3.0 Field Survey Methods

To confirm the findings from the desktop review, a field survey was conducted. The following section presents the methods used to conduct the flora and fauna surveys in January 2021.

3.1 Fauna Survey

The terrestrial fauna survey comprised a diversity of survey methods including the set-up of six quadrat sites (50 m x 50 m) with Elliot, pitfall, cage and funnel traps, motion-activated cameras with bait-stations, call playback, acoustic recording with song-meters and active searches.

The fauna survey was undertaken between 15 and 21 January 2021 led by AECOM ecologist William Riddell. The team included:

- Azrai Parish-Perandis (AECOM Environmental Consultant)
- Tiwi Rangers:
  - Colin Kerinaiua
  - Shane Austral.

3.1.1 Trapping sites

A total of six trapping sites were surveyed, comprising three sites in Gravel Pit 1, two sites in Gravel Pit 2 and one site within the Creek Road Alignment. These sites were surveyed as 50 m x 50 m quadrats according to NT *EPA Guidelines for Assessment of Impacts on Terrestrial biodiversity* (2013). Each quadrat was surveyed using a variety of trapping techniques comprising:

- 20 Elliot traps
- two cage traps
- four pitfall lines comprising one deep pitfall trap per line (28 cm diameter and 60 cm deep)
- two funnel lines comprising two funnel traps per line
- one motion-activated camera with bait station and drift fence
- three hair-tubes.

All trapping sites were surveyed for a total of three nights. The exception was Fauna Site 3 where pitfall and funnel traps were used for only two nights because of time being lost due to inclement weather.

Hair collected in hair-tubes were sent to Georgeanna Story (Scats About) for identification of species.

3.1.2 Motion-activated Camera

All six trapping quadrats had motion-activated camera traps installed for a period of approximately one month. The traps were installed during the January 2021 surveys and were collected on 18 February 2021.

Cameras were set up according to the *Camera Trapping Standard Operating Procedure for the Top End Long-term Monitoring Program* (Gillespie et al., 2017). This is the method developed and implemented by the Flora and Fauna Division of the NT Department of Environment, Parks and Water Security (DEPWS).

3.1.3 Bird surveys

The following methods were used to survey for birds, including threatened species:

20-minute bird surveys

20-minute bird surveys were undertaken at each of the six survey quadrats. Surveys were undertaken by two people with a pair of binoculars each. Surveys were conducted either in the early morning (7 – 10am) or late afternoon (4-6pm). Birds were identified by sight and calls.

Masked Owl surveys

The Masked Owl was surveyed by undertaking call-playback surveys using a Boom 3 Bluetooth Speaker. Call playback comprised playing pre-recorded calls of a mixture of Masked Owl screeches and chatter for 40 seconds to one minute and waiting for one minute before spotlighting the surrounding trees. If no owls were detected a second call was played and the area was spotlighted again immediately after the playback call.

Masked Owl call playback was undertaken over three separate nights on January 16, 17 and 20 and included:

- eight playback calls in Gravel Pit 1
- five playback calls in Gravel Pit 2
- two playback calls in each of the three road chainages.

Red Goshawk survey

Red Goshawk was surveyed by driving slowly along the length of the Paru Road project area and scanning the treetops to search for nests and individual birds. The survey was undertaken driving at approximately 20 km/hour with one person driving whilst the passenger searched for nests and birds in the tallest trees.

The Red Goshawk survey was completed over two hours on 17 January 2021.

3.2 Flora Survey

3.2.1 Vegetation Mapping

A vegetation survey was undertaken within the project area to map vegetation communities. Vegetation assessments were undertaken within 20m x 20m quadrats, between 16 and 21 January 2021 by senior botanist David van den Hoek. Vegetation structure and species composition was recorded to NVIS Level V by describing the three dominant species within the three dominant strata. Vegetation communities with similar structure and species composition were grouped to provide vegetation community descriptions, as outlined by *Northern Territory guidelines and field methodology for vegetation survey and mapping* (Brocklehurst, *et.al*., 2007). Samples of species that could not be identified in the field were collected and were identified later at the NT Herbarium.

3.2.2 Threatened Flora Surveys

The following threatened flora species were identified as potentially occurring within the project area:

- *Mitrella tiwiensis* (Vulnerable – EPBC and TPWC Act) – Monsoon forest
- *Typhonium jonesii* (Endangered – EPBC and TPWC Act) – Eucalypt open forest and woodland
- *Typhonium mirabile* (Endangered – EPBC and TPWC Act) - Eucalypt open forest and woodland
- *Garcinia warrenii* (Endangered –TPWC Act) - Watercourses
- *Cycas armstrongii* (Vulnerable – TPWC Act) - Eucalypt open forest and woodland
- *Luisia corrugata* (Vulnerable – TPWC Act) – Monsoon forest
- *Tarennoidea wallichii* (Endangered – TPWC Act) – Monsoon forest

The threatened flora survey was designed to determine the extent of occurrence of threatened flora species within the project area.

The survey was informed by vegetation mapping and focused on areas of impact within the project area, including:

- Eucalypt open forests and woodlands within:
    - Road alignments:
        - South Road Alignment

    - Creek Road Alignment
    - North Road Alignment
  - Gravel pits:
    - Gravel Pit 1 (South)
    - Gravel Pit 2 (North)
- Monsoon forests and watercourses
  - Creek Road Alignment

Areas of sensitive vegetation within Gravel Pit 1 and Gravel Pit 2, such as monsoon forests and drainage areas, were not surveyed for threatened species as these areas are unsuitable for gravel extraction. Due to the sensitivity of these vegetation communities, native vegetation buffer were applied according to *NT Land Clearing Guidelines* (DENR 2020):

- Drainage buffer– 25 m
- Medium value vegetation community – 100 m
- High value vegetation community – 250 m

Incidental surveys were undertaken in areas where likelihood of threatened species occurrence was determined as low. Targeted surveys were undertaken in areas where threatened species were determined as likely to occur and impacts from the project likely. The following surveys were undertaken:

- Targeted *Typhonium spp.* survey within:
  - Road alignments
  - Gravel Pits
- Incidental *Cycad armstrongii* survey within:
  - Road alignments
  - Gravel Pits
- Incidental surveys within Creek road alignment for the following species:
  - *Mitrella tiwiensis*
  - *Garcinia warrenii*
  - *Luisia corrugata*
  - *Tarennoidea wallichii.*

Incidental surveys were undertaken during vegetation mapping surveys and targeted threatened species surveys. Detailed methods for the *Typhonium spp.* survey are provided in the section below.

Typhonium spp. Survey

Typhonium spp. are seasonally dormant geophytic perennial forbs that emerge from underground corms following rainfall around the beginning of January. The optimal survey timing on Melville Island for *Typhonium spp.* is during the months of January and February.

Surveys were undertaken between 16 and 22 January 2021 by a survey team of seven surveyors led by experienced botanist David Liddle. The team also included:

- David van den Hoek (AECOM Senior Botanist)
- Azrai Parish-Perandis (AECOM Environmental Consultant)
- Tiwi Rangers:
  - Colin Kerinaiua

- Derek Puruntatameri
- Warren Smith
- Shane Austral.

Surveyors were trained to undertake *Typhonium spp.* surveys by:

- Observing plants of both species with varied leaf forms to familiarise surveyors with the target species.
- Using of a handheld GPS to:
  - Navigate along parallel transect survey lines
  - Collect mature *Typhonium spp.* records.

The survey was designed to target both *Typhonium jonesii* and *T. mirabile* as both species occur in similar habitat and have a similar level of detectability. Parallel transects were designed to target the survey area. The survey was conducted in two stages:

- Stage 1 - Detection survey – 15 m to 17 m wide transects, undertaken to first determine the presence or absence of the species. Previous *Typhonium spp.* surveys undertaken using a 17 m transect width in similar habitat recorded a 12% to 40% survey coverage with a 0.92 confidence interval of detecting the species (Brennan *et.al* 2015).
- Stage 2 - Abundance survey – 5 m wide transects, undertaken to determine the number of plants within a significant patch. Given that the survey was undertaken in early January when ground vegetation strata averaged around 30% cover, a 1.5 m to 2 m ground viability was determined, resulting in the effective area observed being between 60% and 80% coverage.

Stage 1 detection surveys were undertaken within the following areas:

- Road alignments:
  - South Road Alignment
  - Gravel Pit 1 Road Alignment
  - Creek Road Alignment
  - North Road Alignment
- Gravel pits:
  - Gravel Pit 1 (South)
  - Gravel Pit 2 (North).

The detection survey within the South Road Alignment and North Road Alignment included six parallel transect lines spaced 15 m either side of the proposed Paru Road realignment centreline (DIPL 2019), covering a 150 m wide survey corridor centred on the road realignment.

Within the Creek Road Alignment 15 m wide parallel transect lines were constrained to within the project area boundary, reducing the number of transect lines required for survey. A *Typhonium spp*. model was applied to the survey area and transect lines were placed within areas modelled as having a high (>0.5) or moderate (0.25 – 0.49) probability of *Typhonium spp.* occurring (DEPWS 2020). Transect lines were extended a minimum of 30 m into unmodelled area to account for the scale limitations of the model.

Detection surveys designed within gravel pits focused on areas identified as suitable for the extraction of gravel according to the following attributes:

- Slope 0 – 4%
- Supports *Eucalyptus* / *Corymbia* spp. woodland / open forest on well drained gravelly soils
- Does not impact on drainage areas or sensitive vegetation communities.

Parallel transect lines spaced 17 m apart were applied to Stage 1 detection survey areas that met gravel extraction criteria within Gravel pit 1 and Gravel pit 2 survey areas. The Typhonium model was applied as a guide to prioritise survey effort.

Results of the Stage 1 detection survey were considered against the potential project impacts to inform the application of Stage 2 abundance surveys (5 m wide transects). Total number of plants and patch size were recorded to determine the significance of the patch and potential project impacts. Records collected during the Stage 1 survey were removed from the final count to prevent recounting of Stage 2 survey records.

Parallel transect designs were produced within an ArcGIS mapping project and uploaded onto handheld GPS devices to provide a spatially rectified moving map for reference in the field. Each surveyor was equipped with a handheld GPS and data collection protocols were established to record mature individuals of each species. Leaf samples were collected for molecular analysis from plants and groups of plants that could not be confidently identified. The following information was recorded for each collected plant:

- Location
- Photo of leaf shape
- A leaf sample stored in a sealed ziplock plastic bag with silica gel.

Leaf samples were sent to a lab for molecular taxonomic identification.

Spatial records of occurrence for both *Typhonium jonesii* and *T. mirabile* detected during the survey were then added to records download from the DEPWS Vegetation Site Database (VSD) to create a record of all known records for each species. These updated records were used to calculate 2 km Area of Occupancy (AOO) grid cells using RedlistR program to minimise the number of cells generated. The number and distribution of records within each AOO cell were analysed to determine the significance of potential project impacts.

4.0 Results

4.1 Fauna Survey

Fauna Site Summary tables are presented in Appendix A and a list of all species recorded during the survey is provided in Appendix B. A description of the results for the fauna survey is presented below.

4.1.1 Amphibians

Two amphibians were recorded within the project area (Appendix B). The most common species was Ornate Burrowing Frog (*Platyplectrum ornatum*), which was recorded on 14 occasions. Northern Territory Frog (*Austrochaperina adelphe*) was recorded once at Fauna Site 5. Amphibians were trapped within pitfall traps.

4.1.2 Birds

A total of 31 bird species were recorded within the project area, including two threatened species and a potential nest of a third (Appendix B).

Red Goshawk *Erythrotriorchis radiatus*

One potential Red Goshawk nest was identified within the Gravel Pit 1 project area, approximately 80m from Paru road (-11.726740°, 130.658890°) (Plate 1 and Plate 2). The nest was high in a *Eucalyptus miniata* tree. The nest was slightly larger than a typical Red Goshawk nest and was located within the fork of two branches in suitable nesting habitat for the species (Eucalyptus tall open forest).

The survey was undertaken outside of the Red Goshawk breeding season (June to December) therefore it could not be determined with certainty whether the nest belongs to the species. Sarah Ryan at Plantation Management Partners was shown the nest and has indicated that it will be monitored during annual forestry surveys for the species.

Plate 1 Potential Red Goshawk (*Erythrotriorchis radiatus*) nest in *Eucalyptus miniata*

Plate 2 Potential Red Goshawk nest within Gravel pit 1 project area

Partridge Pigeon *Geophaps smithii*

Partridge Pigeon was recorded in five locations during the January 2021 survey. Partridge Pigeons were recorded in two locations in Gravel Pit 1, in two locations within the Creek Road Alignment and in one location at the south of Gravel Pit 2. Three sightings consisted of solitary Partridge Pigeon whilst two sightings were of a pair.

Masked Owl (Tiwi subspecies) *Tyto novaehollandiae melvillensis*

Two Masked owl were identified during nocturnal call playback surveys for the species, including one bird in Gravel Pit 1 and one in Gravel Pit 2 (Plate 3). On both occasions a single Masked Owl responded to call playback by flying towards the call, undertaking chatter and roosting close by.

Plate 3 Masked Owl (*Tyto novaehollandiae melvillensis*) observed within Gravel Pit 2 project area

4.1.3 Mammals

Seven mammal species were recorded within the project area (Appendix B). All mammals were recorded within pitfall and Elliot traps, with the exception of Northern Brown Bandicoot (*Isoodon macrourus*) and Brushtail Possum (*Trichosurus vulpecula*) that were recorded incidentally. Three threatened mammal species were trapped during the survey.

Black-footed Tree-rat *Mesembriomys gouldii*

Two Black-footed Tree-rats were recorded within the project area (Plate 4). One individual was recorded at Fauna Site 2 within the Gravel pit 1 project area and one was recorded at Fauna Site 4 within the Creek Road Alignment. Both individuals were caught in Elliot traps.

Pale Field-rat *Rattus tunneyi*

One Pale Field-rat was recorded at Fauna Site 4 within the Creek Road Alignment (Plate 5). The individual was caught in an Elliot trap.

Butler's Dunnart *Sminthopsis butleri*

Three Butler's Dunnarts were recorded within the project area (Plate 6). One individual was recorded within Gravel Pit 1 at Fauna Site 1, one was recorded within the Creek Road Alignment at Fauna Site 4 and one was recorded within Gravel Pit 2 at Fauna Site 6. All three individuals were caught in pitfall traps.

Butler's Dunnart was differentiated from the sympatric Red-cheeked Dunnart (*Sminthopsis virginiae*) by the small body and tail length, lack of a prominent dark head-stripe and lack of rufous-coloured cheeks.

Plate 4 Black-footed Tree-rat (*Mesembriomys gouldii*) captured on a motion-activated camera

Plate 5 Pale Field-rat (*Rattus tunneyi*)

Plate 6 Butler's Dunnart (*Sminthopsis butleri*) in a pitfall trap

4.1.4 Reptiles

Seven reptiles were recorded in the project area, including one threatened species (Appendix C). Reptiles were trapped within pitfall and funnel traps, with the exception of the Mertens' Water Monitor that was recorded incidentally during Typhonium surveys.

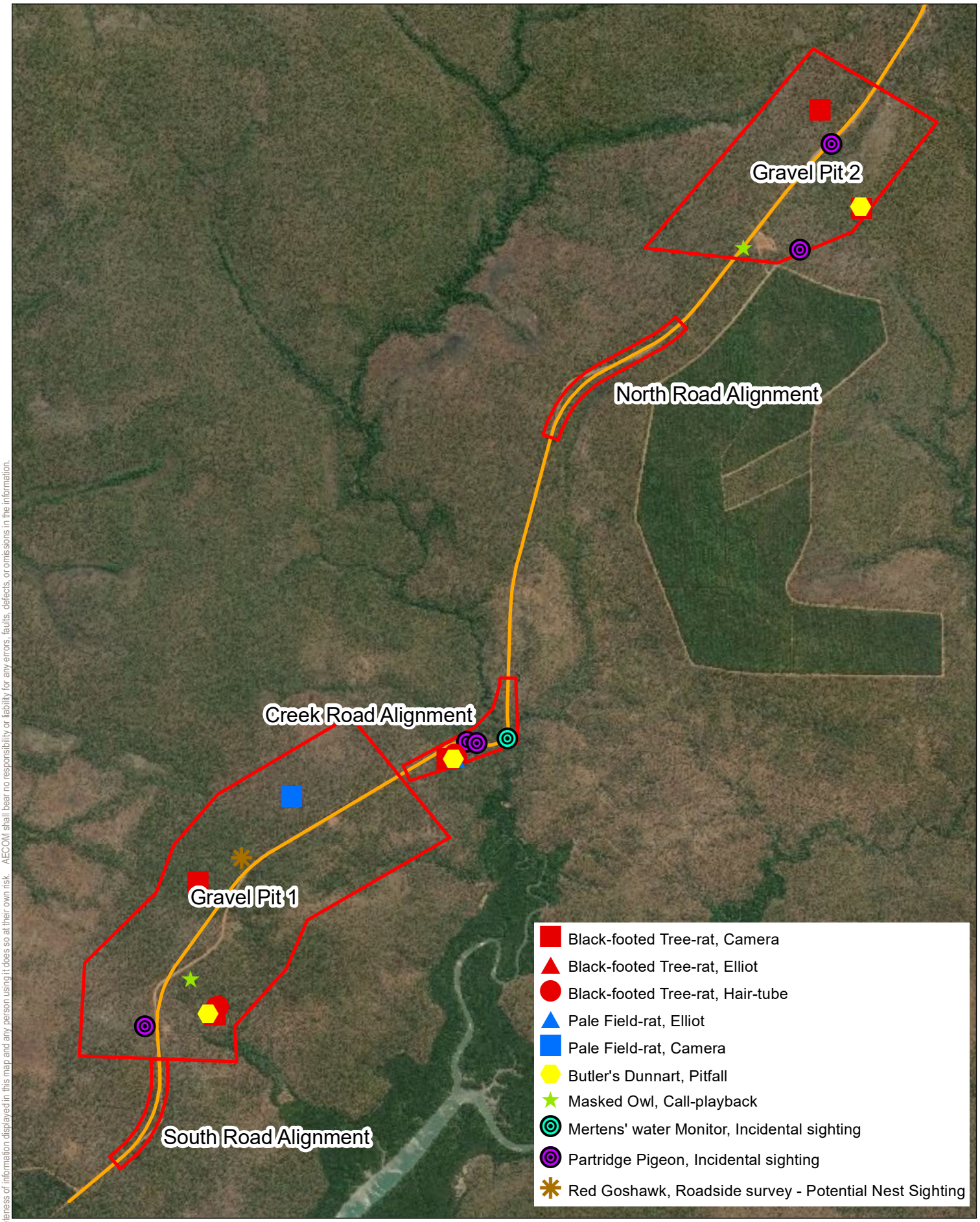
Mertens' Water Monitor *Varanus Mertensi*

One Mertens' Water Monitor was recorded incidentally close to a creek within the Creek Road Alignment.

Plate 7 ***Ctenotus hilli***

Threatened fauna species detected within the project area are displayed in Figure 6.

A summary of results from the deployment of motion-activated cameras for approximately one month is provided in Appendix D.



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Base Data: Esri, DigitalGlobe
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Paru Road Proposed Alignment
Project Area

Threatened fauna records observed within the project survey area

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	23-Feb-2021
VERSION	1

Figure 6

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4.2 Flora Survey

4.2.1 Vegetation Mapping

Ground truthing of desktop vegetation mapping resulted in nine vegetation types being identified within the project area.

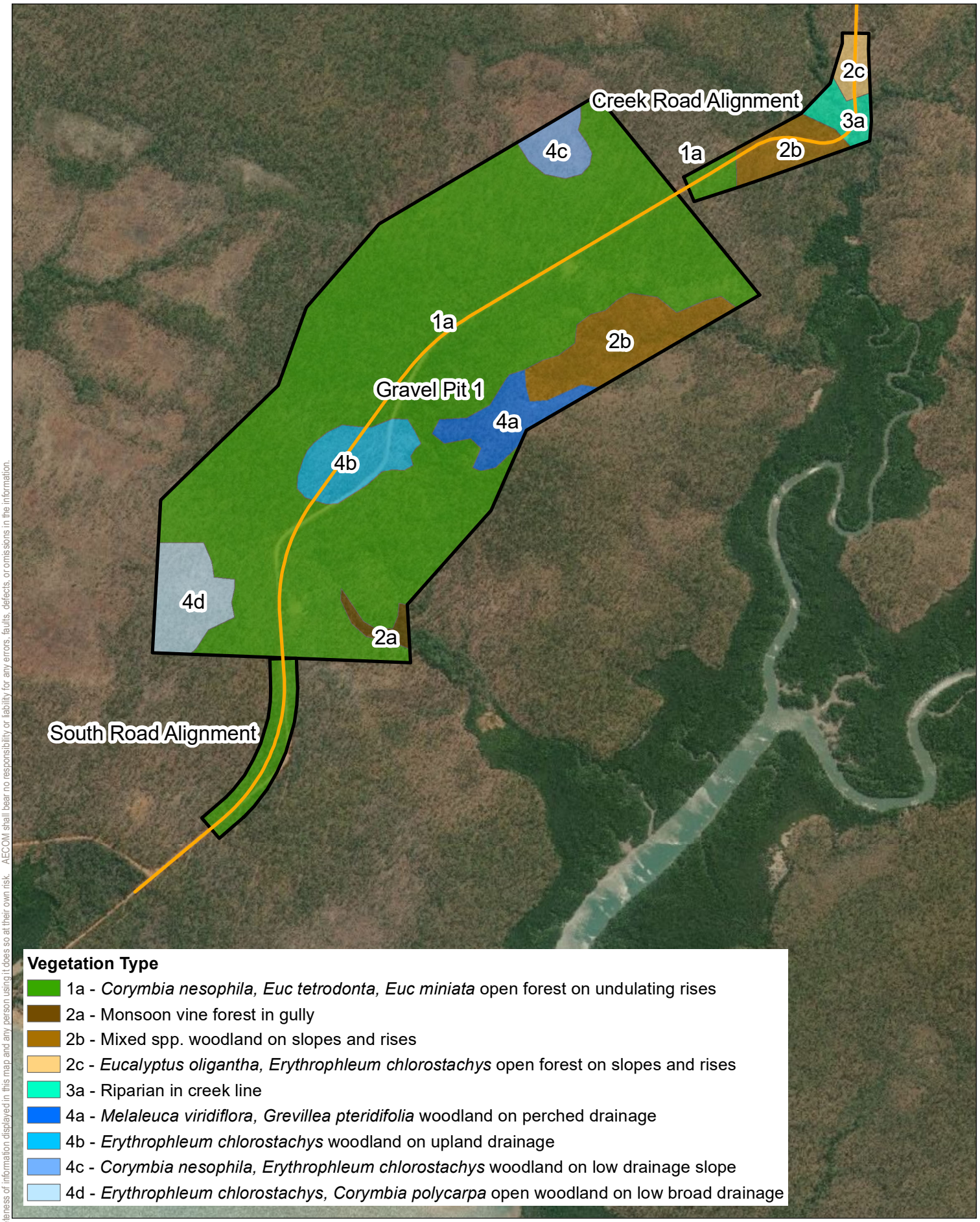
The majority of the project area (81.5%) has been mapped as 1a - *Corymbia nesophila, Eucalyptus tetrodonta, E. miniata* open forest on undulating rises. Areas of mixed forest (2b and 2c) were also recorded on slopes and rises in the southern project area, making up a total of approximately 6% of the project area. Small areas of 2a - Monsoon vine forest in gully (0.5%) and 3a – Riparian vegetation in creek line (1.1%) were recorded, with the majority of the 3a being located within the Creek Road Alignment project area. The remaining 10.6% of the project area was mapped as either upland perched drainages or broad lowland drainage slopes and flats (4a – 4d).

Vegetation community descriptions, land type, habitat descriptions and area of the project area are provided in Table 5. A map showing the location and extent of each vegetation community within the project area is shown below in Figure 7 (south) and Figure 8 (north). Vegetation community descriptions are provided in Appendix E.

Table 5 Ground-truthed vegetation communities mapped within the project area

Unit Code	Habitat description	Land Type	Vegetation Community	Area of project area
1a	*Corymbia nesophila, Eucalyptus tetrodonta, E. miniata* open forest on undulating rises	Undulating rises	*Corymbia nesophila, Eucalyptus tetrodonta, Eucalyptus miniata* mid high open forest over *Erythrophleum chlorostachys, Grevillea decurrens, Terminalia ferdinandiana* mid high open shrubland over *Sorghum plumosum, Chrysopogon latifolius, Eulalia mackinlayi* mid high tussock grassland	312.8ha (81.5%)
2a	Monsoon vine forest in gully	Gully	*Acacia auriculiformis*, *Canarium australianum*, *Terminalia microcarpa* mid high open forest over *Clerodendrum tomentosum*, *Alphitonia excelsa*, *Pandanus spiralis* mid high open shrubland over *Curcuma australasica*, *Dioscorea bulbifera*, *Ampelocissus acetosa* mid high open forbland	1.8ha (0.5%)
2b	Mixed spp. woodland on slopes and rises	Slopes and rises	*Erythrophleum chlorostachys*, *Corymbia bella*, *Acacia auriculiformis* mid high woodland over *Terminalia ferdinandiana*, *Petalostigma pubescens*, *Lophostemon lactifluus* mid high open shrubland over *Mnesithea rottboellioides*, *Alloteropsis semialata*, *Chrysopogon latifolius* mid high tussock grassland	20.3ha (5.3%)
2c	*Eucalyptus oligantha, Erythrophleum chlorostachys* open forest on slopes and rises	Slopes and rises	*Eucalyptus oligantha*, *Erythrophleum chlorostachys*, mid high open forest over *Planchonia careya*, *Acacia lamprocarpa*, *Terminalia ferdinandiana*, mid high open shrubland over *Chrysopogon latifolius*, *Mnesithea rottboellioides*,	2.8ha (0.7%)

Unit Code	Habitat description	Land Type	Vegetation Community	Area of project area
			Ampelocissus acetosa mid high tussock grassland	
3a	Riparian in creek line	Creek line	*Melaleuca leucadendra*, *Acacia auriculiformis*, *Lophostemon lactifluus* mid high open forest over *Pandanus spiralis*, *Litsea glutinosa*, *Livistona humilis* mid high open shrubland over *Mnesithea rottboellioides*, *Chrysopogon latifolius*, *Ampelocissus acetosa* mid high tussock grassland	4.3ha (1.1%)
4a	*Melaleuca viridiflora, Grevillea pteridifolia* woodland on perched drainage	Perched drainage	*Melaleuca viridiflora*, *Grevillea pteridifolia*, ± *Eucalyptus tetrodonta* mid high open woodland ± isolated trees over *Petalostigma pubescens*, *Melaleuca viridiflora*, *Verticordia cunninghamii* mid high shrubland over *Eriachne avenacea*, *Schoenus sparteus*, *Sorghum plumosum* mid high open tussock grassland	16.7ha (4.4%)
4b	*Erythrophleum chlorostachys* woodland on upland drainage	Upland drainage	*Erythrophleum chlorostachys* mid high woodland over *Terminalia ferdinandiana*, *Melaleuca viridiflora*, *Corymbia foelscheana* mid high shrubland over *Mnesithea rottboellioides*, *Planchonia careya* mid high tussock grassland	9.5ha (2.5%)
4c	*Corymbia nesophila, Erythrophleum chlorostachys* woodland on low drainage slope	Low drainage slope	*Corymbia nesophila*, *Erythrophleum chlorostachys* mid high woodland over *Erythrophleum chlorostachys*, *Pandanus spiralis*, *Melaleuca viridiflora* mid high open shrubland over *Sorghum plumosum*, *Planchonia careya*, *Melaleuca viridiflora* mid high tussock grassland	4.5ha (1.2%)
4d	*Erythrophleum chlorostachys, Corymbia polycarpa* open woodland on low broad drainage	Low broad drainage	*Erythrophleum chlorostachys*, *Corymbia polycarpa*, *Acacia auriculiformis* mid high open woodland over *Melaleuca viridiflora*, *Grevillea pteridifolia*, *Petalostigma pubescens* mid high shrubland over *Sorghum plumosum*, *Thaumastochloa major*, *Spermacoce stenophylla*	9.7ha (2.5%)



Vegetation Type

- 1a - *Corymbia nesophila, Euc tetrodonta, Euc miniata* open forest on undulating rises
- 2a - Monsoon vine forest in gully
- 2b - Mixed spp. woodland on slopes and rises
- 2c - *Eucalyptus oligantha, Erythrophleum chlorostachys* open forest on slopes and rises
- 3a - Riparian in creek line
- 4a - *Melaleuca viridiflora, Grevillea pteridifolia* woodland on perched drainage
- 4b - *Erythrophleum chlorostachys* woodland on upland drainage
- 4c - *Corymbia nesophila, Erythrophleum chlorostachys* woodland on low drainage slope
- 4d - *Erythrophleum chlorostachys, Corymbia polycarpa* open woodland on low broad drainage

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0 0.125 0.25 0.5 0.75 1
Kilometres

Data sources:
Base Data: Esri, DigitalGlobe
Field data: AECOM Australia

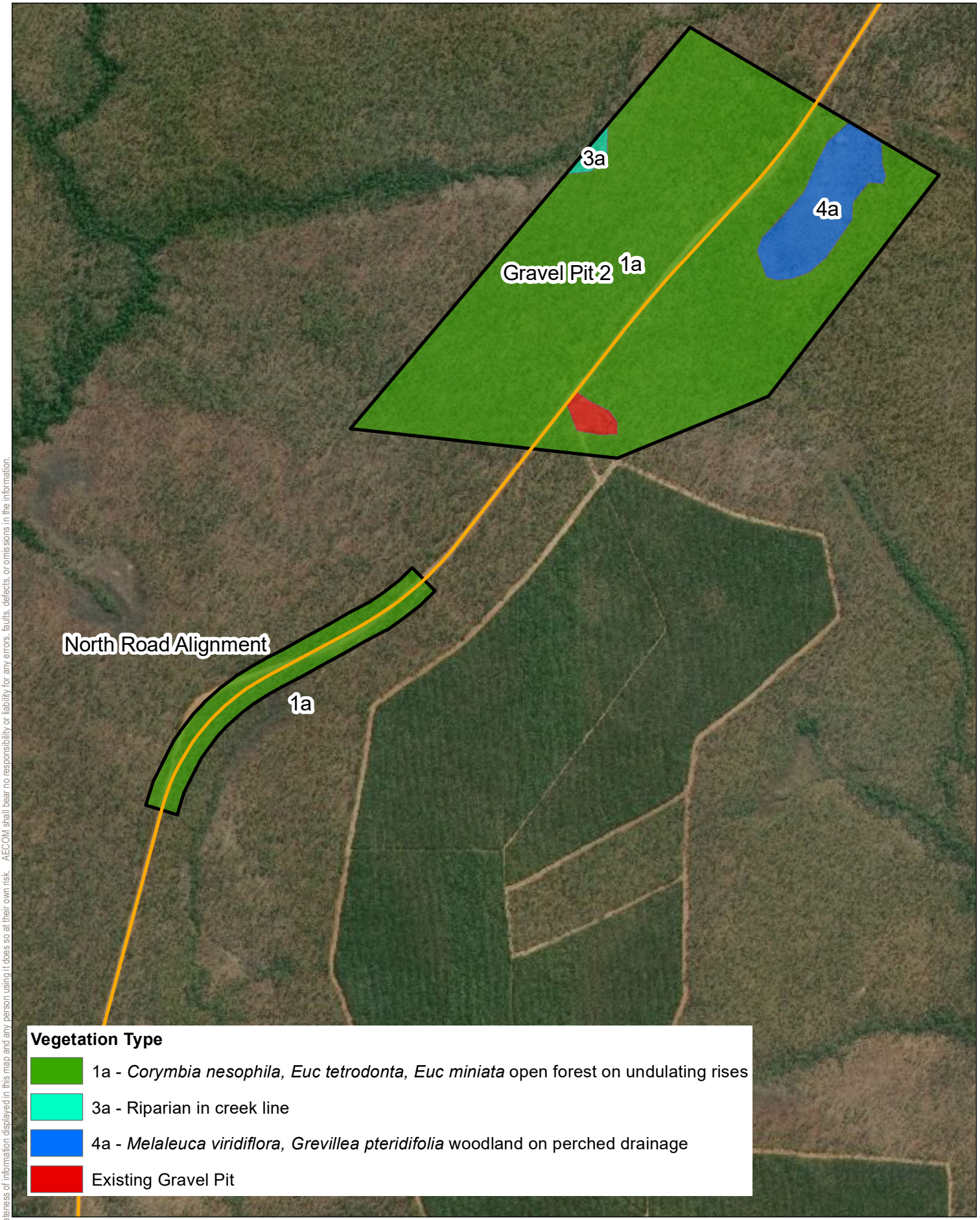
Paru Road Proposed Alignment
Project Area

Ground-truthed vegetation map of the southern project area

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	23-Feb-2021
VERSION	1

Figure 7

A4 size



Vegetation Type

- 1a - *Corymbia nesophila, Euc tetrodonta, Euc miniata* open forest on undulating rises
- 3a - Riparian in creek line
- 4a - *Melaleuca viridiflora, Grevillea pteridifolia* woodland on perched drainage
- Existing Gravel Pit

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Paru Road Proposed Alignment
Project Area

Ground-truthed vegetation map of the northern project area

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	23-Feb-2021
VERSION	1

Figure 8

A4 size

4.2.2 Threatened Flora Survey

The following threatened flora species were not recorded during incidental surveys:

- *Mitrella tiwiensis*
- *Garcinia warrenii*
- *Luisia corrugata*
- *Tarennoidea wallichii*
- *Cycad armstrongii.*

Several Cycads were observed during the survey, but most were determined to be *Cycas maconochiei* and not the vulnerable *Cycas armstrongii*.

A total of 198 *Typhonium jonesii* (Plate 8) and 564 *T. mirabile* (Plate 9) were recorded within the project area during threatened flora surveys. Table 6 shows the total number of *Typhonium spp*. recorded within the project area.

Table 6 *Typhonium jonesii* and *T. mirabile* recorded within each project survey area

Typhonium sp.	Project survey area	Survey records	Desktop records	Total
Typhonium jonesii	South Road Alignment	44	13	57 (24%)
	Creek Road Alignment	13	2	15 (6%)
	North Road Alignment	0	0	0 (0%)
	Gravel Pit 1 (South)	122	21	143 (60%)
	Gravel Pit 2 (North)	19	6	25 (10%)
	Total	**198 (83%)**	**42 (18%)**	**240**
Typhonium mirabile	South Road Alignment	0	0	0 (0%)
	Creek Road Alignment	170	1	171 (30%)
	North Road Alignment	0	0	0 (0%)
	Gravel Pit 1 (South)	394	0	394 (70%)
	Gravel Pit 2 (North)	0	0	0
	Total	**564 (99.8%)**	**1 (0.2%)**	**565**

Survey results have significantly added to the number of *Typhonium spp*. records. Table 7 shows the number of records from the survey compared to desktop records.

Table 7 Total number of *Typhonium jonesii* and *Typhonium mirabile* known occurrences

Typhonium sp.	Survey records	Desktop records	Total
Typhonium jonesii	198 (30%)	463 (70%)	661
Typhonium mirabile	564 (82%)	124 (18%)	688

A map showing the Stage 1 and Stage 2 survey tracks, the distribution of all currently known records and the AOO cell locations is provided in Figure 9 for *Typhonium jonesii* and in Figure 10 for *T. mirabile*.

A high-density patch containing 304 *Typhonium mirabile* was recorded within Gravel Pit 1 following Stage 2 abundance surveys (5 m transects). The patch was found to have 124 plants during the Stage 1 detection survey (15 m transects) and subsequent Stage 2 surveys increased detection by 60%. The patch size is 2.37 ha, representing a density of 1 plant per 78 m². This high-density patch contains approximately half of known *Typhonium mirabile* and is considered to be a conservation significant sub-population of the species (refer Figure 11).

A total of 83 Typhonium records were also recorded as *Typhonium sp.* unknown (Plate 10), 80 of which were in Gravel Pit 1 survey area and 3 records within the Creek Road Alignment survey area.

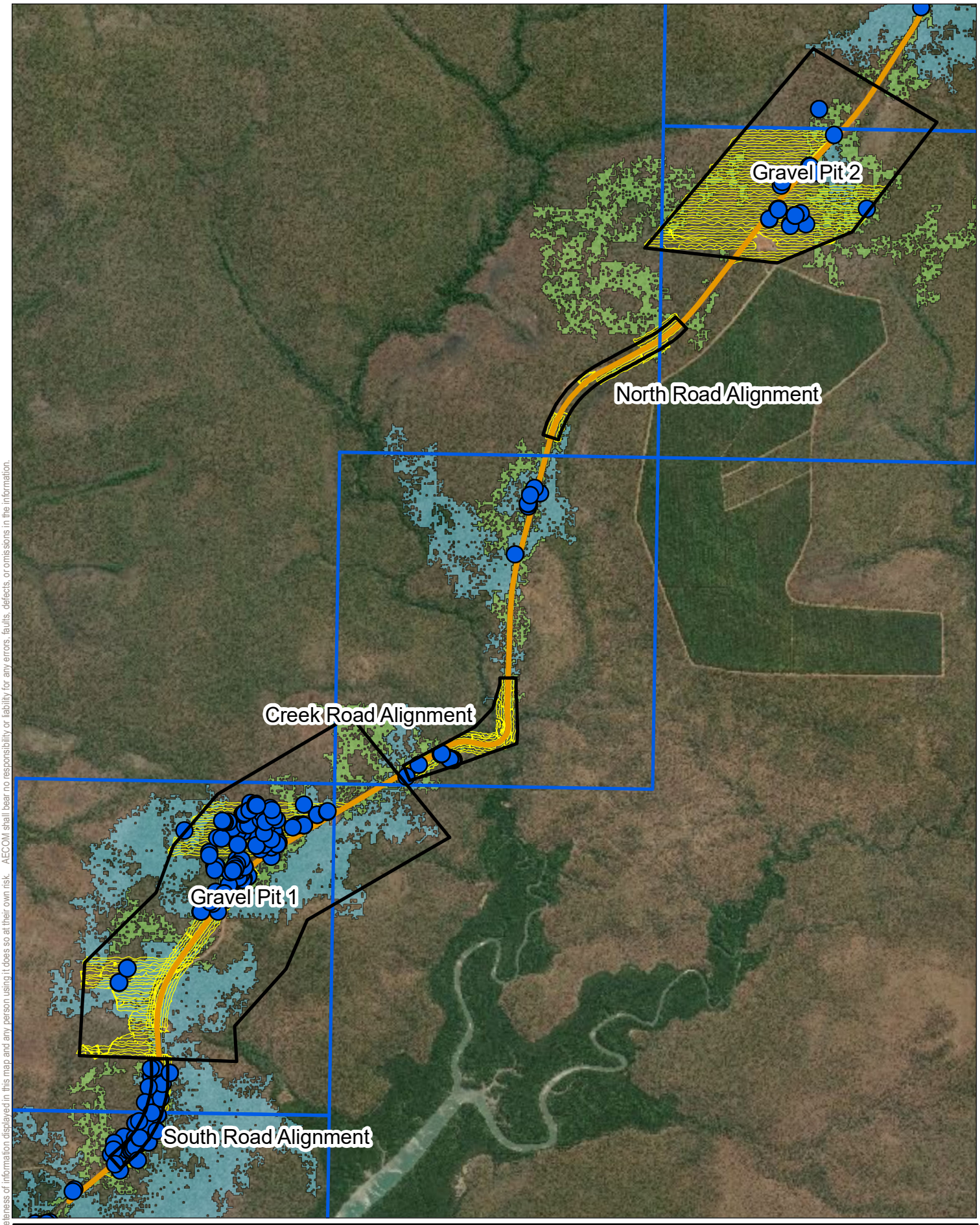
A total of 16 leaf samples were collected for molecular identification. Of these, six samples have been sent to the lab including five *Typhonium mirabile* (three from Gravel Pit 1 and two from the Creek Road Alignment) and one *Typhonium sp.* unknown collected from Gravel Pit 1..

Lab results have confirmed the field identification of collected *Typhonium mirabile* and determined *Typhonium sp.* unknown to be Typhonium mirabile. Further analysis of field data, including photos of leaf morphology has provided evidence to support determining all *Typhonium sp.* unknown to be *Typhonium mirabile*. All records have been changed to reflect this update.

Plate 8 *Typhonium jonesii* in flower

Plate 9 ***Typhonium mirabile***

Plate 10 ***Typhonium sp.*** **unknown (determined through DNA lab analysis to be** ***Typhonium mirabile*****)**



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- *Typhonium jonesii* records
- Stage 1 survey tracks
- Paru Road Proposed Alignment
- *Typhonium jonesii* AOO grid
- Moderate likelihood *Typhonium spp.* habitat
- High likelihood *Typhonium spp.* habitat
- Project Area

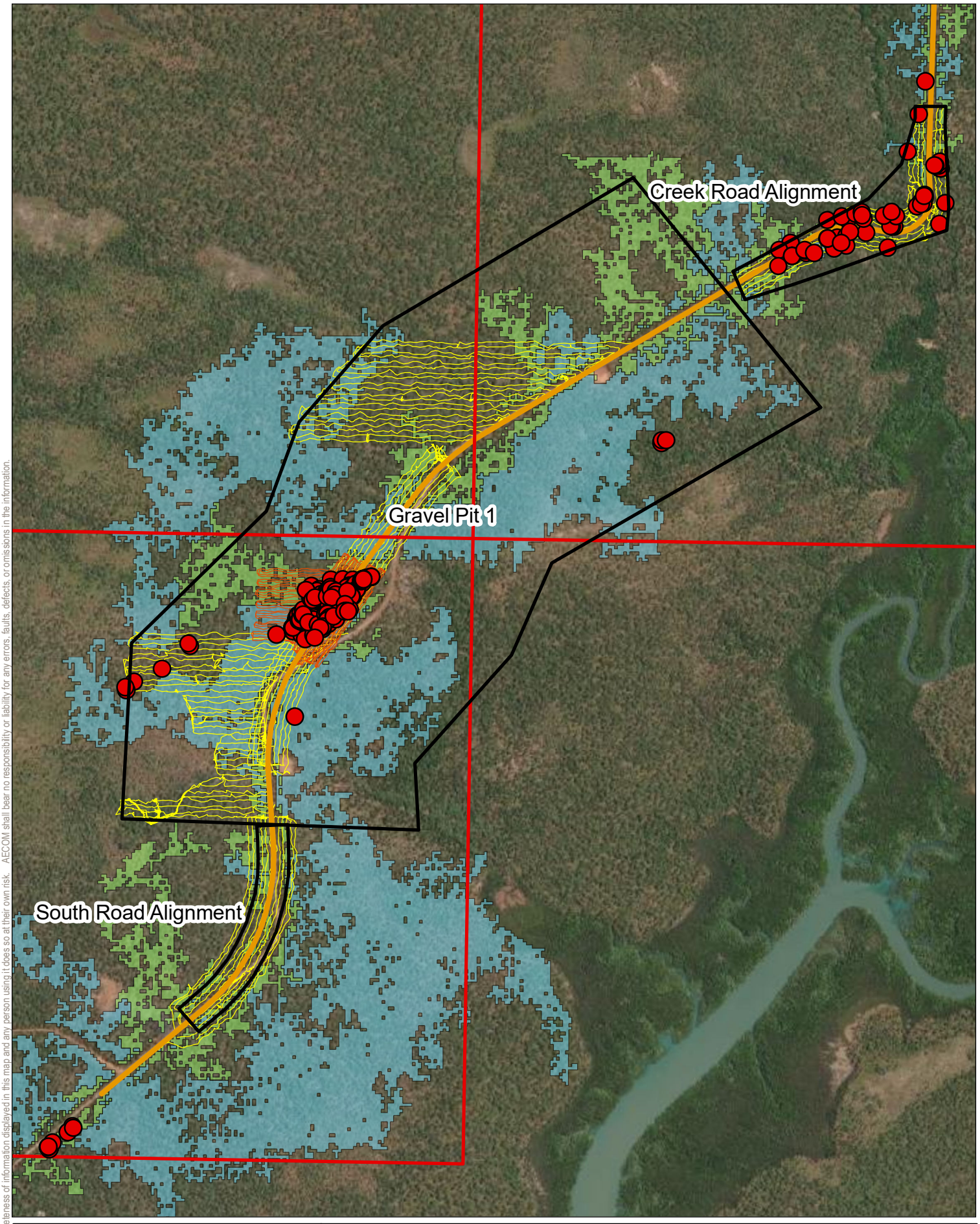
Typhonium jonesii survey results

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	23-Feb-2021
VERSION	1

Figure 9

A4 size

Filename: P:\606x\60626775\900_CAD_GIS\920_GIS\02_MXDs\Final Report Maps Jan 2021\Figure 9 Typhonium jonesii survey results.mxd



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- *Typhonium mirabile* records
- Stage 1 survey tracks
- Stage 2 survey tracks
- *Typhonium mirabile* AOO grid
- Paru Road Proposed Alignment
- Moderate likelihood *Typhonium spp.* habitat
- High likelihood *Typhonium spp.* habitat
- Project Area

Typhonium mirabile survey results

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	15-Apr-2021
VERSION	1

Figure 10

Filename: P:\606x\60626775\900_CAD_GIS\920_GIS\02_MXDs\Final Report Maps Jan 2021\Figure 10 Typhonium mirabile survey results .mxd

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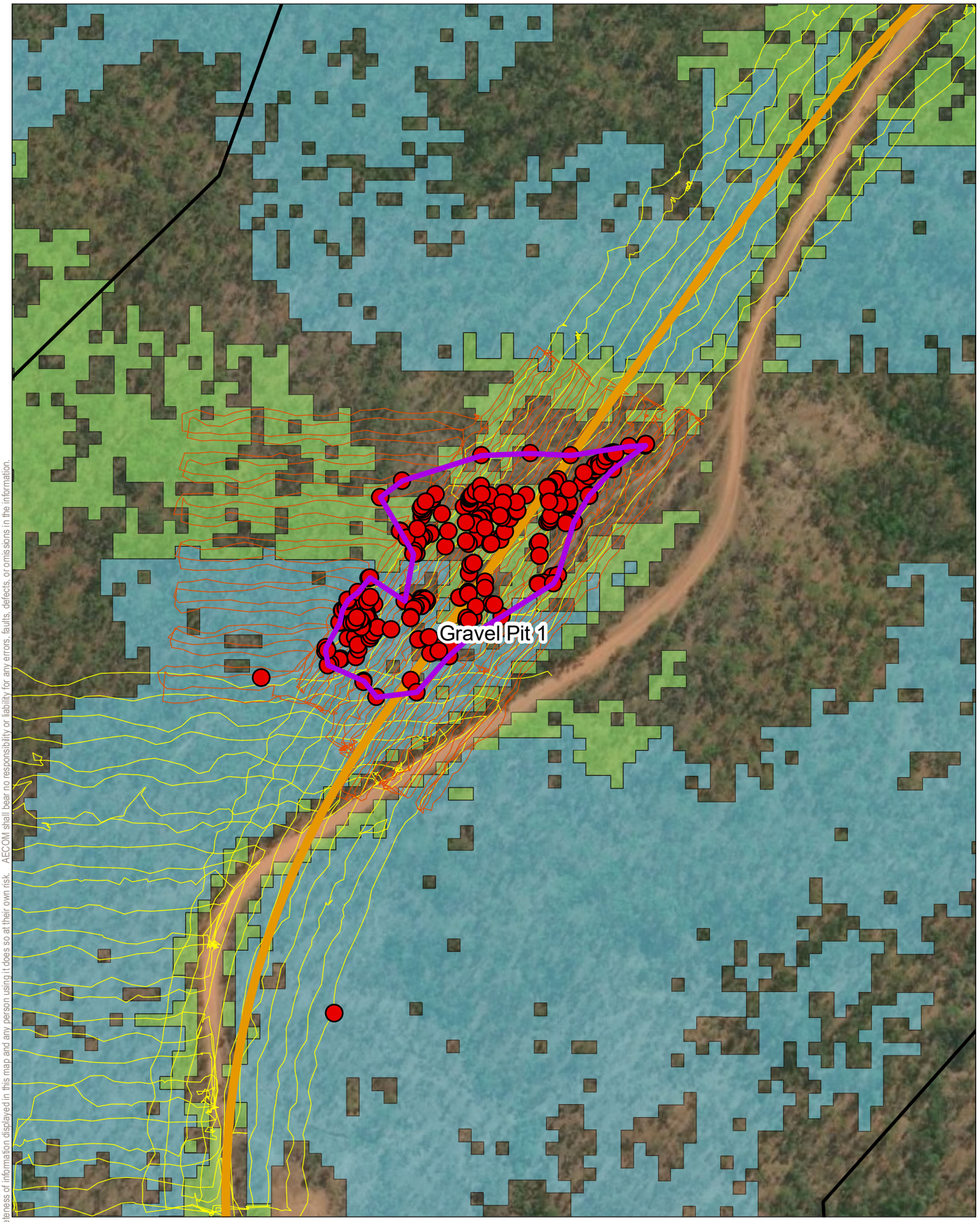

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- *Typhonium mirabile* records
- Stage 1 survey tracks
- Stage 2 survey tracks
- Paru Road Proposed Alignment
- High-density *Typhonium mirabile* patch
- Moderate likelihood *Typhonium spp.* habitat
- High likelihood *Typhonium spp.* habitat
- Project Area

Location of the high-density *Typhonium mirabile* patch

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	23-Feb-2021
VERSION	1

Figure 11

A4 size

Filename: P:\606x\60626775\900_CAD_GIS\920_GIS\02_MXDs\Final Report Maps Jan 2021\Figure 11 High-density Typhonium mirabile patch.mxd

5.0 Proposed Project design

5.1 Area of Impact

Within the two gravel pit project areas, the following five areas suitable for gravel extraction have been identified:

- Gravel Pit 1 area:
  - GP1-1 (6.6 ha)
  - GP1-2 (9.9 ha)
  - GP1-3 (6.5 ha)
- Gravel pit 2 area:
  - GP2-1 (34.0 ha)
  - GP2-2 (3.3 ha)

The maximum area that will be cleared for gravel pits for the project is 60.3 ha. However, a much smaller area is likely to be required to facilitate the road upgrade. The project will adhere to DIPL's *Standard Specification for Environmental Management* for materials extraction within gravel pits, specifically Section 19.1:

- Gravel pits should not exceed 1 ha
- Extraction areas are to be progressively rehabilitated so that one gravel pit is rehabilitated before another one is established

The total area to be cleared within the road alignments is 14.4 ha, according to the following estimates:

- Gravel Pit 1 alignment (4.8 ha to be cleared)
- North Road Alignment (3.0 ha)
- Creek Road Alignment (4.2 ha)
- South Road Alignment (2.4 ha)

The maximum footprint of the project will be 74.7 ha.

The project is unlikely to result in a significant impact to threatened fauna species due to the number of threatened species records throughout Melville Island and fact that the estimated impact area of 74.7 ha represents approximately 1.7% of the total 4,436 ha of woodland habitat on the island. However significant populations of *Typhonium jonesii* and *T. mirabile* were identified during the threatened flora surveys.

5.2 Road alignment

The current Paru Road proposed alignment is a 30 m wide road corridor designed to straighten sections of the road to increase traffic safety. Four road alignment options have been provided for the Creek Road Alignment project area. The likelihood of the current proposed road alignment and various alignment options having a significant impact on the target *Typhonium spp.* within the following project areas outlined below:

- South Road Alignment:
  - *T. jonesii* - Low likelihood of significant impact (impacts 10 (7.5%) of 134 records within AOO cell)
  - *T. mirabile* - Low likelihood of significant impact on *T. mirabile* (no records observed)
- Gravel Pit 1 Road Alignment:

- *T. jonesii* - Low likelihood of significant impact (impacts 8 (5%) of 153 records within AOO cell)
- *T. mirabile* - High likelihood of significant impact (impacts 65 (21%) of 304 records within high density *T. mirabile* patch (High conservation significance, refer Section 4.2.2) and 65 (16%) of 399 within AOO cell.

- Creek Road Alignments:
  - Option 1:
    - *T. jonesii* – Low likelihood of significant impact (impacts 1 (5%) of 22 records within AOO cell)
    - *T. mirabile* – Low Likelihood of significant impact (impacts 20 (12%) of 168 records within AOO cell)
  - Option 2:
    - *T. jonesii* – Low likelihood of significant impact (impacts 1 (5%) of 22 records within AOO cell
    - *T. mirabile* –– Low Likelihood of significant impact (impacts 4 (2%) of 168 records within AOO cell
  - Option 3:
    - *T. jonesii* – High likelihood of significant impact (impacts 9 (41%) of 22 records within AOO cell
    - *T. mirabile* - Low Likelihood of significant impact (impacts 28 (17%) of 168 records within AOO cell
- North Road Alignment:
  - *T. jonesii* - Low likelihood of significant impact (no records observed)
  - *T. mirabile* - Low likelihood of significant impact (no records observed)
- Gravel Pit 2:
  - *T. jonesii* – Low likelihood of significant impact (impact 3 (13%) of 23 records within AOO cell
  - *T. mirabile* - Low likelihood of significant impact (no records observed).

A 30 m wide road corridor has been designed with consideration of the *Typhonium spp.* survey results, to reduce impacts to *Typhonium spp.* populations and high value habitat within the project area. This alignment is referred to henceforth in this report as the preferred alignment. The Paru Road proposed alignment was found to have a high likelihood of significant impact on *Typhonium mirabile* within the high-density *T. mirabile* patch (located in Gravel Pit 1 Road Alignment) and on *T. jonesii* along Option 3 within the Creek Road Alignment. To reduce the project impacts to an acceptable level the Paru Road preferred alignment has incorporated the following changes:

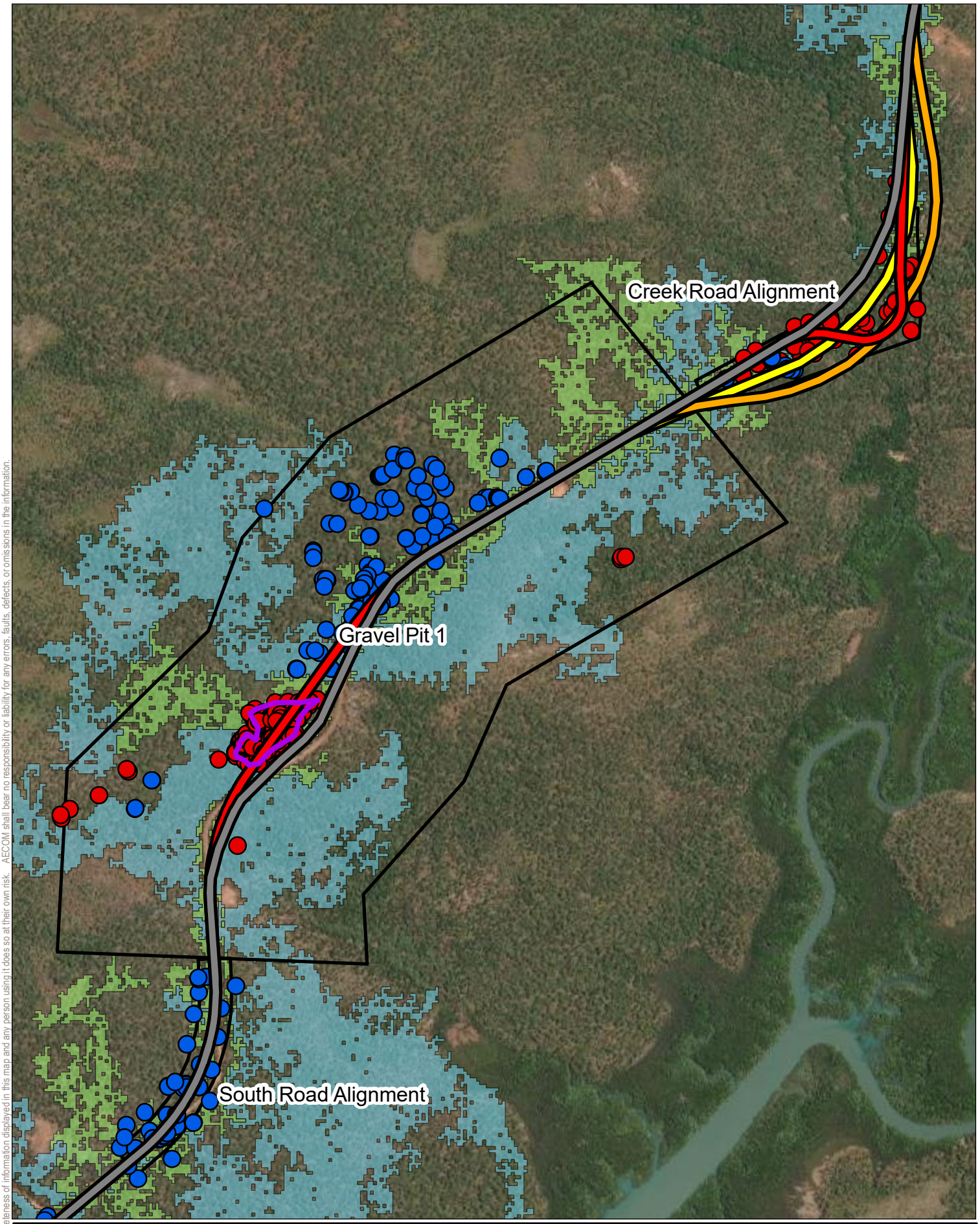
- Gravel Pit 1 Road Alignment – realigned the road corridor to the east of the high-density *T. mirabile* patch.
- Creek Road Alignment – realign the road corridor along Option 1 for the following reason:
  - Does not propose a likely significant impact on the target *Typhonium spp.*
  - Realigned along the shortest route, impacting the smallest area of potential *Typhonium spp.* habitat
  - Located west of the existing bridge crossing, so the existing crossing can be utilised as a low impact road detour during bridge construction.

Figure 12 shows the Paru Road preferred alignment in relation to the original proposed alignment, bridge options and environmental constraints.

The Paru Road preferred alignment proposes to have the following impacts on the target *Typhonium spp.:*

- South Road Alignment:
  - *T. jonesii* - Low likelihood of significant impact (impacts 10 (7.5%) of 134 records within AOO cell)
  - *T. mirabile* - Low likelihood of significant impact on *T. mirabile* (no records observed)
- Gravel Pit 1 Road Alignment:
  - *T. jonesii* - Low likelihood of significant impact (impacts 5 (3.2%) of 153 records within AOO cell)
  - *T. mirabile* - Low likelihood of significant impact on *T. mirabile* (no records impacted)
- Creek Road Alignments:
  - Option 1:
    - *T. jonesii* – Low likelihood of significant impact (impacts 1 (5%) of 22 records within AOO cell)
    - *T. mirabile* – Low Likelihood of significant impact (impacts 20 (12%) of 168 records within AOO cell)
- North Road Alignment:
  - *T. jonesii* - Low likelihood of significant impact (no records observed)
  - *T. mirabile* - Low likelihood of significant impact (no records observed)
- Gravel Pit 2:
  - *T. jonesii* – Low likelihood of significant impact (impact 3 (13%) of 23 records within AOO cell
  - *T. mirabile* - Low likelihood of significant impact (no records observed).

A total of 19 *T. jonesii* and 20 *T. mirabile* are proposed to be impacted by the Paru Road preferred alignment. According to the above impact analysis this development option is not likely to have a significant impact on either of the target *Typhonium spp*.



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- Paru Road Preferred Alignment (Incorporating Bridge option 1)
- Paru Road Proposed Alignment
- Bridge option 2
- Bridge option 3
- *Typhonium jonesii* records
- *Typhonium mirabile* records
- High-density *Typhonium mirabile* patch
- Moderate likelihood *Typhonium spp.* habitat
- High likelihood *Typhonium spp.* habitat
- Project Area

Paru Road alignment options in relation to *Typhonium spp.* records

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	21-Apr-2021
VERSION	1

Figure 12

A4 size

5.3 Gravel Pit Locations

Gravel pit locations have been identified with consideration of the following:

- *Typhonium spp.* survey results
- Slope model (0 - 6% slope)
- Native vegetation buffers:
  - 25 m buffer around wetlands
  - 100 m buffer around moderate value sensitive vegetation patches
  - 250 m buffer around high value sensitive vegetation patches.

Five areas have been identified as being suitable for gravel extraction:

- Gravel Pit 1 area:
  - GP1-1 (6.6 ha)
  - GP1-2 (9.9 ha)
  - GP1-3 (6.5 ha)
- Gravel pit 2 area:
  - GP2-1 (34.0 ha)
  - GP2-2 (3.3 ha)

Results of the *Typhonium spp.* survey show that five *T. jonesii* are located within GP1-1. No *Typhonium spp.* plants were observed within GP1-3 or the southern section of GP1-2. The northern section of GP1-2 (7.6 ha) was not surveyed for *Typhonium spp*. during the 2021 field survey. Given that the northern section of GP1-2 has been modelled to have a moderate likelihood of *Typhonium spp*. occurring, further targeted surveys must be undertaken to determine the likelihood of significant impact, prior to the site being cleared (refer to Figure 13) No *Typhonium spp*. records were observed within areas identified within Gravel Pit 2 (refer to Figure 14).

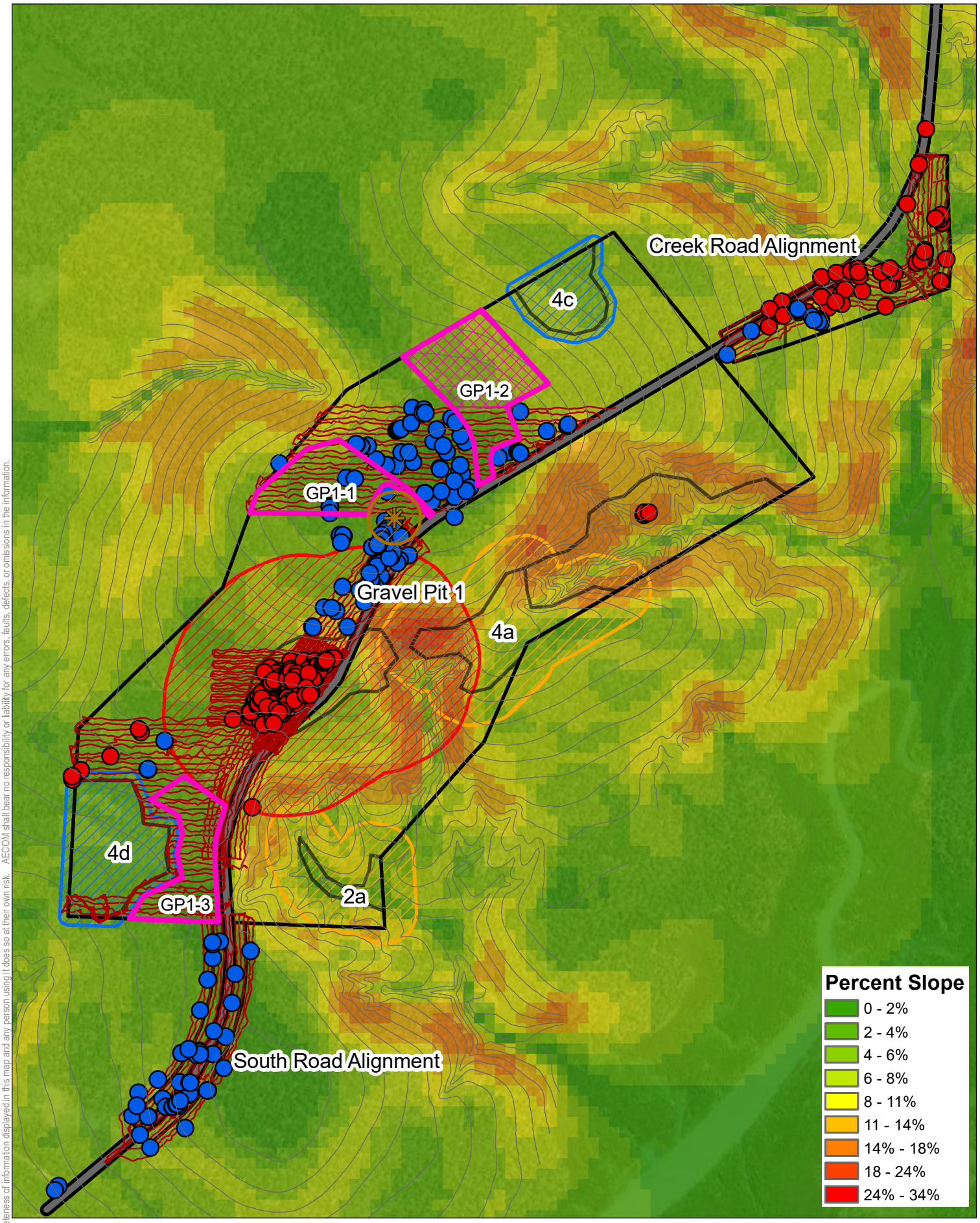
A 20 m native vegetation buffer has been implemented around plants that are to be protected from project impacts.

The location, area and significance of the proposed impact on the target *Typhonium spp.* is outlined in Table 8 below. The area identified as suitable within Gravel Pit 1 project area is shown in Figure 13, and suitable areas within Gravel Pit 2 project area are shown in Figure 14.

Table 8 Proposed gravel pit areas and likely significance of impact on *Typhonium spp.*

Survey Area	Suitable Area	Area ha	Likely significance of impact
Gravel Pit 1	GP1-1	6.6	• *T. jonesii* – Low likelihood of significant impact (impacts 5 (3.2%) of 153 records within AOO cell) • *T. mirabile* – Low likelihood of significant impact (no records observed)
	GP1-2	9.8 (total area) 2.2 (surveyed) 7.6 (unsurveyed)	• *T. jonesii* – Low likelihood of significant impact in area surveyed for *Typhonium spp*. (no records observed within surveyed area). • *T. mirabile* – Low likelihood of significant impact in areas surveyed for *Typhonium spp.* (no records observed within surveyed area) • Area in northern section of GP1-2 has not yet been surveyed for *Typhonium spp.*
	GP1-3	6.5	• *T. jonesii* – Low likelihood of significant impact (no records observed)

Survey Area	Suitable Area	Area ha	Likely significance of impact
			• *T. mirabile* – Low likelihood of significant impact (no records observed)
Gravel Pit 2	GP2-1	34	• *T. jonesii* – Low likelihood of significant impact (no records observed) • *T. mirabile* – Low likelihood of significant impact (no records observed)
	GP2-2	3.2	• *T. jonesii* – Low likelihood of significant impact (no records observed) • *T. mirabile* – Low likelihood of significant impact (no records observed)



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Typhonium jonesii records
Typhonium mirabile records
Typhonium survey tracks
2m Contours
Paru Road Preferred Alignment
Suitable for gravel pit
Requires further *Typhonium spp.* survey
Red Goshawk Nest Buffer 80m
Drainage 25m Buffer
Sensitive veg 100m Buffer
Sensitive veg 250m Buffer
Red Goshawk Nest
Project Area

Area suitable for gravel extraction within Gravel Pit 1

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	21-Apr-2021
VERSION	1

Figure 13

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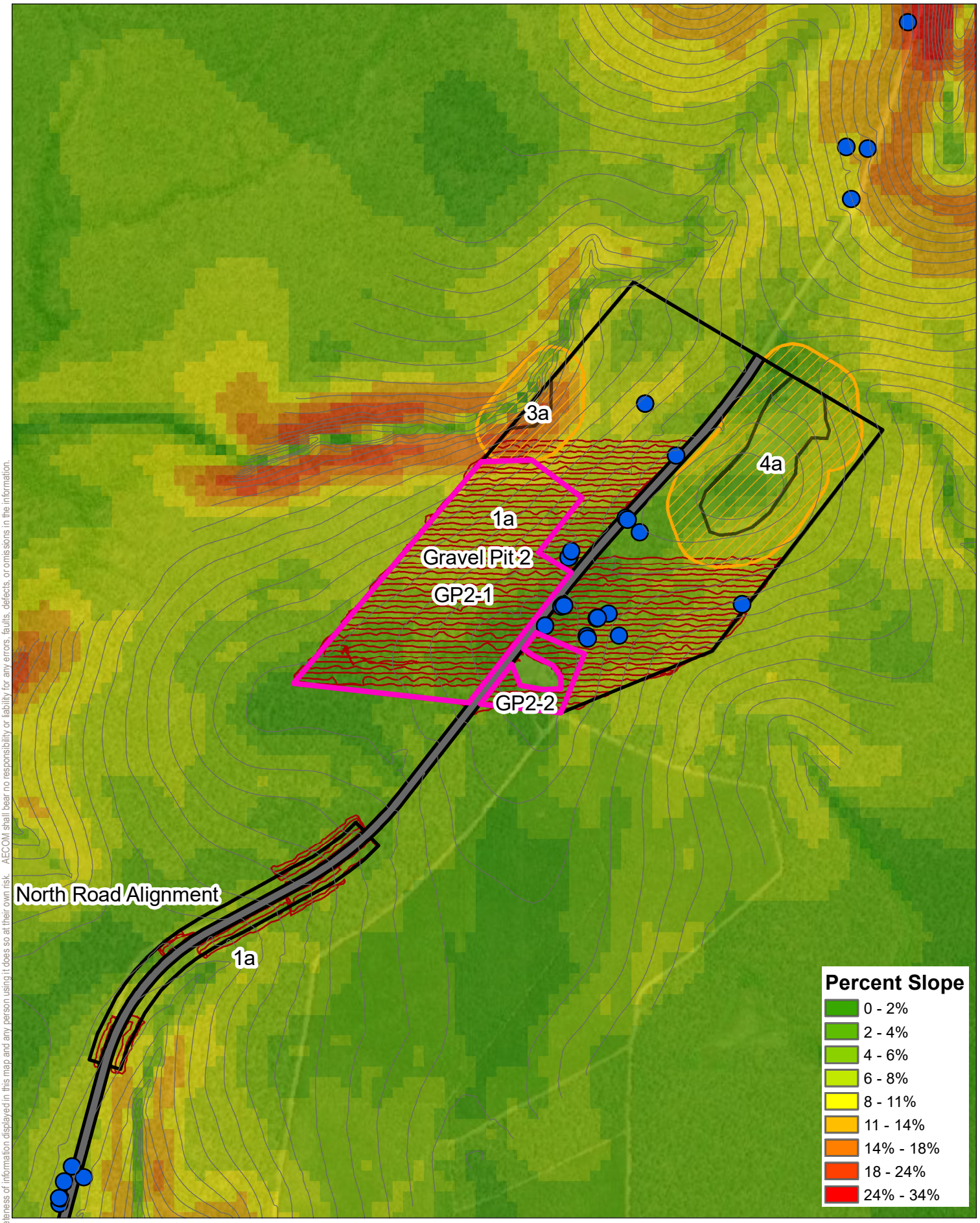
Filename: P:\606x\60626775\900_CAD_GIS\920_GIS\02_MXDs\Final Report Maps Jan 2021\Figure 13 Suitable areas within Gravel Pit 1.mxd



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Typhonium jonesii records
Typhonium survey tracks
2m Contours
Paru Road Preferred Alignment
Suitable for gravel pit
Sensitive veg 50 Buffer
Sensitive veg 100 Buffer
Project Area

Area suitable for gravel extraction within Gravel Pit 2

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	16-Apr-2021
VERSION	1

Figure 14

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5.4 Impacts to threatened species

The following project impact areas have been selected to minimise impacts to *Typhonium jonesii* and *T. mirabile*:

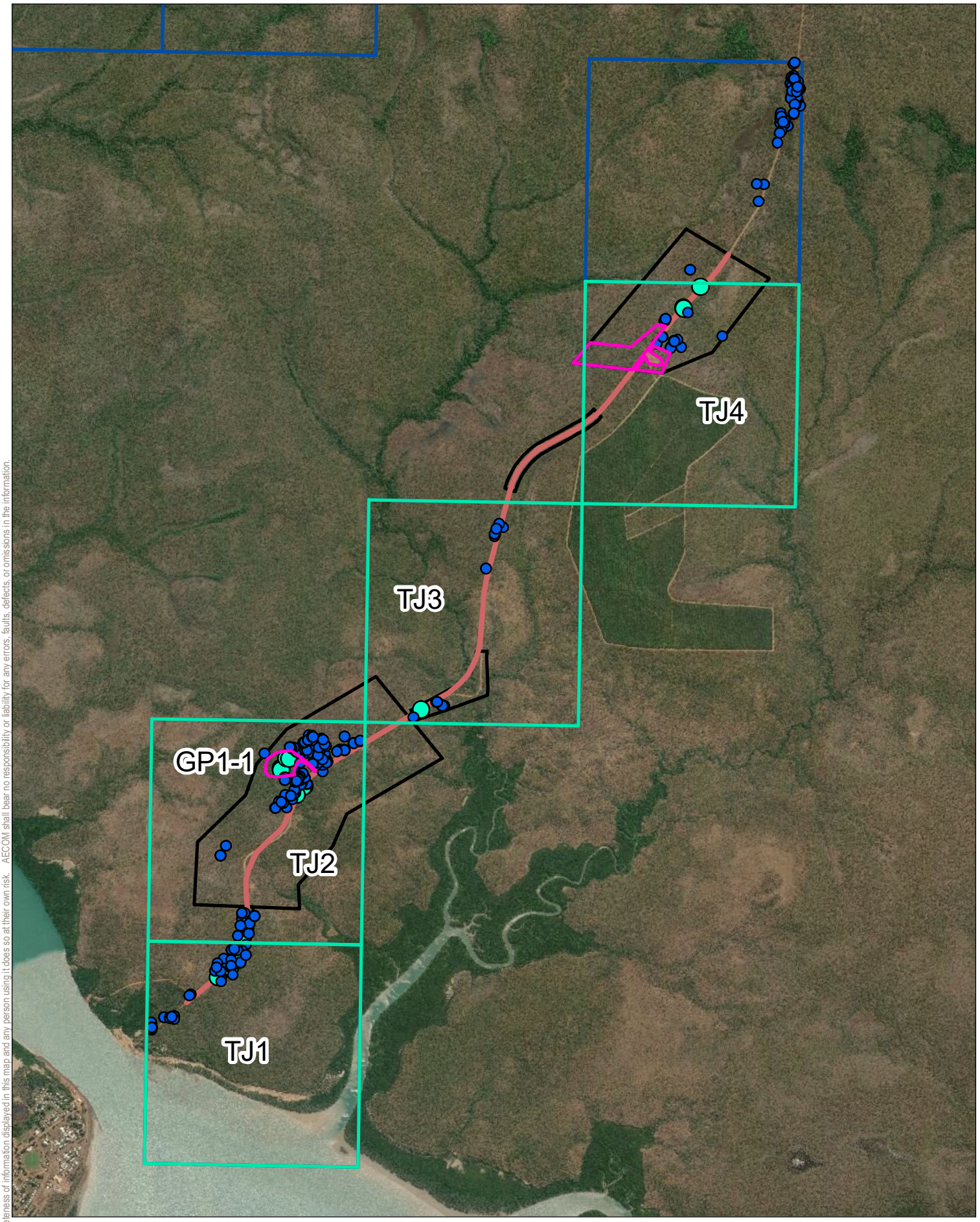
- Paru Road preferred alignment
- Gravel pits
  - GP1-1
  - GP1-2 (within areas currently surveyed for *Typhonium spp.*)
  - GP1-3
  - GP2-1
  - GP2-2.

Assessment of potential impacts to *Typhonium spp.* were undertaken by analysing records within AOO 2 km grid cells. Area of occupancy cells and records within impact areas are shown in Figure 15 for *Typhonium jonesii* and Figure 16 for *Typhonium mirabile*. Proposed impacts to each species and AOO cell are shown below in Table 9.

Table 9 Proposed *Typhonium spp.* impacts within the project area

Typhonium sp.	AOO Cell	Project Area	Records Impacted
T. jonesii	TJ1 (134 records)	South Road Alignment	10 (7.4%)
	TJ2 (153 records)	• Gravel Pit 1 (Road Alignment) • Gravel Pit 1 (GP1-1)	• 5 (3.2%) • 5 (3.2%) Total = 6.5%
	TJ3 (22 records)	Creek Road Alignment	1 (4.5%)
	TJ4 (23 records)	Gravel Pit 2 (Road Alignment)	3 (13%)
	TJ5 (66 records)	Gravel Pit 2	0
T. mirabile	TM1 (399 records)	South Road Alignment Gravel Pit 1	0
	TM2 (168 records)	Gravel Pit 1 Creek Road Alignment	20 (12%)

A total of 24 *Typhonium jonesii* and 20 *T. mirabile* are proposed to be impacted. This equates to approximately 3.6% of the known *Typhonium jonesii* population and 2.9% of the known *T. mirabile* population. The proposed project placement and design has a low likelihood of significant impact to *Typhonium spp.* Both of these species have been further considered in Section 6.0.



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- *Typhonium jonesii* impact records
- *Typhonium jonesii* records
- Paru Road Preferred Alignment
- Suitable for gravel pit
- *Typhonium jonesii* impacted AOO cells
- *Typhonium jonesii* AOO grid
- Project Area

Typhonium jonesii records of occurrence impacted by the recommened project design

PROJECT ID	60571058
CREATED BY	david.vandenhoek
LAST MODIFIED	24-Feb-2021
VERSION	1

Figure 15

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