBC PMST identifies the species or species habitat is likely to occur within the 20 km search radius.		

1. EPBC Act Status / TPWC Act Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory [(m) = marine, (t) = terrestrial, (w) = wetland]

2. Subcategories for EPBC Act listing of migratory species follow those within the Protected Matters Search report

3. EPBC Act Protected Matters Search Tool

4. Two subspecies of Geophaps smithii are listed under the EPBC Act as Vulnerable (Geophaps smithii blaauwi and Geophaps smithii smithii).

5. Subspecies of Limosa lapponica have different listings under the EPBC Act. Limosa lapponica baueri is listed as Vulnerable and Limosa lapponica menzbieri is listed as Critically Endangered.

6. Species listed as Pandion haliaetus in the Protected Matters Search report. Pandion haliaetus cristatus was previously recognised as a subspecies for Australasia and New Caledonia, however it is currently recognised as a species in its own right.

APPENDIX I :

Assessment of Significance

I.1. Introduction

This chapter presents Assessments of Significance for threatened or migratory fauna species listed under the EPBC Act that are present or have a moderate or high potential to occur in the Disturbance Footprint. Assessments of Significance are threshold tests of significance prepared according to the Significant Impact Guidelines to gauge the significance of predicted impacts to threatened and migratory species. The guidelines are designed specifically to determine whether an activity is considered, under the EPBC Act, to have a significant impact on the species.

The following threatened fauna species that are present or have a moderate or high potential to be present in the Disturbance Footprint have been assessed in accordance with the Significant Impact Guidelines:

- Masked Owl (northern) (*Tyto novaehollandiae kimberli*); and
- Ghost Bat (*Macroderma gigas*).

The Northern Quoll (*Dasyurus hallucatus*) has been assessed in accordance with the Northern Quoll Referral Guideline (DotE 2016). This is the only species potentially impacted by the project that has a species-specific guideline available. Species-specific guidelines provide more detailed guidance on assessing the significance of impacts on particular threatened species.

The following migratory species have also been assessed in accordance with the Significant Impact Guidelines:

- Fork-tailed Swift (*Apus pacificus*); and
- Eastern Osprey (*Pandion cristatus*).

I.2. Definitions

The definitions listed in **Table 27** are utilised within the Significant Impact Guidelines and are addressed for the relevant species in the sections below.

Table 26 Definitions used in the Significant Impact Guidelines

Term	Definition	Status to which Term is Relevant
Population of a species	A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable threatened species, occurrences include but are not limited to: - a geographically distinct regional population, or collection of local populations, or - a population, or collection of local populations, that occurs within a particular bioregion.	Critically Endangered, Endangered, Vulnerable

Term	Definition	Status to which Term is Relevant
Important population of a species	An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: - key source populations either for breeding or dispersal - populations that are necessary for maintaining genetic diversity, and/or - populations that are near the limit of the species range.	Vulnerable
Invasive species	An 'invasive species' is an introduced species, including an introduced (translocated) native species, which out-competes native species for space and resources or which is a predator of native species. Introducing an invasive species into an area may result in that species becoming established. An invasive species may harm listed threatened species or ecological communities by direct competition, modification of habitat or predation.	Critically Endangered, Endangered, Vulnerable
Habitat critical to the survival of a species	'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary: - for activities such as foraging, breeding, roosting, or dispersal - for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) - to maintain genetic diversity and long-term evolutionary development, or -for the reintroduction of populations or recovery of the species or ecological community. Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.	Critically Endangered, Endangered, Vulnerable
Important habitat for a migratory species	An area of 'important habitat' for a migratory species is: a. habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or b. habitat that is of critical importance to the species at particular life-cycle stages, and/or	Migratory

Term	Definition	Status to which Term is Relevant
	c. habitat utilised by a migratory species which is at the limit of the species range, and/or d. habitat within an area where the species is declining.	
Ecologically significant proportion	Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species (each circumstance will need to be evaluated). Some factors that should be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (for example, site fidelity and dispersal rates).	Migratory
Population of a migratory species	'Population', in relation to migratory species, means the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries including Australia.	Migratory

I.3. Masked Owl (Northern)

Scientific Name: *Tyto novaehollandiae kimberli*

EPBC Act Status: Vulnerable

TPWC Act Status: Vulnerable

Important Population Assessment

Key source population either for breeding or dispersal

Data on occurrences of the species across the island has historically been quite limited. Surveys for the Masked Owl (northern) have been largely restricted to the mineral leases on the western side of the island and the majority of potential habitat on the island has not been surveyed. The low number of records for the species is likely to be an artefact of the low number of surveys completed on the island, rather than reflecting the rarity of the Masked Owl (northern) on Groote Eylandt.

However, individuals of the Masked Owl (northern) have been observed across Groote Eylandt. There is one opportunisitic sighting of the species in October 2018 which was recorded during flora surveys. There is also a record from 2016 within the Southern Lease, in close proximity to the Study Area (Cumberland Ecology 2016). The species was also recorded to the west of the Southern Lease in 2017 by Cumberland Ecology (2019c) and within the Eastern Leases in 2014 by Cumberland Ecology (2015a). The NR Maps database also holds 10 records of the species observed between 2012 and 2017 within the locality, however none occur within the Study Area.

The location of Masked Owl (northern) records on Groote Eylandt, based on the NR Maps database are shown in **Figure 15**.

Habitat for the Masked Owl (northern) includes open forest and woodland, which is widespread and contiguous on the island.

The Masked Owl (northern) is sedentary and territorial. Little is known of the home ranges of the northern subspecies, however individual home ranges of the southern form of the species are known to vary between 150 ha and 1,200 ha in breeding and non-breeding seasons respectively. Individual owls detected on the island would likely disperse across home ranges that include the Disturbance Footprint.

The sex and breeding status of individuals potentially occurring within the Disturbance Footprint are unknown, but for the purposes of this assessment it is assumed that they represent one to several breeding pairs of birds.

Although the Masked Owl (northern) occurs widely across northern Australia, with the limited data available, it is assumed that the owls on Groote Eylandt constitute a distinct and important population. The individuals that potentially occur within the Disturbance Footprint are considered to comprise a subset, or small part of the Groote Eylandt population, which for the purposes of this assessment is considered to be a key source population.

Populations that are necessary for maintaining genetic diversity

Groote Eylandt is a large island with relatively pristine vegetation and intact assemblages of native flora and fauna. The owl population on the island has not been studied in detail; however, given an approximate home range of 1,200 ha in the non-breeding season, individuals are likely to move around the extensive available habitat across the island.

It is unclear if and to what extent the species travels between Groote Eylandt, and other islands and the mainland.

Island populations of fauna are often genetically distinct. For the purposes of this assessment it is assumed that the island population could represent a distinct form of the species and so is important for maintaining genetic diversity.

Populations that are near the limit of the species range

The Disturbance Footprint is not located near the limit of the range of the Masked Owl (northern). It occurs across the top end of the NT, Queensland and Western Australia.

Conclusion

For the reasons outlined above, the population of the Masked Owl (northern) that is likely to occur within the Disturbance Footprint is considered to comprise an 'important population' as defined by the Significant Impact Guidelines.

Significant Impact Criteria

Lead to a long-term decrease in the size of an important population of a species

The project will reduce the area of potentially occupied habitat for this species by removing approximately 14 ha of additional habitat within the Disturbance Footprint, beyond what is already approved to be cleared. This additional habitat comprises riparian habitat and lateritic woodland and forest habitat. This constitutes a very small portion of the open forest and woodland on Groote Eylandt and the overwhelming majority of this habitat on the island would remain. The project is unlikely to lead to a long-term decrease in the size of an important population of the species.

Reduce the area of occupancy of an important population

The project will clear approximately 14 ha of additional habitat which would marginally reduce the area of occupancy of an important population. This is a very minor area when considering the very large areas of similar habitat that will remain on the island as a whole. Overall, it is considered unlikely the project will significantly reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

The population of the Masked Owl (northern) is not likely to be fragmented as a result of the project as this species is highly mobile and able to fly over disturbed areas to access other habitats.

Adversely affect habitat critical to the survival of a species

The habitat to be removed within the Disturbance Footprint includes approximately 14 ha of additional habitat which contains foraging habitat and hollow-bearing trees potentially used for breeding. Extensive areas of foraging and breeding habitat will remain across the island. Recent surveys within the Disturbance Footprint identified a total of 52 large trees, with the highest concentration of large trees occurring in proximity to the Emerald River and Emerald River Southern Tributary (33 large trees having been recorded within 100 m of these waterways). DENR previously indicated that the presence of large trees could be used as an indicator of potential breeding habitat for the Masked Owl as large trees would most likely be associated with large hollows.

Tree hollows are critical for survival of owls, but the area to be removed constitutes a very small portion of the available tree hollows on the island and so the habitat clearance is unlikely to threaten the survival of the species as a whole.

Disrupt the breeding cycle of an important population

As stated above, trees will be removed that may contain hollows suitable for breeding, and it is possible that some breeding pairs could have breeding disrupted in the long term by the clearing of habitat. Large areas of similar habitat, including suitable breeding habitat, will remain in the locality that will continue to provide habitat for this species. Accordingly, the project is unlikely to disrupt the breeding cycle of the population of the Masked Owl (northern) on Groote Eylandt.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Masked Owl (northern) population of Groote Eylandt is unlikely to decline as a result of habitat to be removed for the project. The project will remove only a very small area of potential foraging and breeding habitat for this species, and large areas of similar habitat across the island will remain and continue to provide habitat for this species.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

DENR and ALC (2019) have identified weed invasion, feral cats and potential invasive species (e.g. ants) as posing a medium to high threat to the Masked Owl (northern). Weed invasion has been categorised as having a high threat rating. GEMCO's Weed Management Manual will be implemented for the project to ensure project activities do not introduce weeds. These measures include inspecting and washing vehicles that enter the Disturbance Footprint, in particular during the construction phase.

It is considered unlikely that the project will result in other invasive species becoming established in habitat for the Masked Owl (northern). Few feral animals occur on Groote Eylandt, and the TSMP and GEMCO's Cane Toad Management Plan facilitate the management of feral animals. It is unlikely that any invasive plant or animal will become established as a result of the project.

Introduce disease that may cause the species to decline

Disease is not known to be a threat to this species and no disease that may affect it is present on Groote Eylandt. It is therefore considered unlikely that the project will introduce any form of pathogen or disease that may cause the Masked Owl (northern) to decline.

Interfere substantially with the recovery of the species

The project is not expected to interfere substantially with the recovery of the Masked Owl (northern). The project will result in the removal of a small area of habitat, including potential breeding habitat for this species. Large areas of similar habitat occur in the locality that will remain and continue to provide high quality habitat for this species.

Conclusion

For the purposes of this assessment it is assumed that the potential occurrence of the Masked Owl (northern) in the Disturbance Footprint would form a subset or small part of an important population found on Groote Eylandt. The project will result in the removal of approximately 14 ha of additional habitat comprising foraging and breeding habitat for the species. This constitutes a very small portion of the open forest and woodland on Groote Eylandt. The project will not cause the establishment of invasive species in the suitable habitat that remains, and will not increase the risk of disease or interfere with the recovery of the species.

Accordingly, no significant impact is predicted to occur to the Masked Owl (northern) as a result of the project.

I.4. Northern Quoll

Scientific Name: *Dasyurus hallucatus*

EPBC Act Status: Endangered

TPWC Act: Critically Endangered

Introduction

The *Northern Quoll Referral Guideline* (DotE 2016) has been utilised to assess the significance of impacts of the project on the Northern Quoll. The guideline:

- Outlines likely habitats critical to the survival of the Northern Quoll;
- Outlines populations important for the long-term survival of the Northern Quoll;
- Details survey and mitigation expectations; and
- Clarifies what is likely to constitute a significant impact on the Northern Quoll.

Each of these items are discussed in the sections below in relation to potential impacts from the project.

Critical Habitat

Habitat critical to the survival of the Northern Quoll is defined in the Northern Quoll Referral Guideline (DotE 2016) as:

> *Habitat within the modelled distribution of the northern quoll (refer to maps 1–5) which provides shelter for breeding, refuge from fire / or predation and potential poisoning from cane toads. Habitat critical to the survival usually occurs in the form of:*
>
> > *- off shore islands where the northern quoll is known to exist*
> >
> > *- rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creek lines*
> >
> > *- structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs.*
>
> *Dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the northern quoll is also considered habitat critical to the survival of the northern quoll.*

The habitat within the Disturbance Footprint, Study Area and Groote Eylandt all occur within the modelled distribution of the Northern Quoll and provides shelter for breeding, refuge from predation and potential poisoning from cane toads. Within the Study Area, this available habitat includes rocky habitats and structurally diverse woodland or forest. The habitat is on a major offshore island that is a stronghold of the Northern Quoll. Therefore the habitat to be impacted is critical to the survival of the Northern Quoll. The project will directly impact 14 ha of additional habitat for the Northern Quoll, and indirectly impact other areas of critical habitat.

Population Assessment

The population of Northern Quolls to be impacted comprises an important population. All occurrences of endangered species are taken to represent a "population of a species" according to the Significant Impact Guidelines.

The population of the Northern Quoll on Groote Eylandt is known to be substantial and widespread across the island. **Figure 15** shows the location of Northern Quoll records on Groote Eylandt and **Figure 16** shows the location of records within the Study Area during recent surveys.

The Groote Eylandt population is one of the few remaining populations in Australia that appears to be thriving, as it is not impacted by the Cane Toad, which is a key threat to the Northern Quoll on the mainland. As such, the population of Northern Quoll on Groote Eylandt has high conservation significance (NRETAS 2009).

An important population of the Northern Quoll is defined in the Northern Quoll Referral Guideline as populations which are:

- high density quoll populations, which occur in refuge-rich habitat critical to the survival of the species, including where cane toads are present

- occurring in habitat that is free of cane toads and unlikely to support cane toads upon arrival i.e. granite habitats in WA, populations surrounded by desert and without permanent water

- subject to ongoing conservation or research actions i.e. populations being monitored by government agencies or universities or subject to reintroductions or translocation.

The population within the Disturbance Footprint, Study Area and Groote Eylandt all constitute an important population in accordance with this definition as they occur in habitat that is free of cane toads.

Survey

Surveys have consistently verified the occurrence of the Northern Quoll on Groote Eylandt.

All recent studies by Cumberland Ecology (2015a, 2016, 2019c) and that by Heiniger and Gillespie (2017) detected the species at numerous locations within the Study Area and surrounding areas. These studies used the recommended survey methods detailed within the Northern Quoll Referral Guideline, and included both motion-sensor camera surveys and habitat assessment. The Northern Quoll was detected during these surveys across a wide variety of habitats including lateritic and sandstone woodland and forest, riparian habitats and coastal habitats.

Mitigation

The Northern Quoll Referral Guideline details the main threats to the Northern Quoll and provides mitigation advice for the various threats. **Table 28** details the threats relevant to the project and the mitigation measures proposed. Mitigation measures proposed for the project align with the recommended mitigation measures within the Northern Quoll Referral Guideline.

Table 27 Key threats and relevant mitigation measures for the Northern Quoll

Threats and Key Impacts	Relevant Project Mitigation Measures
Habitat clearing, modification or land use change	Table 2 of the Northern Quoll Referral Guideline recommends a range of mitigation measures relevant to habitat clearing, with measures targeted towards minimising habitat clearing and rehabilitating disturbed areas. The following mitigation measures will be implemented for the project. These measures are consistent with those outlined in the Northern Quoll Referral Guideline. • Avoiding areas of sandstone outcropping • Limiting clearing to the smallest possible area • Utilising existing access tracks where possible • Providing workforce training on threatened species, including Northern Quolls and their ecology
Introduction and increases of invasive species (e.g. cane toads, gamba grass, feral cats and pigs, wild dogs)	Table 2 of the Northern Quoll Referral Guideline recommends a range of mitigation measures for managing the potential introduction of invasive species. Relevant mitigation measures from this guideline will be implemented for the project. These include: • Implementation of GEMCO's Cane Toad Management Plan. This includes procedures relating to barging of equipment, inspections of barges and vehicles, Cane Toad fencing at the port and airport and use of a Cane Toad detection dog at the port. These measures are all aimed at preventing the introduction of cane toads to Groote Eylandt • Implementation of GEMCO's quarantine and weed management procedures. These include inspecting and washing vehicles prior to entering the Disturbance Footprint • Personnel responsible for vegetation clearing will participate in workforce training on quarantine protocols and associated risks involved with invasive species
Traffic	Table 2 of the Northern Quoll Referral Guideline recommends a range of mitigation measures for traffic impacts (which may result in vehicle strike leading to direct mortality or habitat fragmentation). The following mitigation measures will be implemented for the project: • Using only small numbers of dozers for clearing activities • Implementing speed controls and ensuring, through workforce training, that speed controls are understood • Construction of an underpass for the realigned public access track, which would provide an alternative to crossing the haul road These measures are consistent with those outlined in the Northern Quoll Referral Guideline.

Threats and Key Impacts	Relevant Project Mitigation Measures
Inappropriate fire regimes	Table 2 of the Northern Quoll Referral Guideline recommends a range of mitigation measures for fire. The following mitigation measure will be implemented for the project. • Workforce training addresses procedures in the event of unexpected fire events This measure is consistent with the mitigation measures outlined in the Northern Quoll Referral Guideline.

Significant Impact Criteria (Northern Quoll Referral Guideline)

For the purposes of this assessment, impacts are considered in terms of the direct impacts of clearing required by the construction of the haul road, and fragmentation of a patch of woodland and forest between the haul road, the Emerald River and, in future mining areas.

Result in the loss of habitat critical to the survival of the northern quoll

The Northern Quoll occurs in most habitats across Groote Eylandt, which is over 230,000 ha in size and so most of the island represents critical habitat, as explained above. The proposed access corridor would entail clearing of 14 ha more than would be cleared by the approved haul road. However, when considered in context, the additional 14 ha is small relative to the habitats used by the species on the island. Consequently, the loss of critical habitat is not considered to be a significant impact to the species.

Northern Quoll breeding (denning) habitat typically includes rocky areas amid structurally diverse vegetation. However, the species also uses dens in hollow-bearing trees, hollow logs and termite mounds. Such habitats are widespread across Groote Eylandt and the area of additional habitat that would be cleared by the realigned haul road is very small in comparison. Additionally, rocky habitats have been deliberately avoided when selecting the location of the haul road.

The sheltering and denning sites to be cleared from the additional 14 ha that would be cleared by the proposed access corridor are not unique and are extensively represented across the island. There will be no significant loss of denning or shelter habitat for the species.

Decrease the size of a population important for the long-term survival of the northern quoll and therefore interfere with the recovery of the species

The project has a limited potential to reduce the Northern Quoll population during the initial clearing for the project, and, as a result of road mortality, during operation of the haul road. However, the additional impacts are considered small relative to the overall size of the population on the island, as explained below.

Extensive information exists about the status of the Northern Quoll on Groote Eylandt and there is a high degree of confidence that this species is currently abundant and widespread in all suitable habitat types across the island. Both foraging and breeding habitat occurs across the island. **Figure 15** shows the location of records held within the NR Maps database. **Figure 16** shows the records of the species within the Study Areas from recent studies. The NR Maps databased holds over 2,500 records of the Northern Quoll across Groote Eylandt including within and beyond the Study Area.

Northern Quolls are highly mobile and are known to forage in disturbed habitats around roads and towns on Groote Eylandt. They have also been found to occur within areas of mine rehabilitation in the existing mine and exploration areas within the Eastern Leases (Cumberland Ecology 2015a). Recent studies by Cumberland Ecology (2019c) identified the occurrence of the species across a wide variety of habitats including lateritic and sandstone woodland and forest, riparian habitats and coastal habitats.

The project will clear approximately 14 ha of additional habitat that has not been approved. This loss of habitat is not considered to result in a significant decrease in the size of the population on Groote Eylandt due to the population being abundant and widespread across the island.

Introduce inappropriate fire regimes or grazing activities (i.e. increasing the risk of late dry season high intensity fires to the area) that substantially degrade habitat critical to the survival of the northern quoll or decrease the size of a population important for the long term survival of the species

The haul road will only be accessed by mining traffic and is not a public road and, therefore, will have no impact on access for Traditional Owners to burn vegetation within the Study Area. Realignment of the public access road is not considered to increase access as it provides an alternative connection for an existing access route.

The project does not involve the introduction of grazing activities.

Fragment a population important for the long term survival into two or more populations

Habitat fragmentation is likely to occur as a result of the project due to the clearing of native vegetation. These impacts were part of the approved layout of the haul road corridor and the increase in width of the realigned access corridor will only result in a minor increase in the fragmentation of habitat. Habitat connectivity will be maintained along the coastline and the movement and dispersal opportunities for the Northern Quoll are not expected to be exacerbated beyond that already approved. Northern Quolls are highly mobile and previous records around roads and towns as well as existing mining areas suggests that they would be capable of accessing suitable habitat either side of the realigned haul road corridor.

Northern Quolls are able to cross disturbed areas and the establishment of the wider haul road is unlikely to hinder the dispersal and movement of the Northern Quoll more than the design of the approved haul road. Additionally, the proposed underpass forming part of the realigned public access track will facilitate the movement of Northern Quolls between areas of critical habitat on either side of the realigned haul road.

The project is not considered to fragment the existing important population of Northern Quolls into two or more populations as habitat fragmentation is not considered to be significantly increased beyond that which has already been approved.

Result in invasive species or increases of them that are harmful to the northern quoll becoming established in its habitat, namely cane toads, feral cats, red foxes or exotic grasses which increase fire risk. This includes actions *which have inadequate quarantine measures in place for movements between the mainland and offshore islands where northern quolls occur*

DENR and ALC (2019) have identified cane toads, feral cats, pigs, herbivores and weeds as posing a medium to very high threat to the Northern Quoll.

Cane Toads are not present on Groote Eylandt, and GEMCO/South32 actively seek to ensure this invasive species is not inadvertently introduced to the island. GEMCO/South32 has a Cane Toad Management Plan which includes quarantine measures to protect Groote Eylandt from Cane Toads and the project will not exacerbate this risk beyond current levels.

Low numbers of feral cats were observed within the adjacent Southern Lease and surrounds during recent surveys by Cumberland Ecology (2019c). Heiniger et al. (2020) also detected low numbers of cats within the Southern Lease. Feral cats occurred in both disturbed areas (i.e. areas subject to exploration) and undisturbed areas, and it is likely they opportunistically move throughout the landscape to areas with abundant prey. The project is unlikely to exacerbate the impact of feral cats beyond current conditions.

Feral Pigs (*Sus scrofa*) and feral herbivores are not established on the island and the project is unlikely to result in the establishment of the species in suitable habitat for the Northern Quoll.

GEMCO's Weed Management Manual will be implemented to ensure the project does not introduce weeds and include inspecting and washing vehicles that enter the Disturbance Footprint.

No other invasive species are considered likely to become established as a result of the project.

Conclusion

Groote Eylandt is an island of over 230,000 ha that is stronghold for the endangered Northern Quoll and the critical habitat on the island is of high conservation value. The Northern Quoll occupies most terrestrial habitats across the island.

The project will clear 14 ha of critical habitat for the Northern Quoll than would be cleared by the approved haul road. Such habitat comprises forest and woodland known to be occupied by the species. However, such additional impacts need to be evaluated in context, as similar habitats are extensive across the island. The additional area required to be cleared for the proposed access corridor is unlikely to significantly worsen any direct and/or indirect impacts of the approved project.

The Northern Quoll is known to utilise disturbed areas on the island and has been recorded within existing mining areas. As such, the species is considered capable of accessing areas of critical habitat on either side of the proposed access corridor.

As the additional impacts of the proposed access corridor are not considered to be significantly greater than the approved haul road, the project is considered unlikely to have a significant impact upon the Northern Quoll.

I.5. Ghost Bat

Scientific Name: *Macroderma gigas*

EPBC Act Status: Vulnerable

TPWC Act Status: Not Listed

Important Population Assessment

Key source population either for breeding or dispersal

The Ghost Bat was not recorded within the Study Area during recent surveys, although it is noted that few surveys were targeted towards recording bats. The Ghost Bat has been previously recorded within dry eucalypt forest within the existing GEMCO mine (URS Australia Pty Ltd 2012), within open woodland in proximity to the existing GEMCO mine (Diete et al. 2015b) and in coastal grass and shrub habitat in the south west peninsular of the island (Diete et al. 2015b). These habitats are considered to constitute foraging habitat for the species. The location of Ghost Bat records on Groote Eylandt based on the NR Maps database are shown in **Figure 15**.

During the daytime, the Ghost Bat roosts in caves, rock crevices and old underground mines (Threatened Species Scientific Committee 2016b). Maternity roosts have very specific microclimate requirements and generally comprise deep natural caves or disused underground mines with relatively stable temperatures of 23°−28°C (Threatened Species Scientific Committee 2016b). Most breeding sites appear to require multiple entranced caves (Threatened Species Scientific Committee 2016b). Foraging by the Ghost Bat on Groote Eylandt and Study Area (including the Disturbance Footprint) would likely occur in proximity to roosting habitat and include a range of habitat types, including closed forest, open forest, sandstone woodland and rock outcrops, woodland/forests, riparian/wetland habitat and coastal habitat.

It is assumed for this assessment, that the population of the Ghost Bat potentially occurring within the Study Area is likely to be part of a broader population on Groote Eylandt. The population of Ghost Bats on Groote Eylandt should be considered to potentially be a key source population as it is an island population that is separate from the declining populations on the mainland.

Populations that are necessary for maintaining genetic diversity

Offshore islands can be important to the overall genetic diversity of a species because the species is typically protected from some of the threats experienced on the mainland (NRETAS 2009).

Therefore, it is assumed for this assessment, that the population of the Ghost Bat potentially occurring within the Disturbance Footprint is likely to be part of a broader population on Groote Eylandt, which may be important to the species for the maintenance of genetic diversity.

Populations that are near the limit of the species range

The species' current distribution is discontinuous, with geographically disjunct colonies occurring in the Pilbara, Kimberley, northern portion of the NT (including Groote Eylandt), the Gulf of Carpentaria, coastal and near coastal eastern Queensland from Cape York to near Rockhampton, and western Queensland (Threatened

Species Scientific Committee 2016b). The population of the Ghost Bat on Groote Eylandt is considered to be towards its northern geographic limits.

Conclusion

For the reasons outlined above, the population of the Ghost Bat that potentially occurs within the Disturbance Footprint is considered to be a part of an 'important population' found on Groote Eylandt as defined by the Significant Impact Guidelines.

Significant Impact Criteria

Lead to a long-term decrease in the size of an important population of a species

The project will reduce the area of potentially occupied habitat for this species by removing approximately 14 ha of additional habitat within the Disturbance Footprint, beyond what is already approved to be cleared. The Ghost Bat is likely to forage in a wide range of habitat types and the area to be cleared represents a very small portion of the foraging habitat on the island and the overwhelming majority of this habitat on the island would remain. The species has been previously recorded within dry eucalypt forest within the existing GEMCO mine (URS Australia Pty Ltd 2012) and therefore it is likely to have some tolerance to disturbance. The project is unlikely to lead to a long-term decrease in the size of an important population of the species.

No potential roosting or breeding habitat will be removed by the project, as the Disturbance Footprint is located outside of areas containing rocky outcropping and caves. These are the only areas within the Study Area that may provide roosting or breeding habitat for the species. The closest areas of rocky outcropping occur approximately 1 km north east and 1.2 km south east of the eastern end of the construction access track within sandstone woodland and forest habitats (see **Figure 14**).

Accordingly, the removal of habitat for the Ghost Bat within the Disturbance Footprint is not considered likely to lead to a long-term decrease in the size of an important population of this species.

Reduce the area of occupancy of an important population

The project will clear approximately 14 ha of additional potential foraging habitat for this species on the island. The foraging habitat to be removed represents a very small proportion of the available habitat on the island and the vast majority will be retained. As noted above, the sandstone outcrops in the Study Area are the only areas that have potential to provide roosting or breeding habitat. No disturbance will be undertaken within these areas. Overall, it is considered unlikely the project will significantly reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

No potential roosting or breeding habitat will be removed for the project, as the Disturbance Footprint is located outside of sandstone outcropping areas, which may support suitable roosting or breeding features. The Ghost Bat is highly mobile and is able to fly over disturbed areas to access alternative habitats relatively easily. Radio-tracking of the Ghost Bat has indicated that foraging areas were centred, on average, 1.9 km from the day roost (Tidemann et al. 1985). The project will result in the removal of a very small proportion of the available foraging habitat for this species and it is unlikely that the removal of this small area of foraging habitat will fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

The habitat to be removed within the Disturbance Footprint includes approximately 14 ha of additional habitat, comprising riparian habitat and lateritic woodland and forest habitat), which contains foraging habitat for the Ghost Bat. Extensive areas of foraging habitat will remain across the island. The removal of this small area of foraging habitat is unlikely to adversely affect habitat critical to the survival of the species.

No potential roosting or breeding habitat will be removed for the project, as the Disturbance Footprint avoids areas of sandstone outcropping, which may support suitable roosting or breeding features.

Disrupt the breeding cycle of an important population

As noted above, the sandstone outcrops in the Study Area are the only areas that have potential to provide roosting or breeding habitat. No disturbance will be undertaken within these areas. Accordingly, the project is not considered likely to disrupt the breeding cycle of an important population of the Ghost Bat.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Ghost Bat population of Groote Eylandt is unlikely to decline as a result of habitat removed for the project. The project will remove only a very small area of potential foraging habitat for this species, and large areas of similar habitat across the island will remain and continue to provide high quality habitat for this species.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

DENR and ALC (2019) have identified cane toads and feral cats as posing a threat to the Ghost Bat. Cane Toads are not present on Groote Eylandt, and GEMCO/South32 actively seek to ensure this invasive species is not inadvertently introduced to the island. GEMCO/South32 has a Cane Toad Management Plan which includes quarantine measures to protect Groote Eylandt from Cane Toads and the project will not exacerbate this risk beyond current levels. Low numbers of feral cats were observed within the adjoining Southern Lease and surrounds during recent surveys by Cumberland Ecology (2019c). The project is unlikely to exacerbate the impact of feral cats beyond current conditions.

No other invasive species are considered likely to become established as a result of the project.

Introduce disease that may cause the species to decline

Disease is not known to be a threat to this species and no disease that may affect it is present on Groote Eylandt. It is considered unlikely that the project will introduce a disease that may cause the Ghost Bat to decline.

Interfere substantially with the recovery of the species

The project is not expected to interfere substantially with the recovery of the Ghost Bat. The project will result in the removal of a small area of foraging habitat for this species, however, large areas of similar habitat occur in the locality that will remain and continue to provide high quality habitat for this species.

Conclusion

For the purposes of this assessment it is assumed that the occurrence of the Ghost Bat on Groote Eylandt is an important population. The project will result in the removal of approximately 14 ha of additional foraging habitat for the species. All areas of potential roosting and breeding habitat is being avoided by the project. The project will not cause the establishment of invasive species in the suitable habitat, and will not increase the risk of disease or interfere with the recovery of the species.

Accordingly, no significant impact is predicted to occur to the Ghost Bat as a result of the project.

I.6. Fork-tailed Swift

Scientific Name: *Apus pacificus*

EPBC Act Status: Migratory

TPWC Act Status: Not Listed

Important Habitat Assessment

Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species

The Fork-tailed Swift occurs across the entire mainland and is also found on various offshore islands. It has broad habitat preferences, and is typically found in forest and woodland habitat, which is the main habitat type across Groote Eylandt. This bird species is likely to forage in the forest and woodland areas of the Disturbance Footprint, and these habitats are widespread across the island. Therefore, the Disturbance Footprint would not support an ecologically significant proportion of the population of this species. The location of Fork-tailed Swift records on Groote Eylandt are shown in **Figure 17**.

Habitat that is of critical importance to the species at particular life-cycle stages

This species is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher, mostly over inland plains but sometimes above foothills or in coastal areas (DAWE 2020a). There is potential fly-over habitat for this species above the vegetation within Disturbance Footprint and it is expected to forage aerially about these areas on occasion. Foraging habitat is not of critical importance to the occurrence of the species as a whole on Groote Eylandt. No breeding habitat is present within the Disturbance Footprint (and Groote Eylandt) as breeding occurs outside of Australia.

Habitat utilised by a migratory species which is at the limit of the species range

The Fork-tailed Swift occurs throughout much of mainland Australia and offshore islands. None of the habitat within the Disturbance Footprint is at the limit of the range for this species.

Habitat within an area where the species is declining

Groote Eylandt is not reported to be an area where the species is declining. Suitable habitat for the Fork-tailed Swift is relatively pristine across the majority of Groote Eylandt.

Conclusion

For the reasons outlined above, the Disturbance Footprint area is not considered to be an important habitat for the Fork-tailed Swift as defined by the Significant Impact Guidelines.

Significant Impact Criteria

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The habitat within the Disturbance Footprint is not considered an important habitat for the Fork-tailed Swift.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species

The habitat within the Disturbance Footprint is not considered important habitat for the Fork-tailed Swift.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species

As stated above, the Disturbance Footprint (and Groote Eylandt) is not considered to support an ecologically significant proportion of the population of the Fork-tailed Swift.

Conclusion

Habitat within the Disturbance Footprint does not provide important habitat for the Fork-tailed Swift and is not considered to support an ecologically significant proportion of the population of this species.

Accordingly, no significant impact is predicted to occur to the Fork-tailed Swift as a result of the project.

I.7. Eastern Osprey

Scientific Name: *Pandion cristatus*

EPBC Act Status: Migratory

TPWC Act Status: Not Listed

Important Habitat Assessment

Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species

The Eastern Osprey occurs widely throughout the coastal areas of northern Australia, occasionally occurring in inland areas. Habitat for this species occurs along the coastline of the Study Area and along the Emerald River, however the individuals occurring in these areas would represent a very small proportion of the overall population of the species on Groote Eylandt, as the species occurs around the coastline and other permanent waterways. Therefore, the Disturbance Footprint would not support an ecologically significant proportion of the population of this species. The location of Eastern Osprey records on Groote Eylandt are shown in **Figure 16**.

Habitat that is of critical importance to the species at particular life-cycle stages

The Eastern Osprey is likely to breed in areas of the coastline and more permanent sections of the waterways that occur within the Study Area, which includes the section of the Emerald River that intersects the Disturbance Footprint. The Disturbance Footprint intersects approximately 120 m of the Emerald River. While such waterways could be used for breeding by some animals, such habitat is not of critical importance to the occurrence of the species as a whole on Groote Eylandt.

Habitat utilised by a migratory species which is at the limit of the species range

The distribution of the Eastern Osprey within Australia extends from Esperance in Western Australia to NSW, where records become scarcer towards the south, and into Victoria and Tasmania, where the species is a rare vagrant (DAWE 2020d). None of the habitat within the Disturbance Footprint is at the limit of the range for this species.

Habitat within an area where the species is declining

Groote Eylandt is not reported to be an area where the species is declining. Suitable habitat for the Eastern Osprey is relatively pristine across the majority of Groote Eylandt.

Conclusion

For the reasons outlined above, the Disturbance Footprint is not considered to be important habitat for the Eastern Osprey as defined by the Significant Impact Guidelines.

Significant Impact Criteria

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The habitat within the Disturbance Footprint is not considered important habitat for the Eastern Osprey.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species

The habitat within the Disturbance Footprint is not considered important habitat for the Eastern Osprey.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species

As stated above, the Disturbance Footprint (and Groote Eylandt) is not considered to support an ecologically significant proportion of the population of the Eastern Osprey.

Conclusion

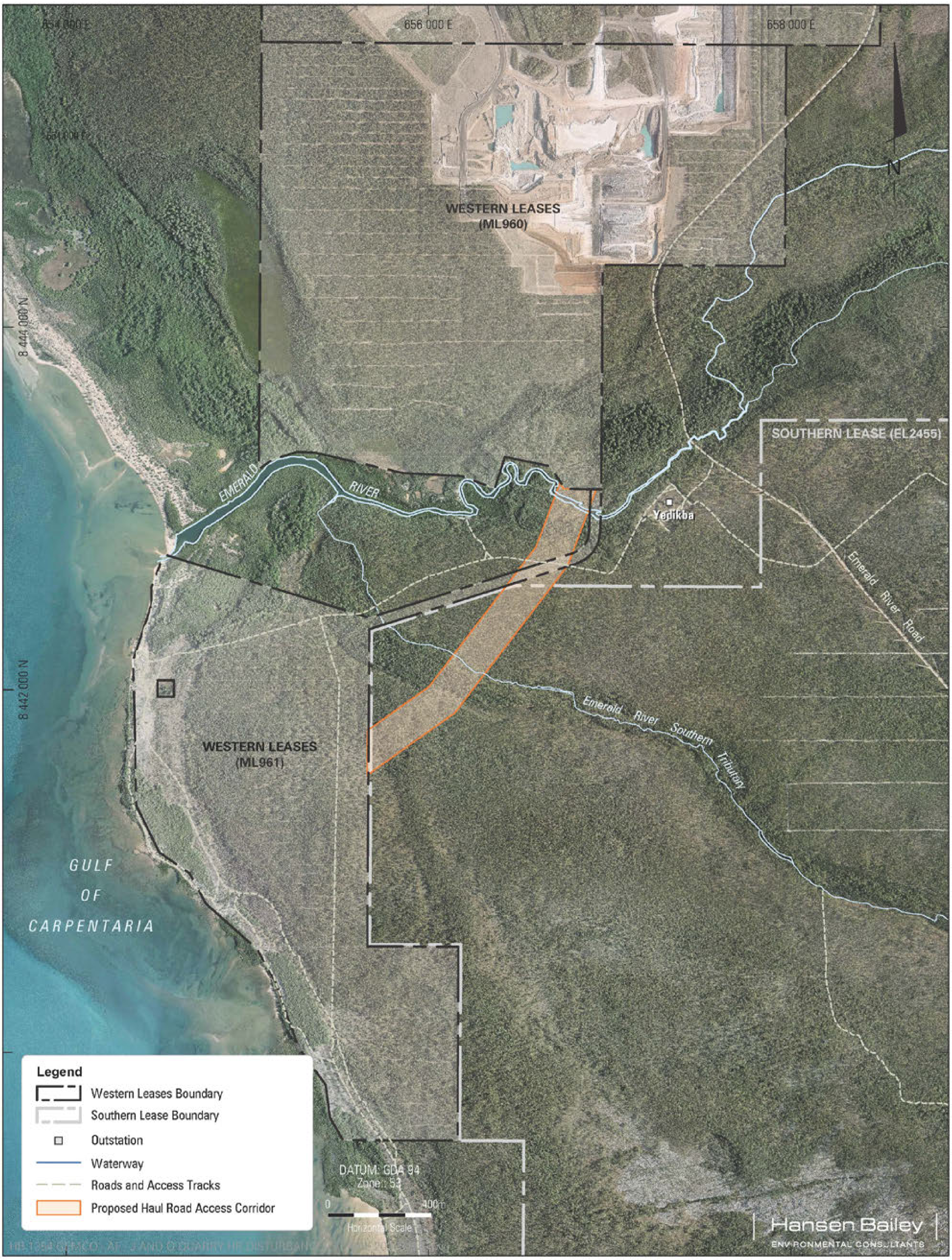
The Disturbance Footprint does not provide important habitat for the Eastern Osprey and is not considered to support an ecologically significant proportion of the population of this species.

Accordingly, no significant impact is predicted to occur to the Eastern Osprey as a result of the project.

FIGURES

Figure 1. Project location

Image Source: Hansen Bailey 2020



J QUARRY HAUL ROAD

Location of Access Corridor

FIGURE 2

I:\...\20001\Figures\RP1\20200501\Figure 2. Location of access corridor

Figure 2. Location of access corridor

Image Source: Hansen Bailey 2020

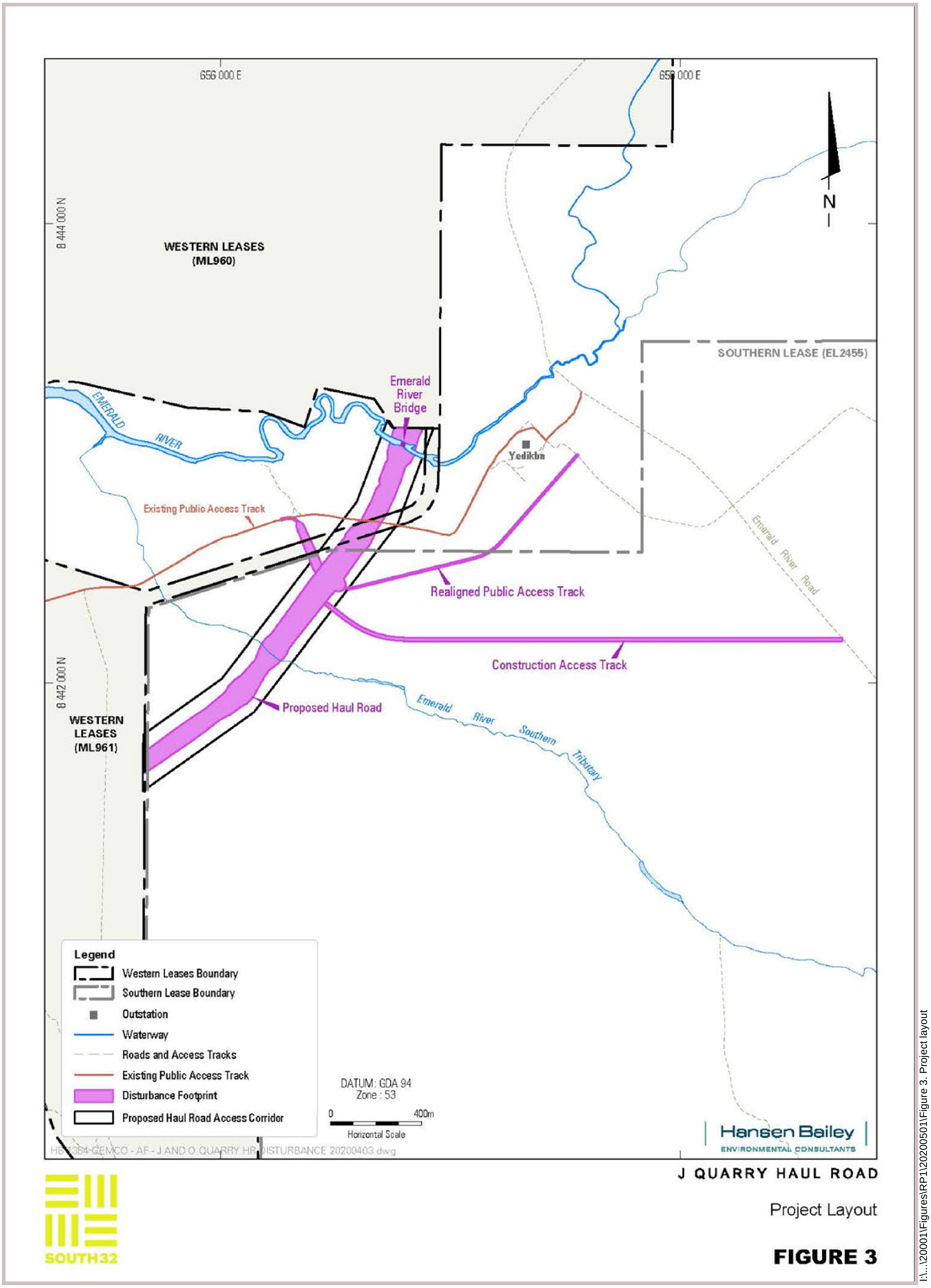


Figure 3. Project layout

Image Source: Hansen Bailey 2020

Figure 4. Bioregion Setting

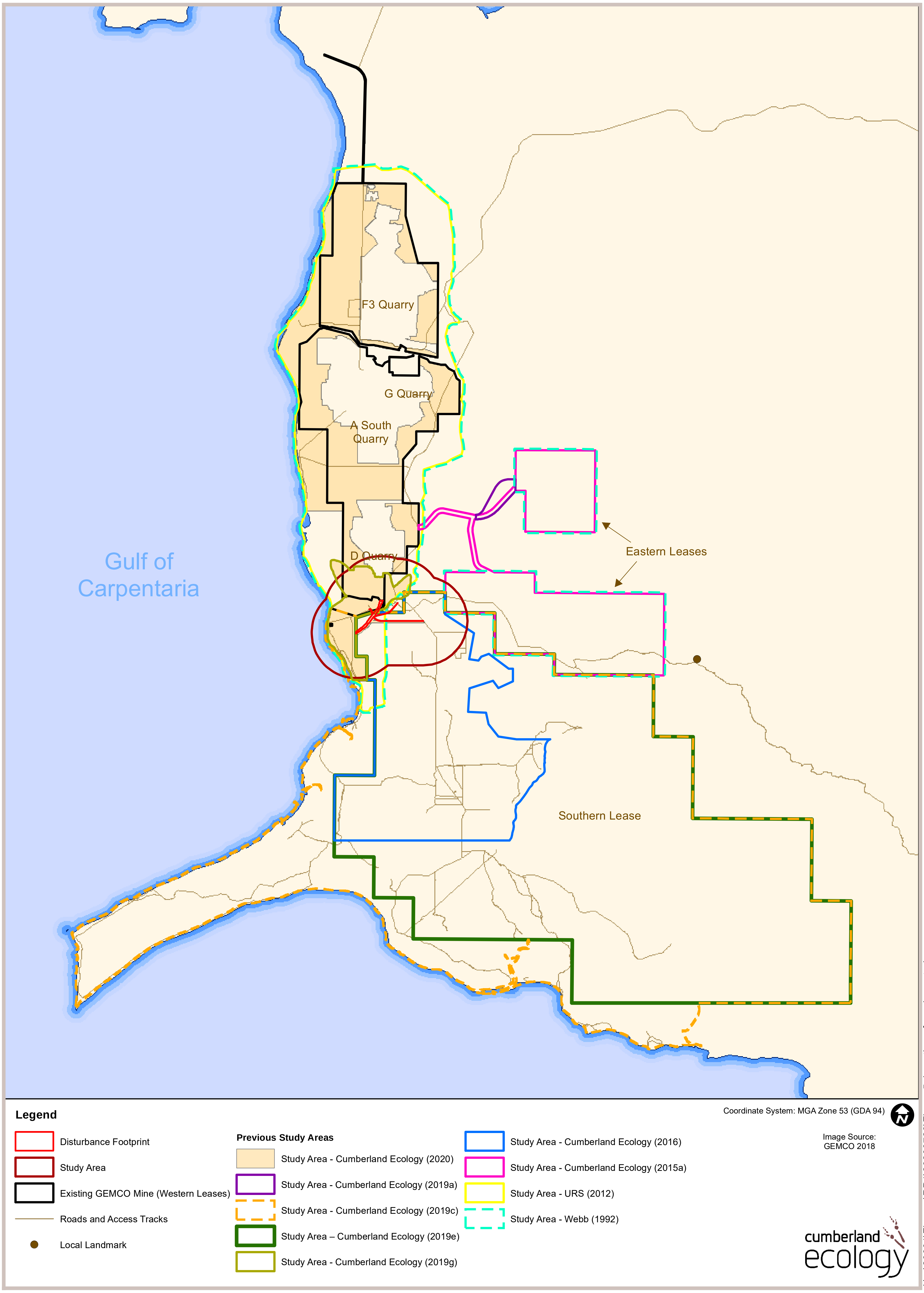


Figure 5. Location of previous study areas

0 2 4 6 km

I:\...\20001\Figures\RP1\20200723\Figure 5. Location of previous study areas

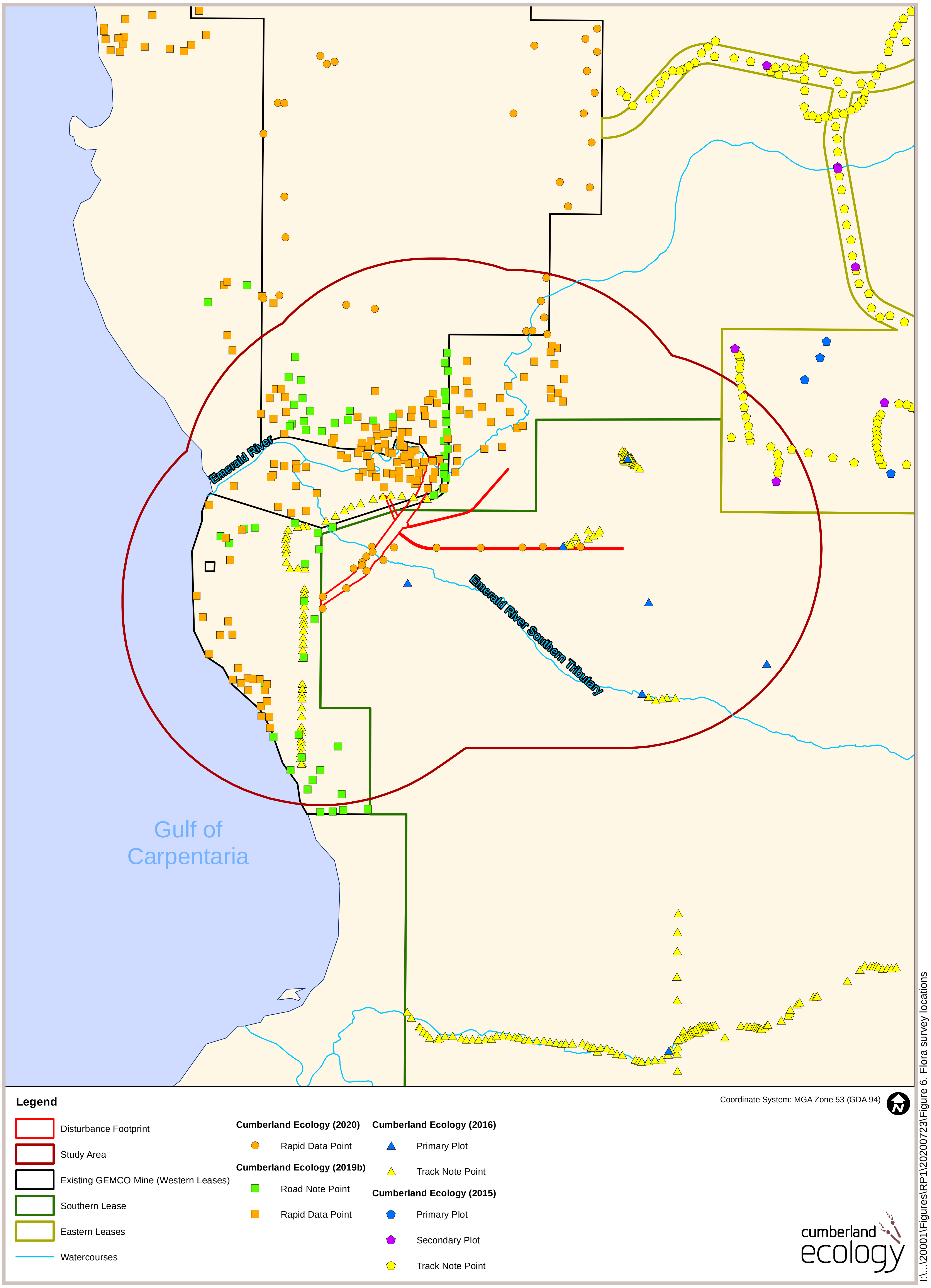


Figure 6. Flora survey locations

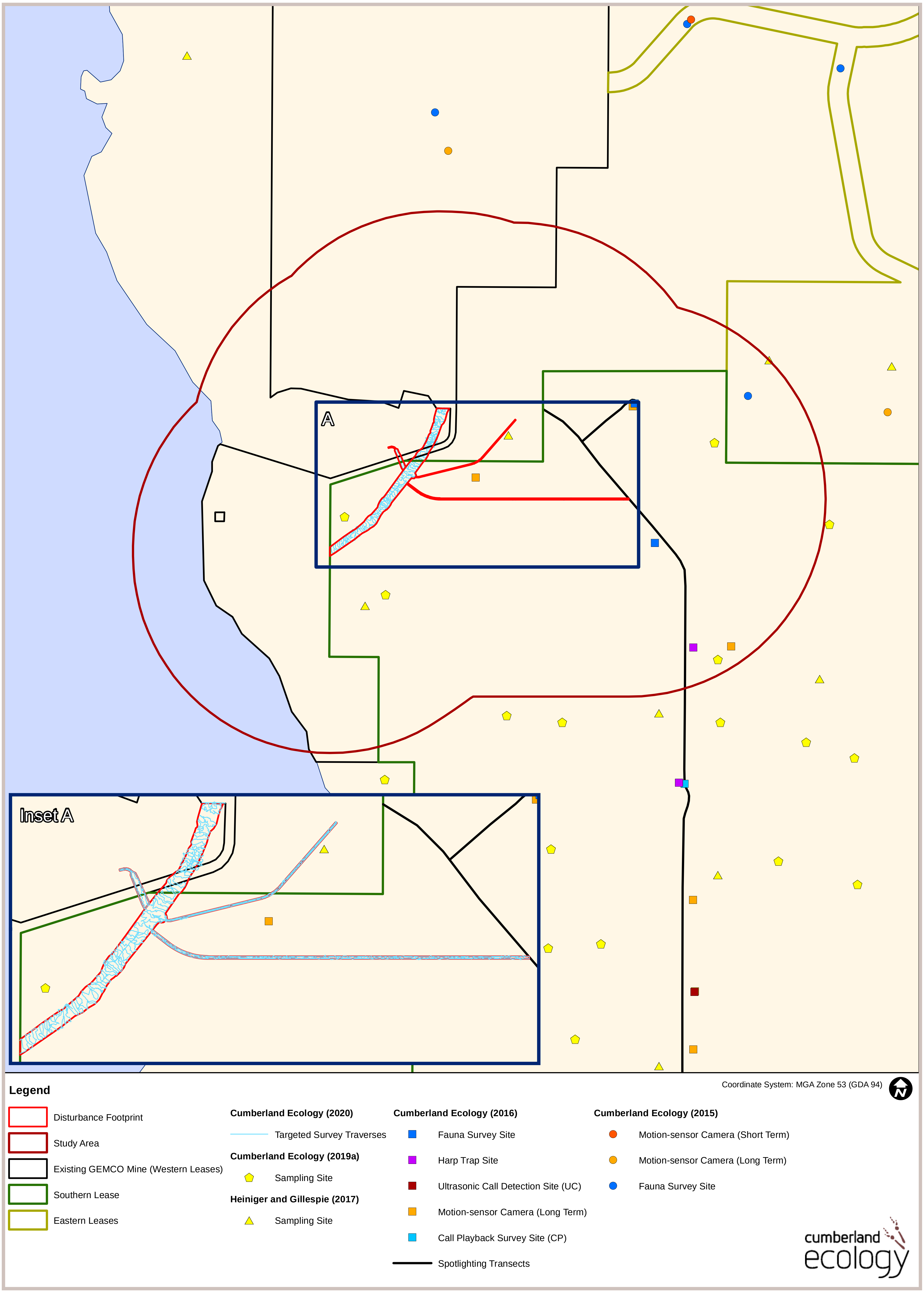
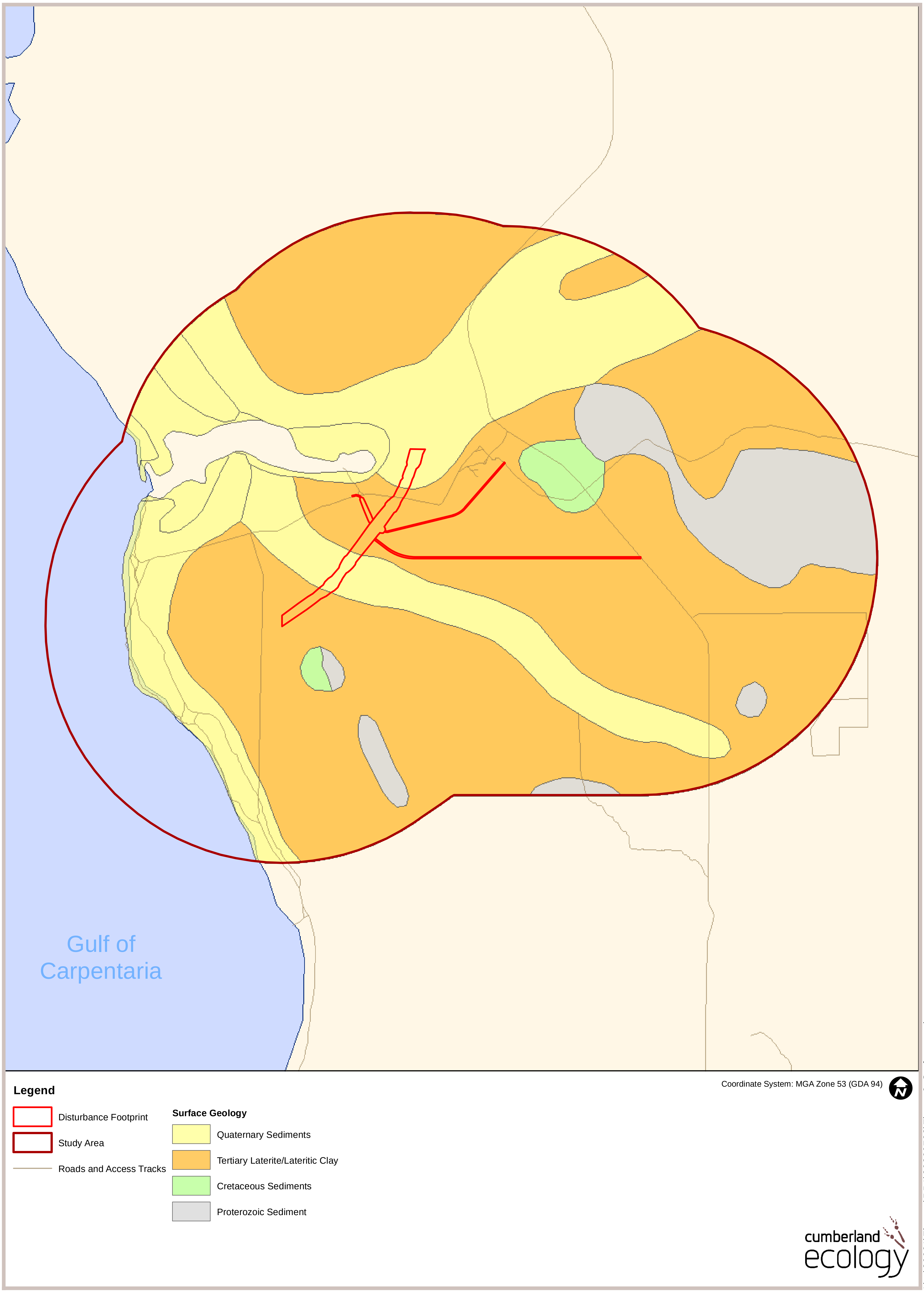


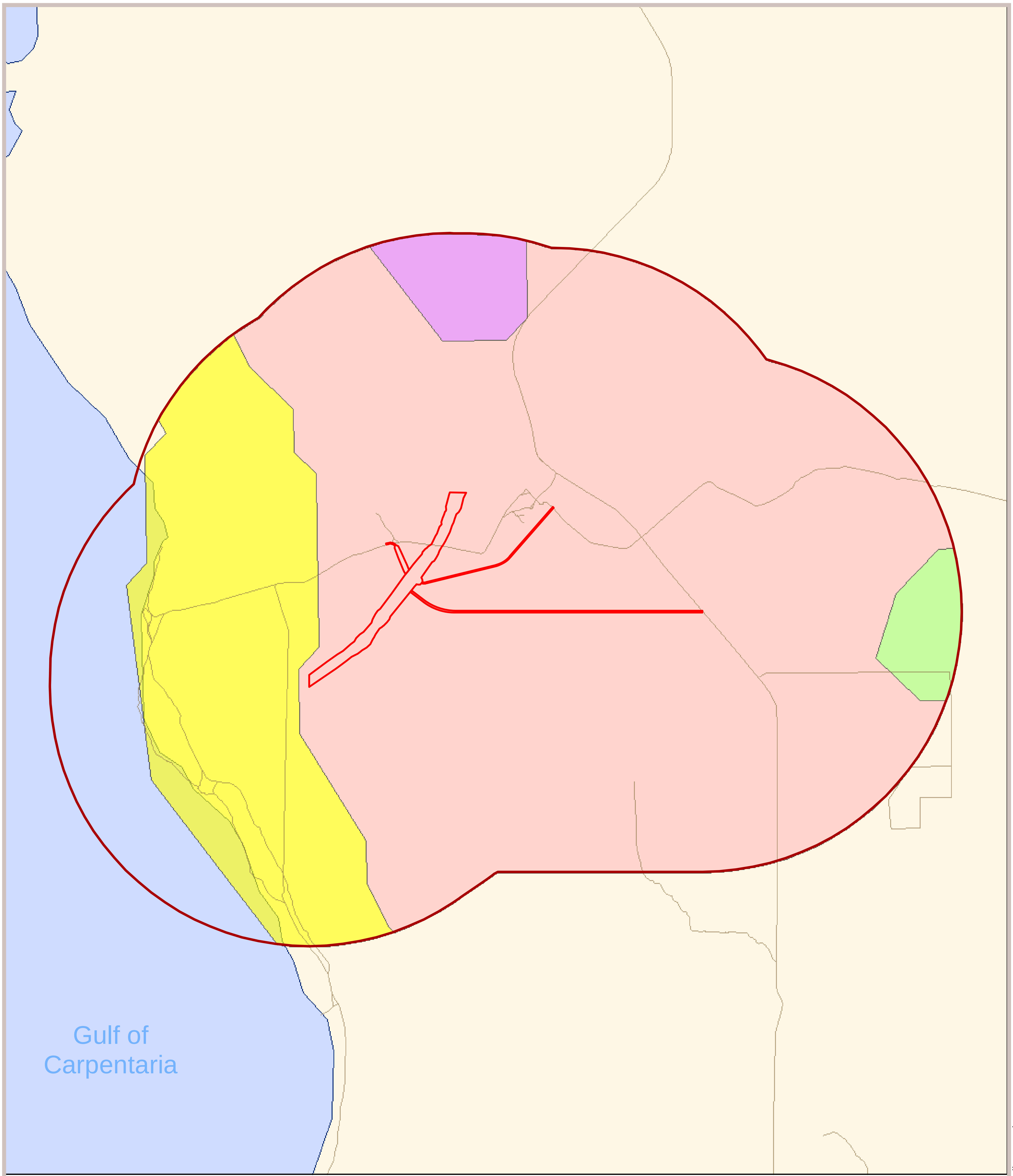
Figure 7. Fauna survey locations

I:\...\20001\Figures\RP1\20201102\Figure 7. Fauna survey locations



I:\...\20001\Figures\RP1\20200723\Figure 8. Surface geology

Figure 8. Surface geology



Legend

Disturbance Footprint

Study Area

Roads and Access Tracks

Soil Classification

AC15: Plains with some incised streams and some flat valleys and spillways subject to local flooding: chief soils are yellow earthy sands, both may contain some ironstone gravels

BA10: Dissected sandstone plateau of high, stony, often steep-sided hills; large areas of bare rock outcrop: chief soils are shallow gritty and stony sands

B34: Coastal dune systems generally consolidated but with many mobile areas; sometimes with a central core of limestone or ancient coral: chief soils are siliceous sands

MY77: Gently sloping terrain: chief soils are neutral red and acid red earths, some of which contain moderate to large amounts of ironstone gravel; some of these gravels are highly manganiferous. Small areas of soils common to unit AC15 occur also

Coordinate System: MGA Zone 53 (GDA 94)

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I:\...\20001\Figures\RP1\20200723\Figure 9. Soils mapping

Figure 9. Soils mapping

0 0.5 1 1.5 2 km

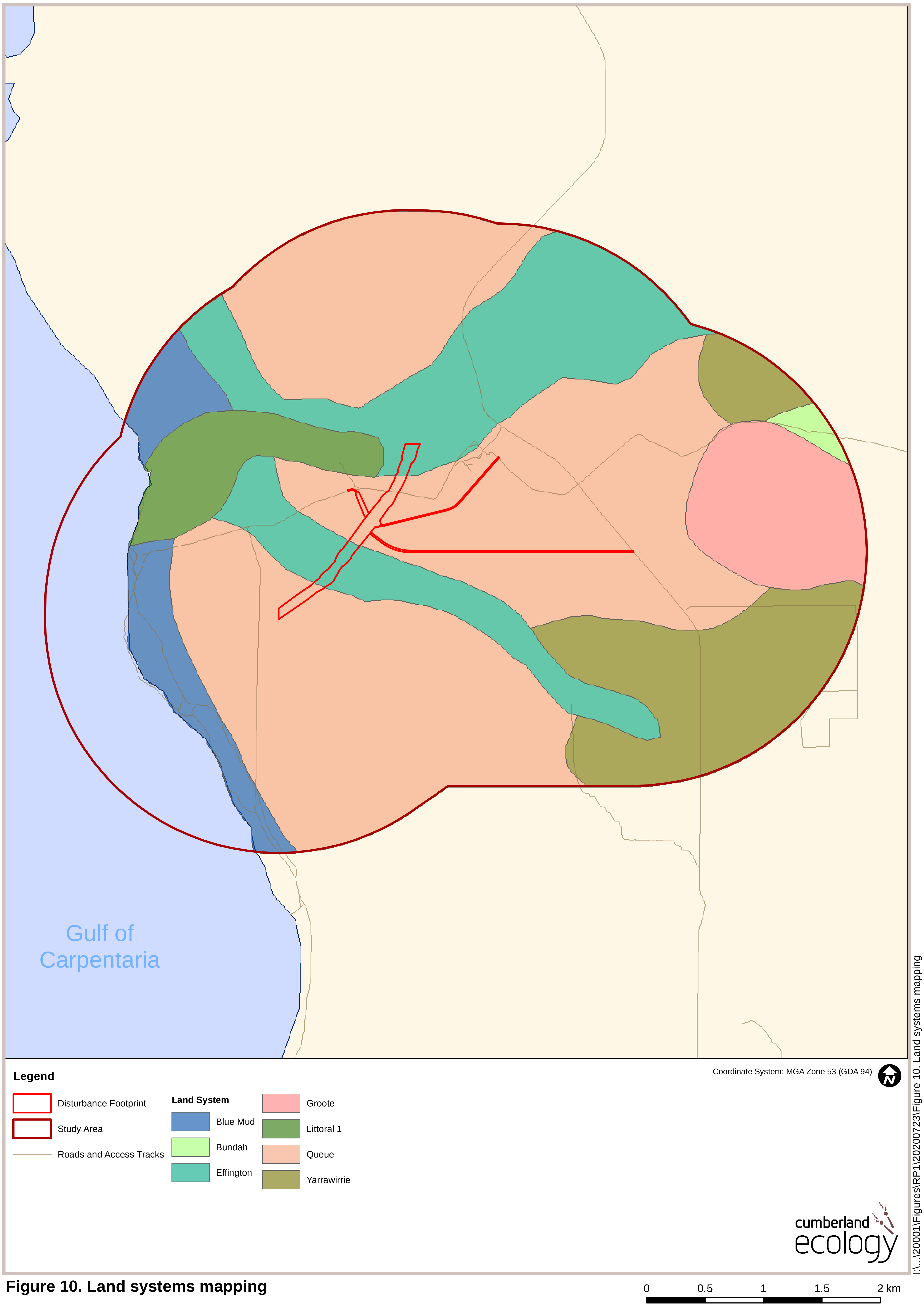


Figure 10. Land systems mapping

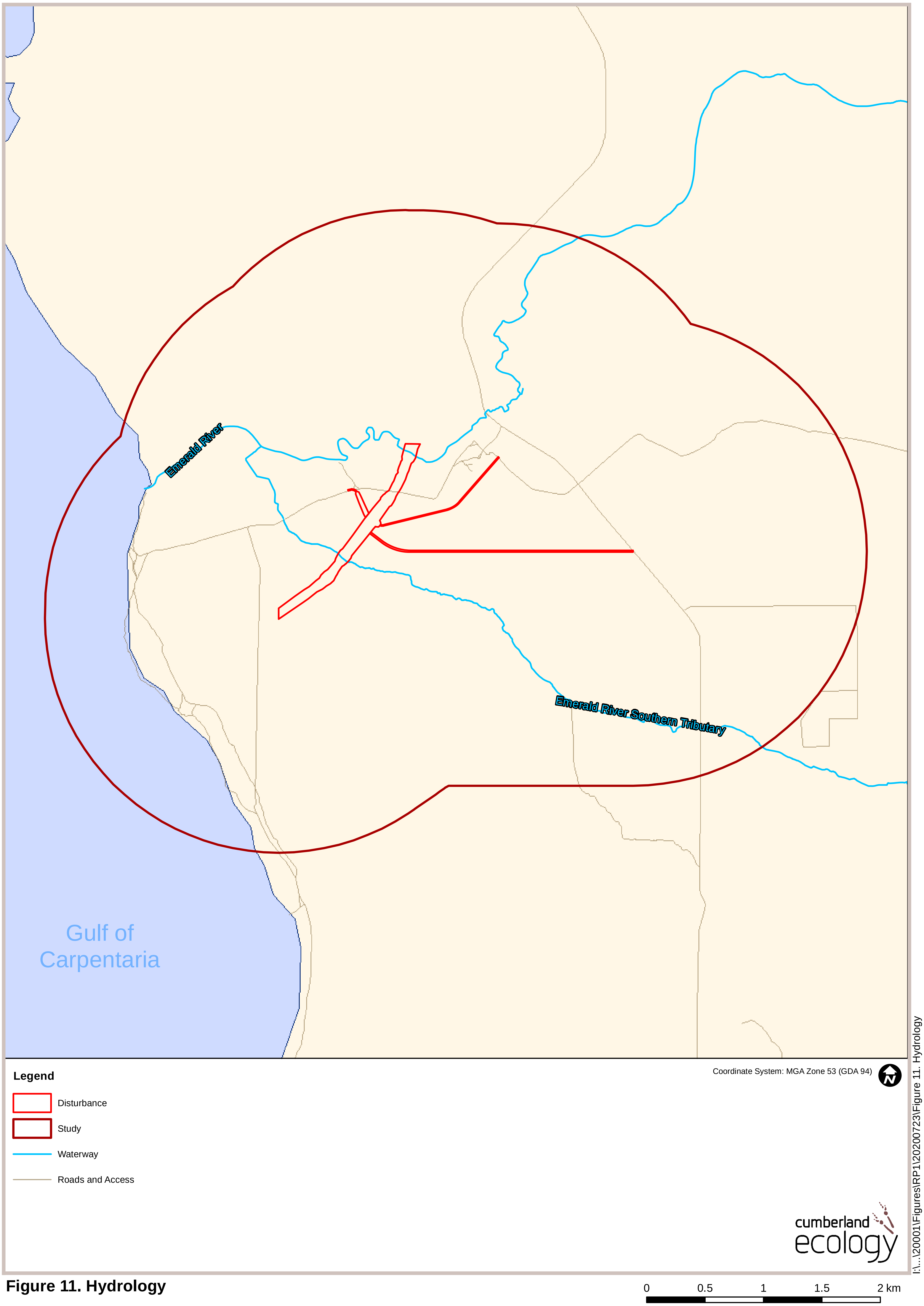
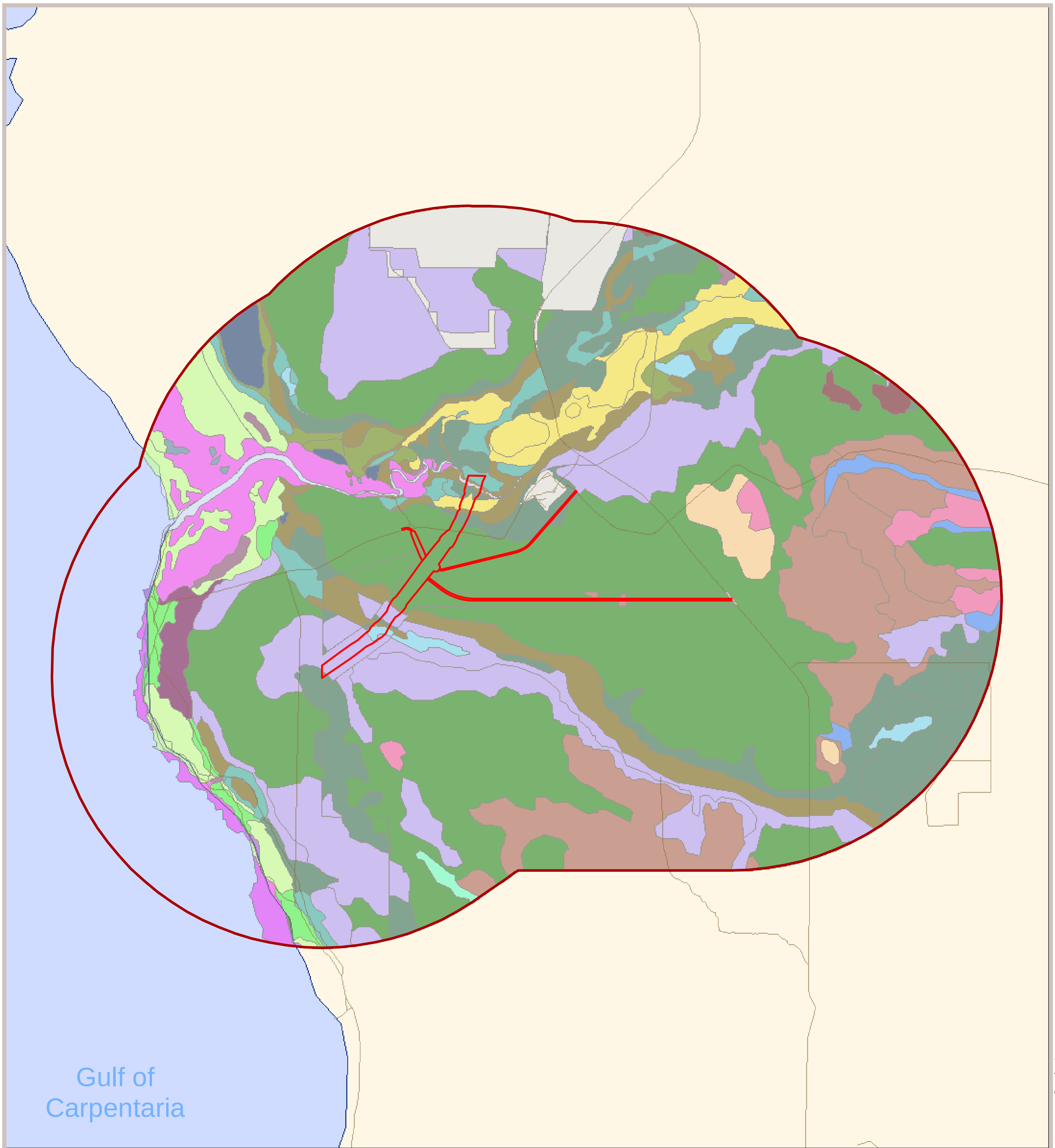


Figure 11. Hydrology



Legend

Coordinate System: MGA Zone 53 (GDA 94)

- Disturbance Footprint
- Study Area
- Roads and Access Tracks

Broad Vegetation Type

- 1: Mangrove
- 3: Dry closed forests or thickets (rainforest) on sand or sandstone
- 4: Riparian and gully closed forests with mixed canopies (rainforest and Melaleuca spp.)
- 5: Eucalypt open forests of lowlands and deeper sandy soils derived from sandstone or deeply weathered parent rocks (lateritic)
- 7: Eucalypt open forests and woodlands of sandstone uplands
- 8: Callitris open forest
- 9: Melaleuca open forests on alluvial plains and drainage systems
- 10: Melaleuca swamps
- 11: Eucalypt woodlands and open woodlands of lowlands with sandy soils
- 12: Eucalypt woodland and open woodlands on shallow soils associated with basement geologies
- 13: Eucalypt woodlands on alluvial soils
- 15: Callitris woodland and open woodland
- 16: Melaleuca woodlands on alluvial soils (wet)
- 17: Melaleuca woodlands on sandy soils (dry)
- 18: Melaleuca open woodlands on alluvial soils (wet)
- 20: Eucalypt low open woodland
- 21: Shrublands on quaternary sand
- 25: Tussock grasslands on Quaternary sand
- 26: Sedge wetlands
- 29: Saline tidal flats and shrublands
- 30: Strand complex
- 33: Cleared/disturbed/regrowth
- 34: Water/ocean
- 36: Eucalypt and/or Melaleuca open forest/vine thicket complex

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I:\...\20001\Figures\RP1\20200723\Figure 12. Broad vegetation types_Study Area

Figure 12. Broad vegetation types within the Study Area

0 0.5 1 1.5 2 km

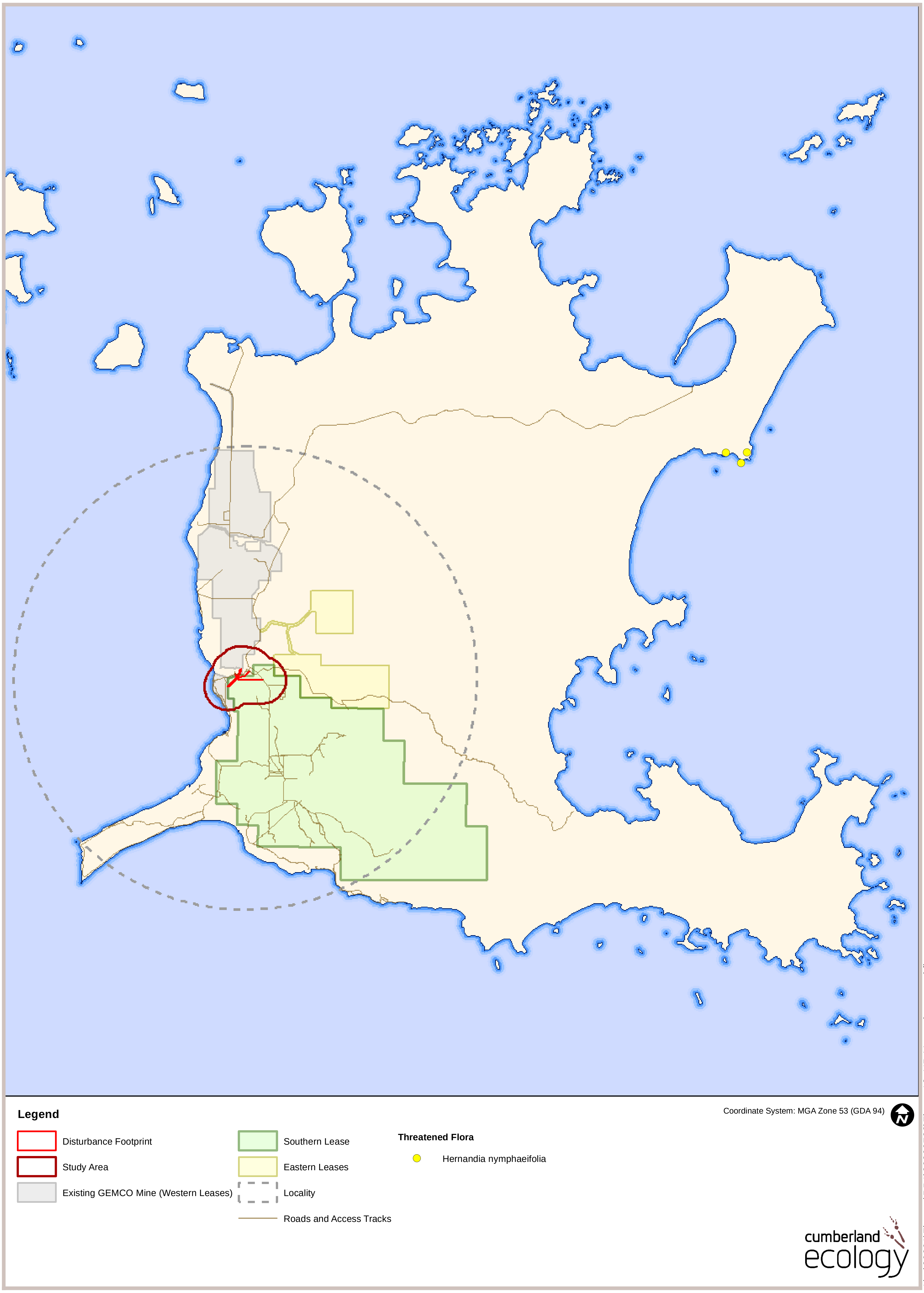


Figure 13. NR Maps Database records of threatened flora on Groote Eylandt

I:\...\20001\Figures\RP1\20200723\Figure 13. NR Maps_threatened flora

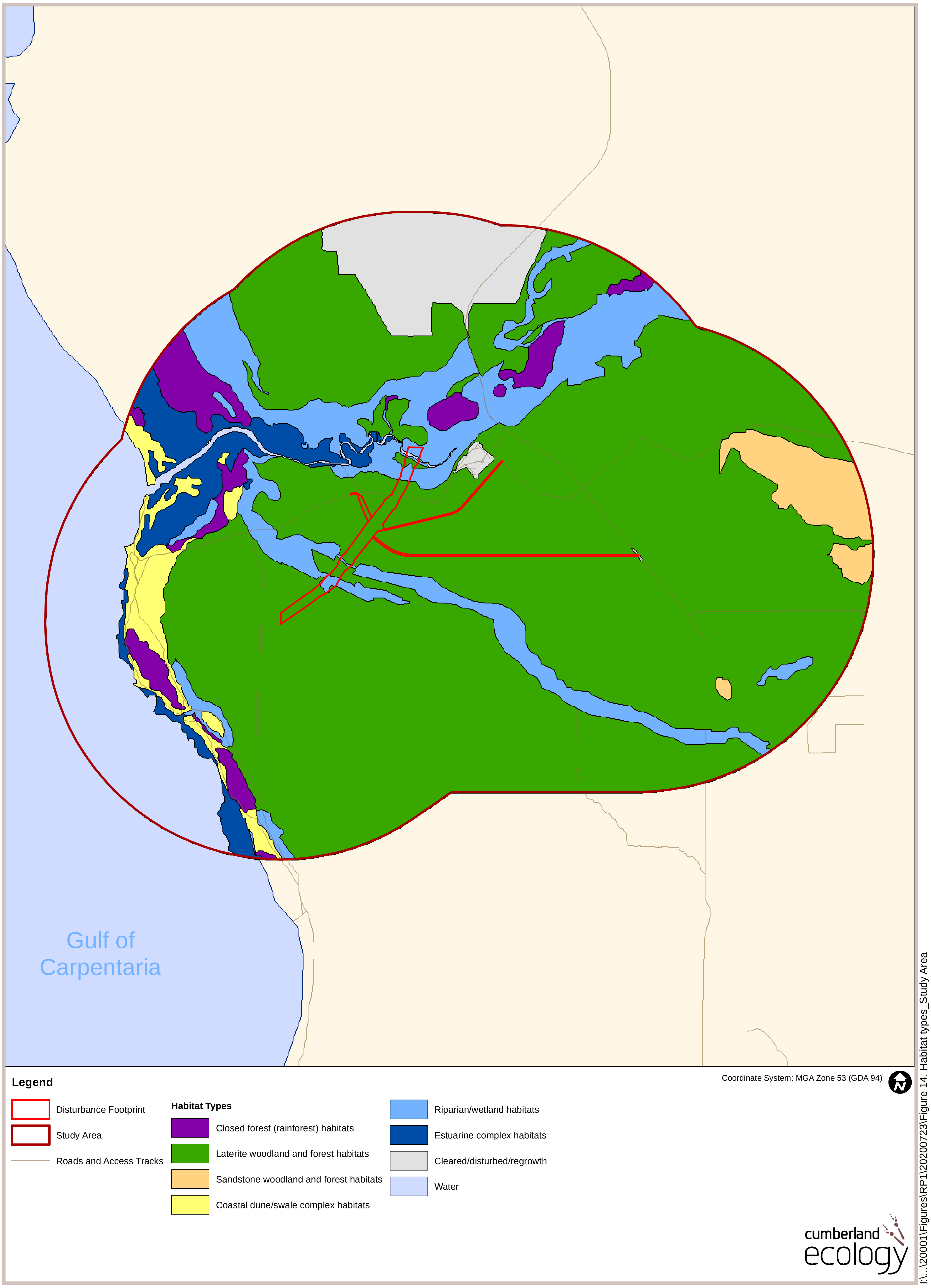


Figure 14. Habitat types within the Study Area

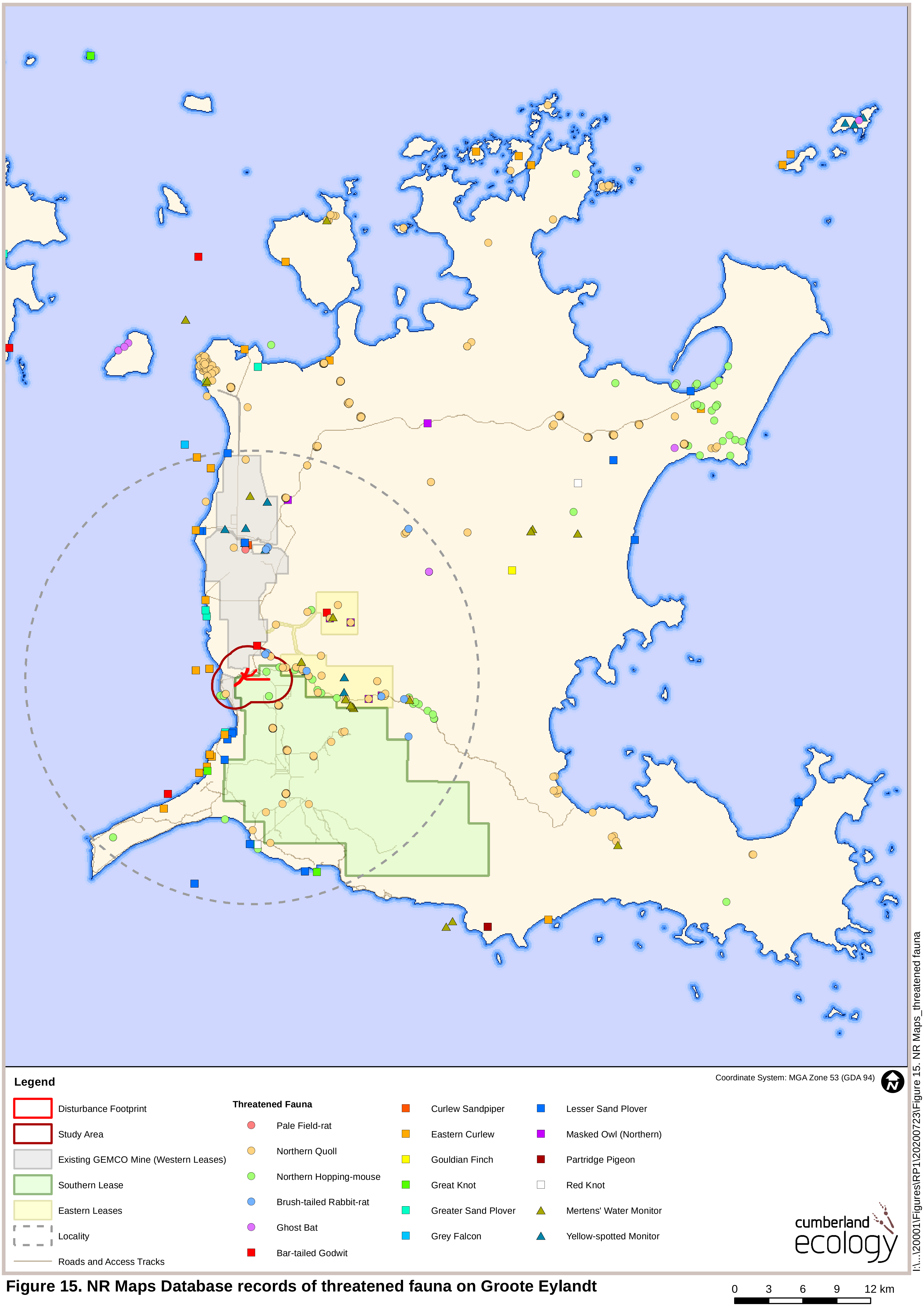


Figure 15. NR Maps Database records of threatened fauna on Groote Eylandt

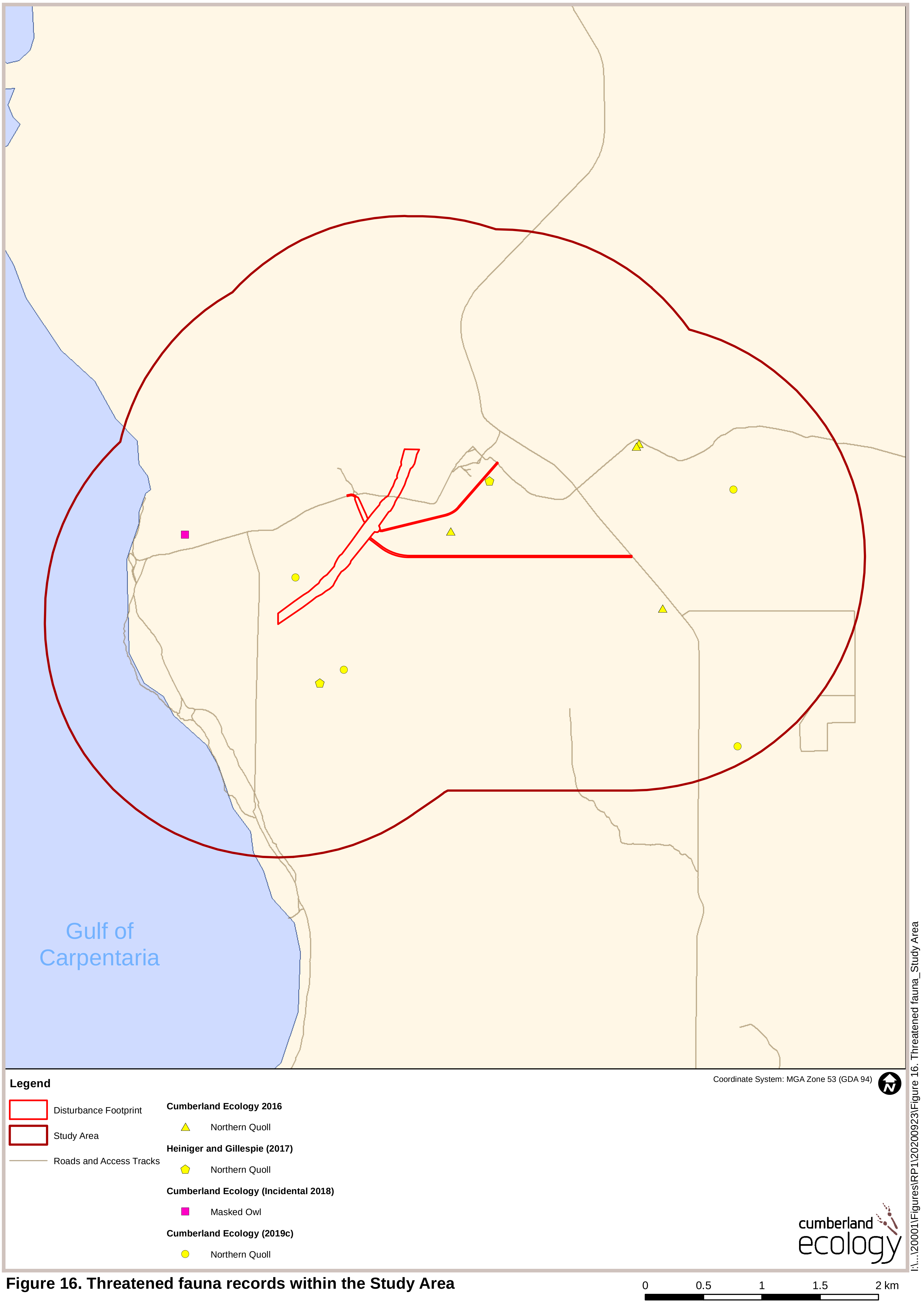


Figure 16. Threatened fauna records within the Study Area

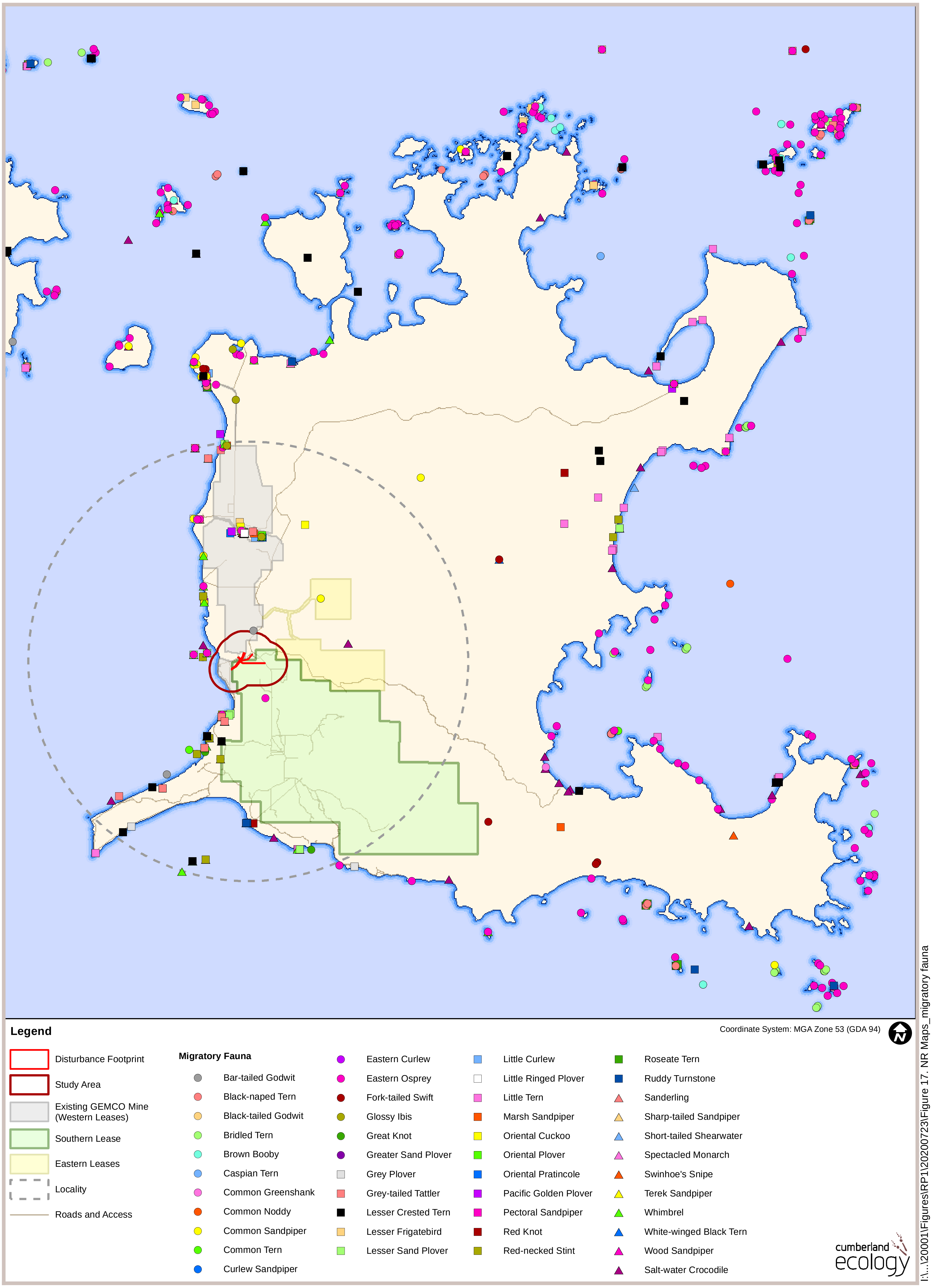
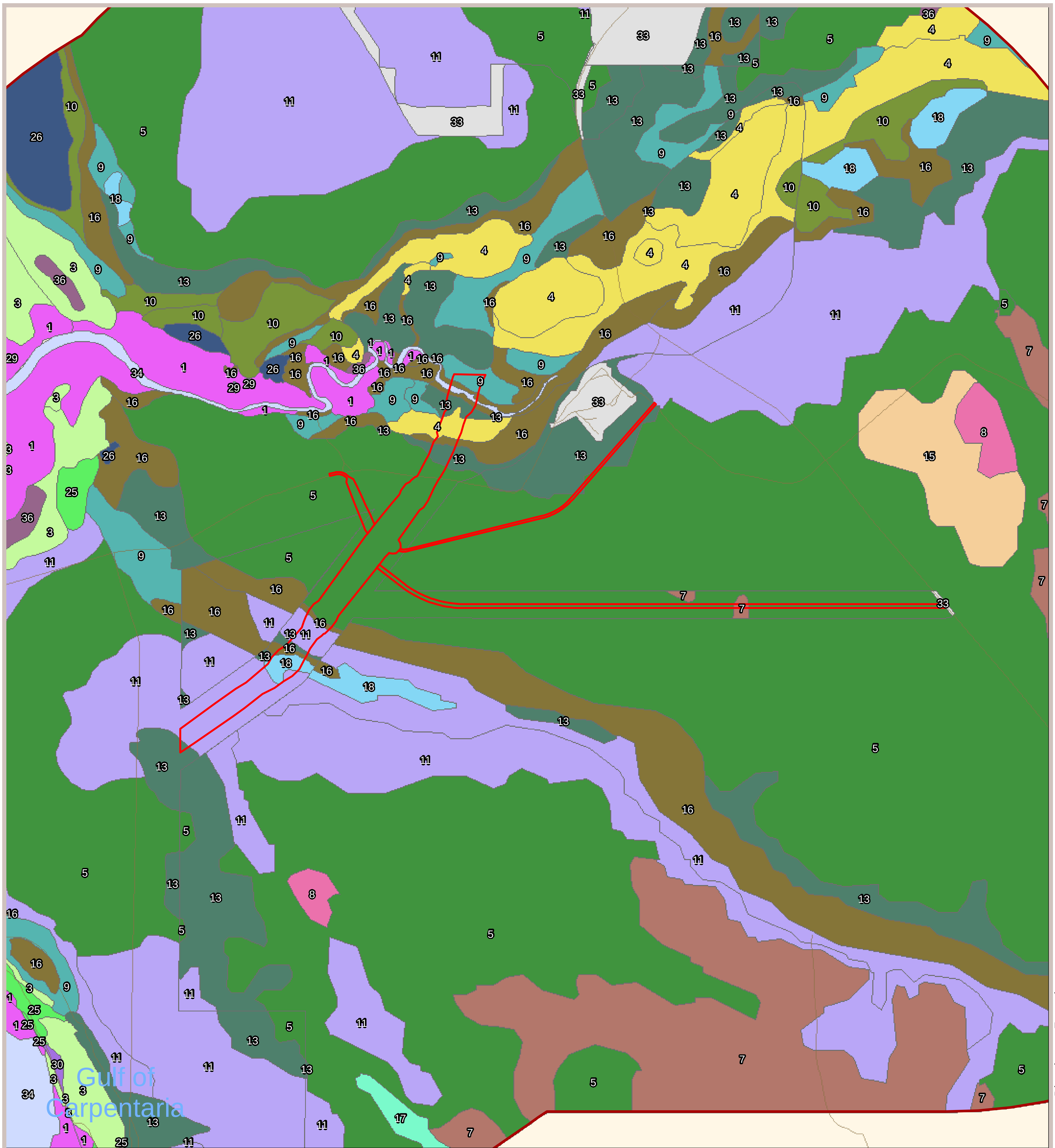


Figure 17. NR Maps Database records of migratory fauna on Groote Eylandt



Legend

Coordinate System: MGA Zone 53 (GDA 94)

- Disturbance Footprint
- Study Area
- Roads and Access Tracks

Broad Vegetation Type

- 1: Mangrove
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- 36: Eucalypt and/or Melaleuca open forest/vine thicket complex

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Figure 18. Broad vegetation types within the Disturbance Footprint

0 0.25 0.5 0.75 1 km

I:\...\20001\Figures\RP1\20200723\Figure 18. Broad vegetation types_Disturbance Footprint

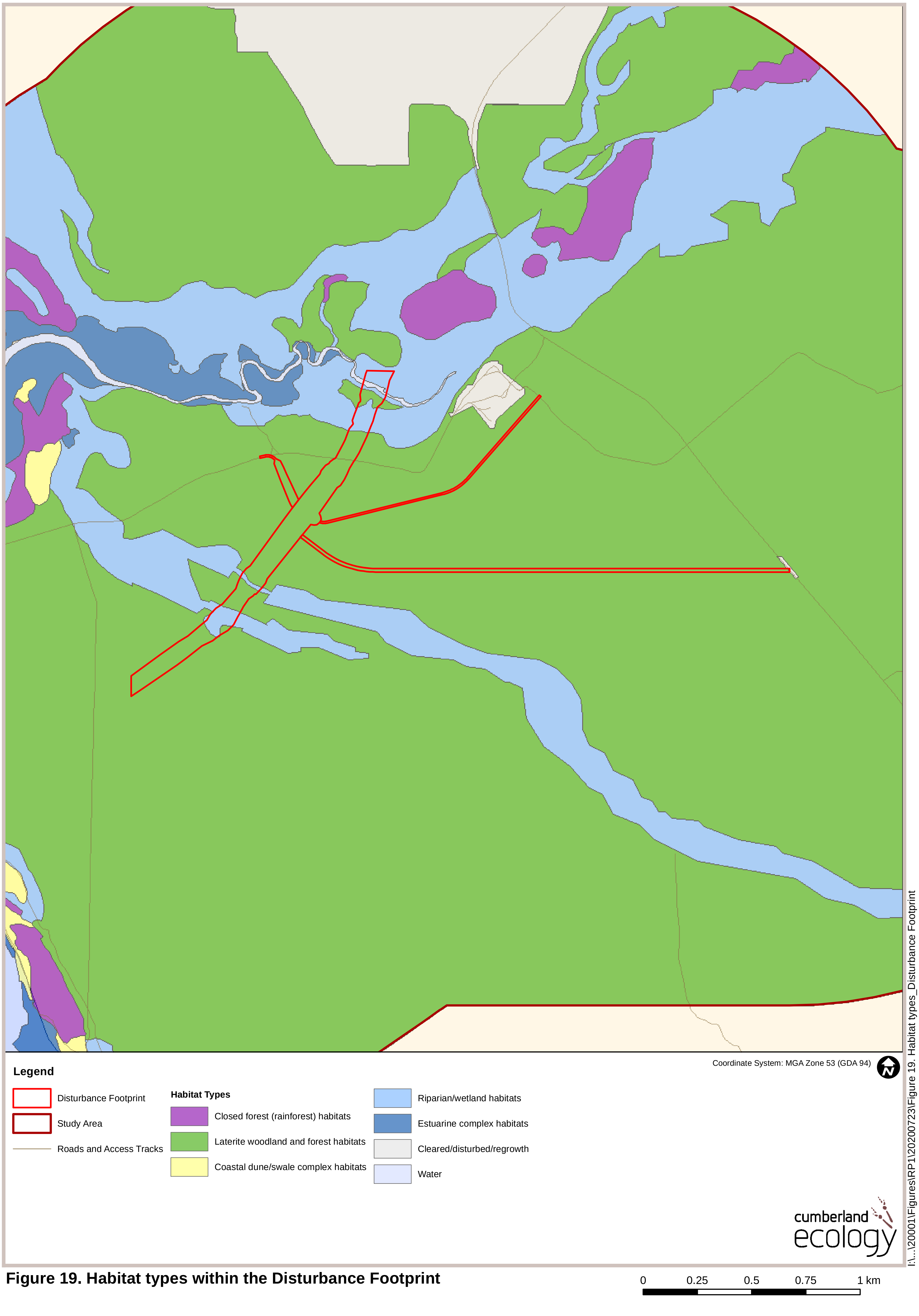

Figure 19. Habitat types within the Disturbance Footprint

E

Referral Information Requirements