

Appendix C

TGS Hydrogeological Assessment



**Territory Groundwater Services
Pty Ltd**

**Pirlangimpi, Pickertaramoor and Milikapiti Access Roads
Melville Island, NT**

**Hydrogeological Assessment & Roadworks Water Supply
Strategy**



*A report prepared by Maria Woodgate (TGS) for the Northern Territory Department of
Infrastructure, Planning and Logistics*

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Disclaimer

This report is solely for the use of the NT Department of Infrastructure, Planning and Logistics. Any reliance on the advice in this report for other purposes is at the users own risk.

The information in this report is considered to be accurate with respect to information provided and conditions encountered at the site at the time of the investigation.

COMMONLY USED ABBREVIATIONS

<i>AHD</i>	<i>Australian Height Datum</i>
<i>mBGL</i>	<i>metres below ground level</i>
<i>EC</i>	<i>Electrical Conductivity – measured in microSiemens per centimetre – $\mu\text{S}/\text{cm}$</i>
<i>L/s</i>	<i>Litres per second</i>
<i>LURF</i>	<i>TLC's Land Use Resource Form</i>
<i>PMP</i>	<i>Plantation Management Partners</i>
<i>RN</i>	<i>Registered bore number</i>
<i>TGS</i>	<i>Territory Groundwater Services P/L</i>
<i>TLC</i>	<i>Tiwi Land Council</i>
<i>TRLC</i>	<i>Tiwi Regional Land Council</i>
<i>VDS</i>	<i>Van Diemen Sandstone</i>

TERMINOLOGY

For clarity and consistency, the following terms are used when discussing groundwater resources in this report:

Bore Yield Class	Litres/second (L/s)	Salinity Class	Electrical Conductivity, microSiemens/cm ($\mu\text{S}/\text{cm}$)
Nil	Dry,0	Potable	<1,875
Very Low	0-1	Moderate	1,875-4,500
Low	1-2	Brackish	4,501-15,000
Moderate	2-4	Saline	>15,000
High	>4		

EXECUTIVE SUMMARY

Key findings and recommendations include:

- *Roadworks should be undertaken at start of dry season when usage is lower and creeks and billabongs are all full.*
- *Access tracks need to have gravel laid on surface to prevent degradation.*
- *Bruce Holland (Tiwi Rangers) and Plantation Management Partners (Quinten Pope) should be given notification prior to use of their bores.*
- *All identified water sources are of low salinity.*
- *Several waterholes, creeks and springs have been identified along the main access roads which are potential road water sources if permission to use is obtained. The application to use these sources has been submitted to the Tiwi Land Council (27 August 2020).*
- *There are only a small number of low-moderate flow rate bores at scattered locations along the road.*
- *There are two aquifers :- the shallower Van Diemen Sandstone which forms the plateau of the central part of the island and is eroded away on the southern part of the island; and the deeper sandstone facies of the underlying Moonkinu Member which underlies the central and northern part of Melville Island.*
- *An estimated minimum of 10 bores (mostly 50m deep or less) may need to be drilled and constructed where there are gaps of >16km between water sources, or water sources are not adequate.*
- *Milikapiti Road – some good waterholes available in the mid-section but will need to drill bores for the more northerly end. No good options around Milikapiti community are available.*
- *Pirlangimpi Road – some waterholes previously used for roadworks are available at the eastern end but these are generally a few kilometers north of the road. There are no sources between ch 42 and PMP's Maxwell Creek Camp so a few bores will need to be drilled and the prospects are along here. A Power and Water production bore at CH42 is available on the proviso that a pumping test is undertaken and a number of other conditions as outlined in this report.*
- *Pickertaramoor Road – A number of waterholes were identified on the ground by TLC in late August 2020. These are generally a kilometer or two from the main road and will need access tracks and final approval to use. There are two low flowing bore (1 L/s) that are available. There is no water available at the Pickertaramoor community end of the road and no prospects for drilling. Cartage of water may be required.*
- *Note that at the time of this study (mid-dry season following two poor wet seasons) there is anecdotal evidence that the water tables are lower than usual, and bores are performing poorly or starting to fail. The option of using the existing road bores, and the chance of success for drilling any additional bores (especially on the Pickertaramoor Road) is contingent on whether the upcoming wet season is average or above average rainfall.*

1. INTRODUCTION

Melville Island is part of the Tiwi Islands, just over 50km directly north of Darwin, NT. The roads on the Islands have deteriorated in recent years due to increased usage. Funding has been allocated by the Federal and Territory governments for road upgrades along 3 main access roads (shown in Figure 1) as follows:

1. Threeways intersection west to Pirlangimpi (~47km)
2. Threeways intersection east to Pickertaramoor (~26km)
3. Threeways intersection south to Paru (~13km). A separate Hydrogeological Assessment and Report is available from this section of road, which was also undertaken by Territory Groundwater Services in 2019.

This assessment and report also includes the road from Threeways intersection north to Milikapiti Community (~28km) in the event that there is funding available to upgrade this road.

The proposed road works will require temporary water supplies additional to the current marginal resources available. The nominal required water supply per 10km of road is 3 L/s located within a water carting practical distance of no more than 8km.

Note that roadworks can utilise brackish to saline water if necessary, so the water supply does not need to be potable.

The Department of Infrastructure, Planning and Logistics, (DIPL), has engaged *Territory Groundwater Services Pty Ltd (TGS)*, to review and assess the hydrogeological conditions and bore infrastructure along the three access roads, as well as develop a water supply strategy for the three access roads. This water supply strategy is designed to meet the requirements of all future road construction works.

A review of water resources completed in 2019 for the Paru Road and including the Threeways area was considered as part of this study.

TGS undertook a desktop assessment and a site visit in July 2020. Site visit objectives were to:

1. Locate and assess the condition of any potentially useable existing bores;
2. Identify prospective drilling targets to meet the expected roadworks water demand; and,
3. Consult with local stakeholders including:
 - Tiwi Island Land Council;
 - Tiwi Islands Regional Council;
 - Plantation Management Partners; and,
 - Power Water Corporation

The results of this assessment are presented in this report in three sections for each access road.

Please note that the roads in question are located on a parcel of land being granted pursuant to the Aboriginal Land Rights (NT) Act and owned by the Tiwi Aboriginal Land Trust. The Tiwi Islands Regional Council (TIRC) has the responsibility for the care, control and management of the roads on the Tiwi Islands, and has been working together with the Northern Territory Government (NTG) to upgrade the roads on Melville Island.

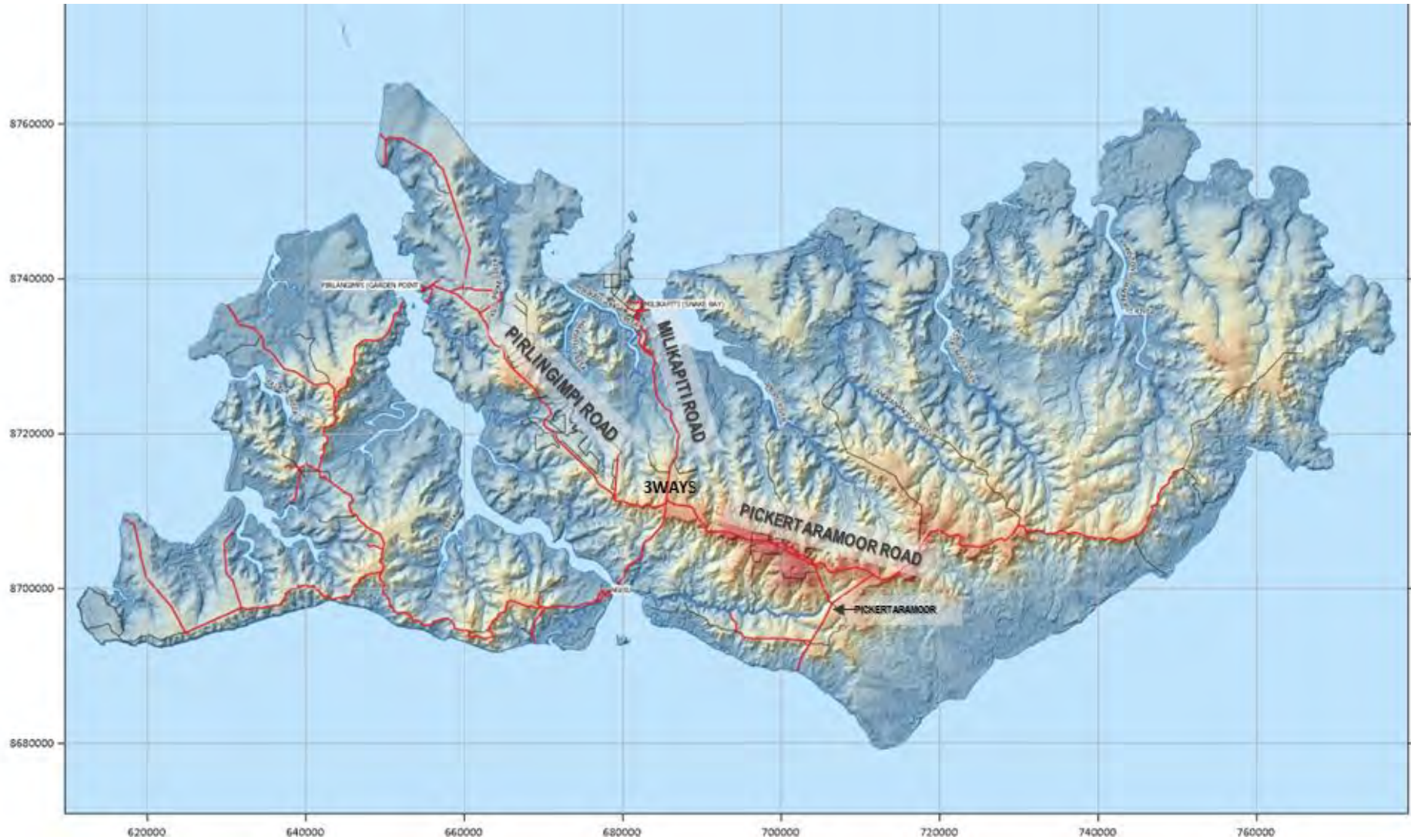


FIGURE 1 A RELIEF MAP SHOWING THE TIWI ISLANDS AND THE PICKERTARAMOOR, PIRLANGIMPI AND MILIKAPITI ACCESS ROAD LOCATION

1.1. Objectives

Road upgrades will be undertaken as part of a \$75 million rolling program, jointly funded by Australian Government and Northern Territory Government which will be distributed over a number of years. Road construction is anticipated to commence in the dry season of 2021.

The objective of this project is to identify and map water supply options for future road construction activities. The aim is to provide DIPL with a high level of confidence in the ability to meet the road construction water demands along the three roads into the future.

The works undertaken included:

Hydrogeological Assessment

1. Literature review;
2. Identify existing bores and water supply prospects such as springs and creeks;
3. Field audit of existing water supply assets to determine condition and viability;
4. Stakeholder consultation to gain information on local resources and negotiate access to resources.

Formulate a Water Supply Strategy

5. Water availability mapping – map of aquifers, springs and creeks, and water supply potential along the three access roads and their adjacent road corridors;
6. An options assessment – identify prospective drilling targets (aquifers) along each road within a cost effective (8km) distance to meet water supply capacity requirements, including siting of bores, expected bore depth, water level and yield;
7. Review AAPA restricted work areas and sacred sites to ensure none are affected by the proposed sites;
8. Specifications and costings – provision of drilling specifications for each road section and generalised costings. Advise on regulatory requirements and permits for drilling in this area;
9. Determine access track and clearing requirements; and,
10. Consult with DIPL's environment section and DENR regarding proposed water supply strategies.

Risk Assessment

11. Identify risks and assess the potential impact any groundwater extraction may have on existing groundwater users/including environmental dependencies.

Reporting

12. Comprehensive final report to include findings, recommendations, maps, and a detailed water supply strategy for the three access roads.

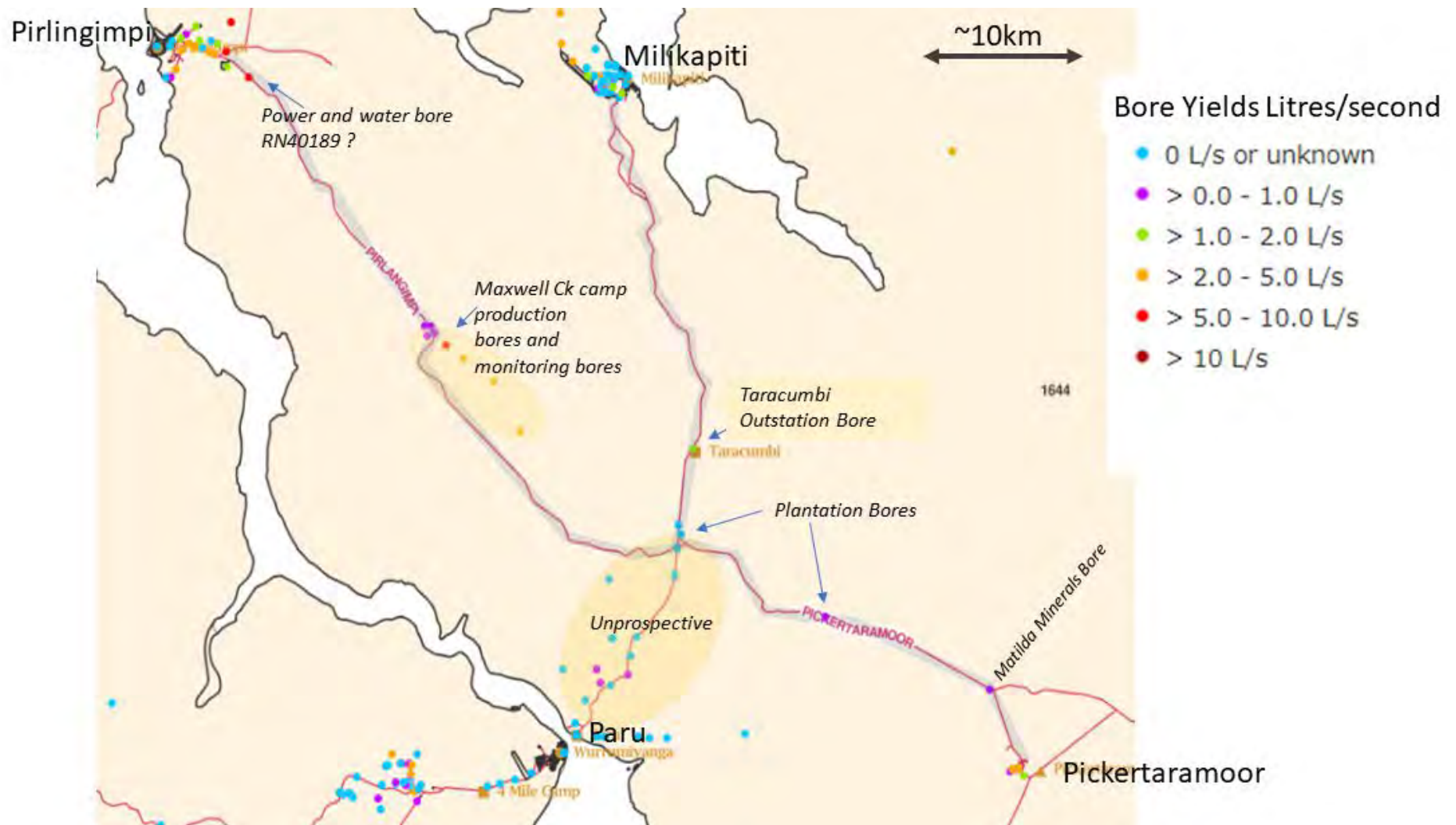


FIGURE 2 EXISTING BORES ON AND NEAR THE THREE ROADS.

2. SITE DESCRIPTION

2.1 Landform and Vegetation

The three access roads in question traverse the central-western part of Melville Island. The landscapes feature low dissected plateaux and undulating laterite rises in the Maxwell Creek area. Elsewhere, this landscape is overlain by the Tertiary Van Diemen Sandstone which forms the plateaux and areas of higher relief as shown in Figure 1. The Van Diemen Sandstone dips gently to the north. Where the sandstone has eroded away, extensive sand plains have built up, fringing the plateau on the northern part of the island.

Along the coast and tidal creeks, the coastal and estuarine plains, and beach and littoral sands occur forming a flat, low-lying coastal landscape. Mangroves fringe the creeks and coastline.

The vegetation along the roads are dominated by Eucalyptus open forest (Woollybutt), with less dominant Acacia open scrublands. Plantations are extensive along the Pirlangimpi Rd and to a lesser extent along the Pickertaramoor road.

2.2 Climate

The climate of the region is dominated by a distinct monsoonal wet season (October to April) and dry season (May to October). The area is subject to tropical cyclones during the wet season. Mean annual rainfall is approximately 2,005mm (measured at the Pirlangimpi airport), the bulk of which falls in the wet season as shown in Figure 3.

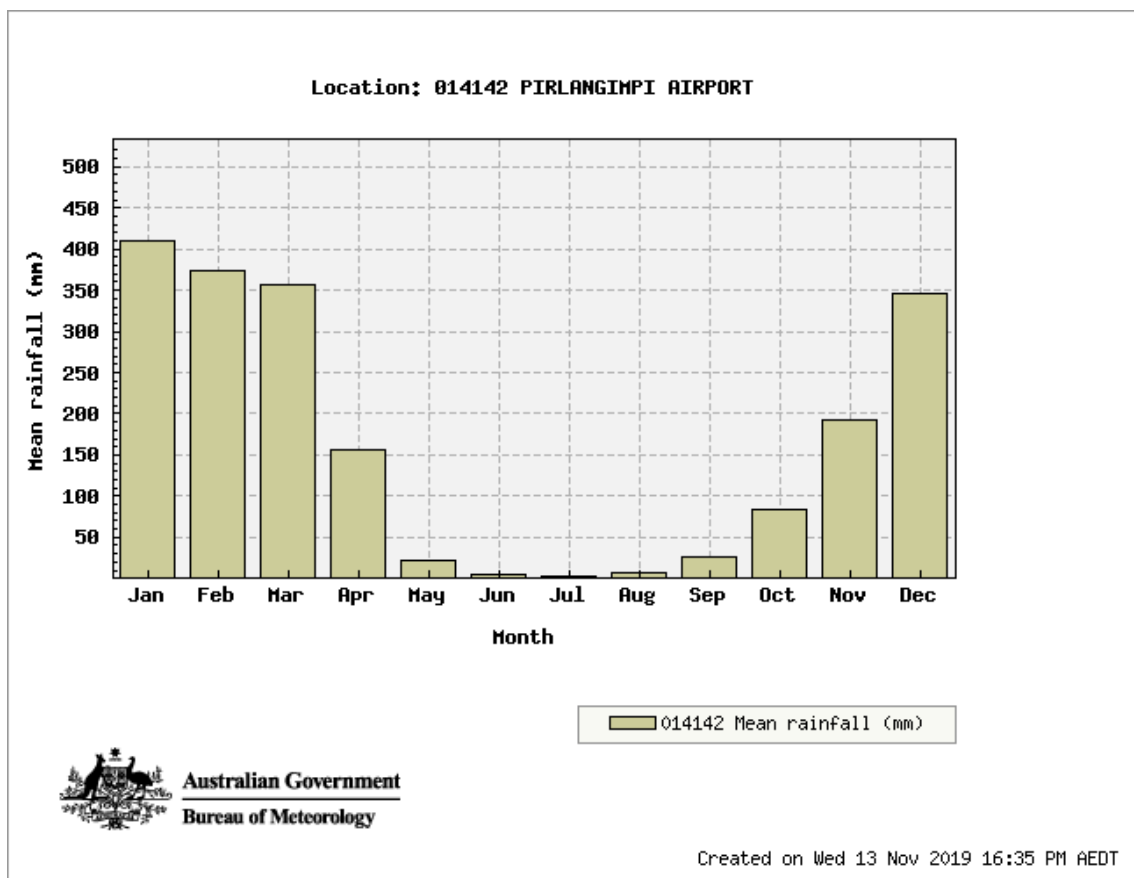


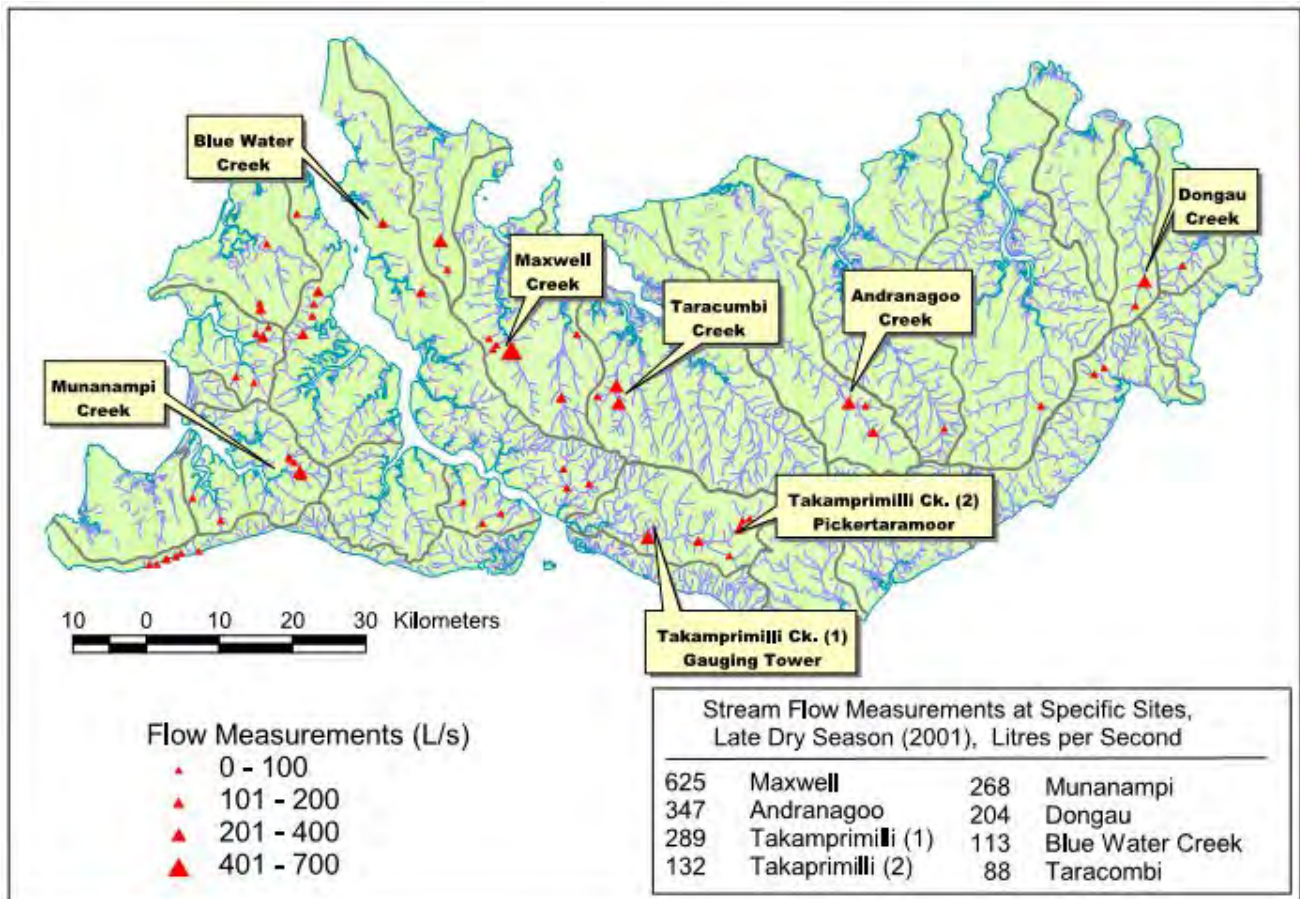
FIGURE 3 MEAN MONTHLY RAINFALLS AT PIRLANGIMPI AIRPORT

2.3 Surface Water

The three central access roads have generally been built at high elevations, in this case, along the top of the plateau which forms a catchment divide. Thus, the roads do not cross any creek systems.

Major nearby creeks at Pickertaramoor, Taracumbi, Maxwell Creek and Blue Water Creek have measurable flows in September and October due to being fed by springs which drain from the Van Diemen Sandstone. Where the Van Diemen Sandstone is thickest, streams tend to flow longer, (i.e. on the northern part of the island), due to the time it takes to drain the sandstone aquifer. Flow estimates are shown in Figure 4.

FIGURE 4 STREAM FLOW AT THE END OF THE DRY SEASON 200-2001 (AFTER HAIG, 2003)



3. GEOLOGY

The study area is covered by the *Melville Island, SC 52-16, 1:250 000 geological mapsheet*.

Melville Island is situated within the Money Shoal Basin consisting of gently dipping Mesozoic and Cenozoic sedimentary rocks which are up to 4-5km thick (Ahmed and Munson, 2013). The stratigraphic succession underlying Melville Island consists of The Moonkinu Sandstone, (Bathurst Island Group), which is unconformably overlain by the Middle Eocene Van Diemen Sandstone (VDS), up to 70m thick on Bathurst Island, but thought to have eroded away to less than 30m in the Pirlangimpi area and only patchy remnants are found south of Threeways.

The VDS is described as friable, cross-bedded, medium-coarse grained quartz sandstone with minor lenses of siltstone and granular conglomerate. Quaternary sediments including coastal deposits and alluvium form a discontinuous cover over the sandstone.

A summary of the stratigraphic succession is shown in Figure 5.

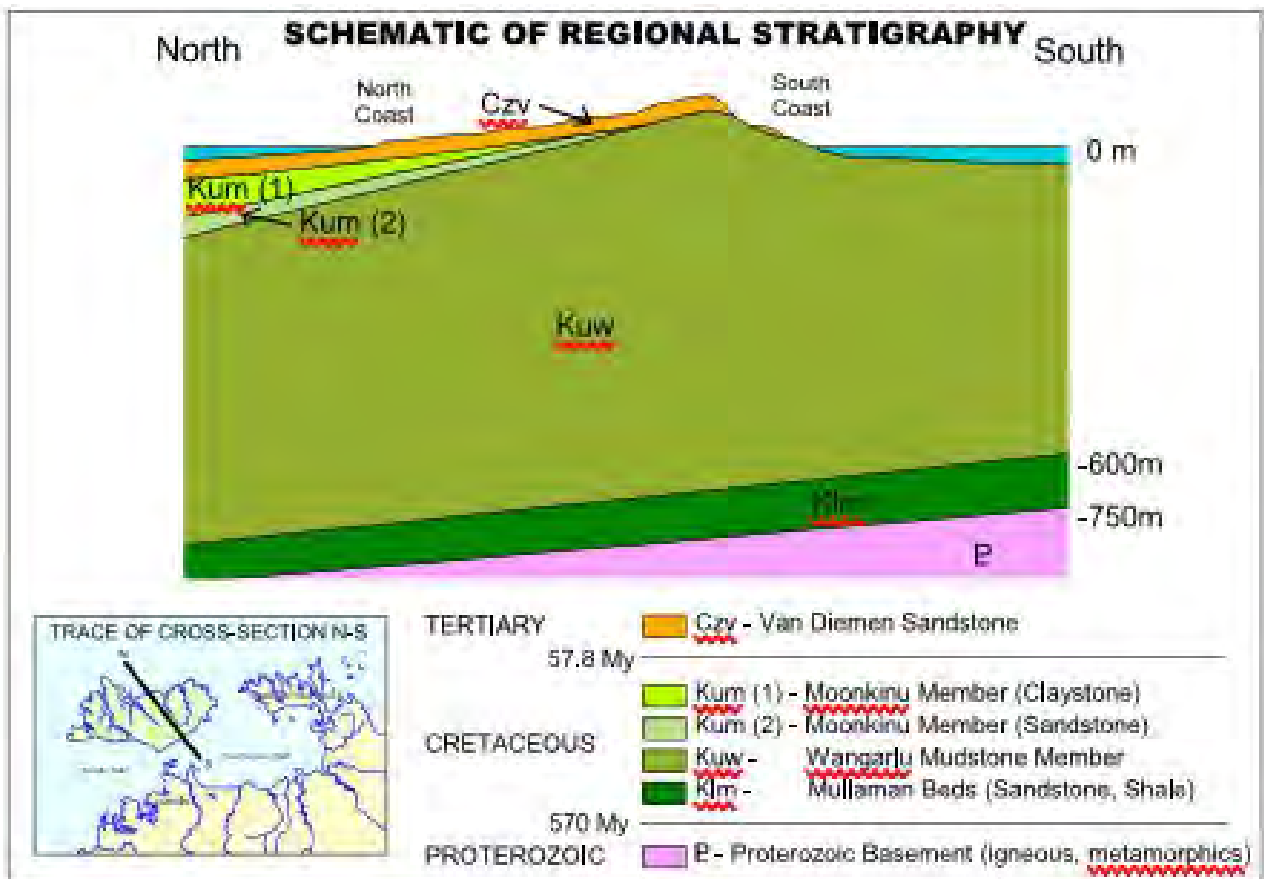


FIGURE 5 SCHEMATIC OF MELVILLE ISLAND STRATIGRAPHY (AFTER HAIG ET AL., 2003).

The surface geology of the study area is shown in Figure 6.

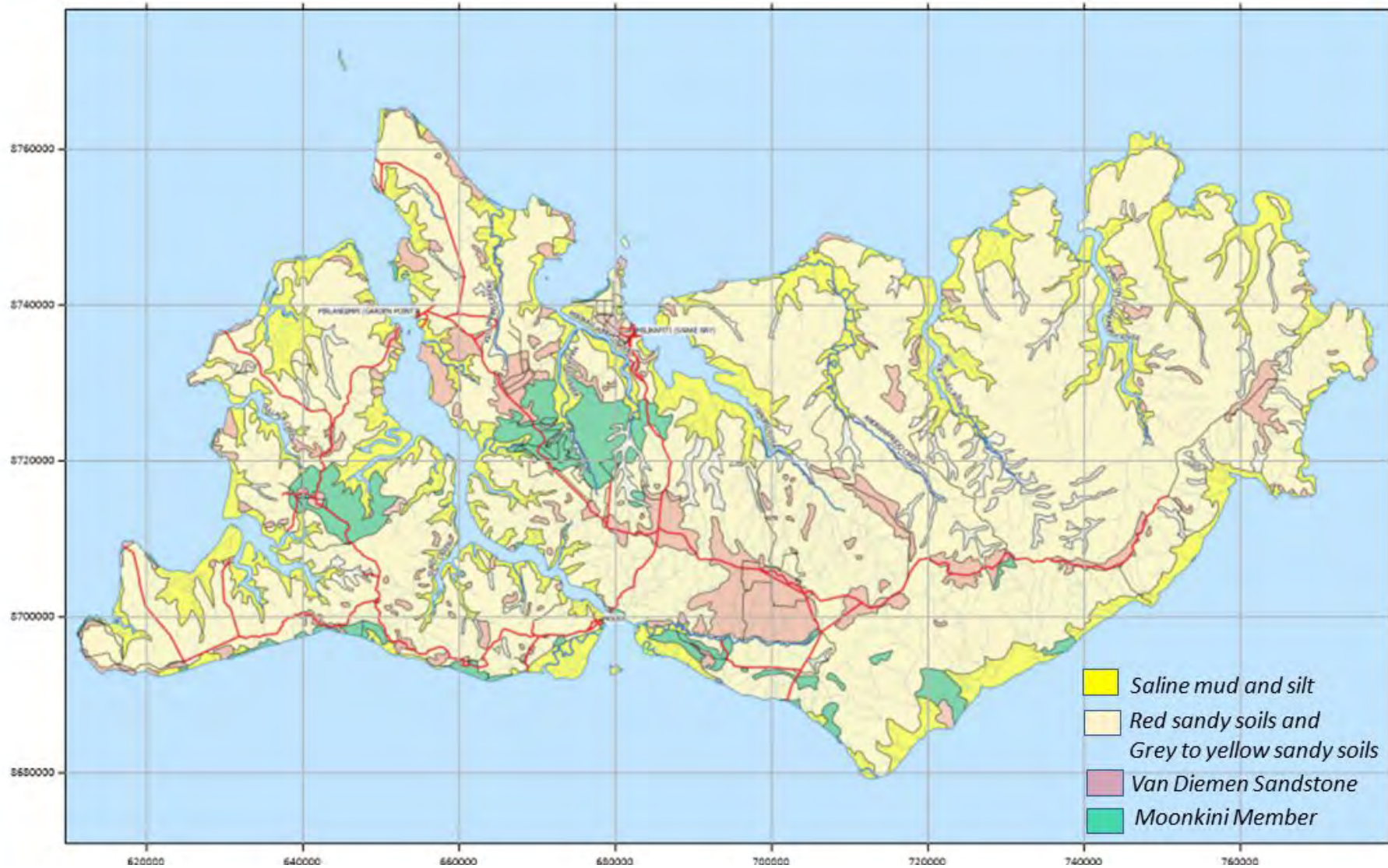


FIGURE 6 MELVILLE ISLAND SIMPLIFIED SURFACE GEOLOGY

4. HYDROGEOLOGY

This assessment is based on a review of all available bore logs, spatial data including maps, digital geological, geophysical, topographic, and satellite data, existing reports, and expert knowledge of the area. The aim is to identify the prospective aquifers within a 10km buffer of the three access roads, (the 'study area').

Regional Groundwater Mapping was undertaken in 2003, (Haig & Matsuyama, 2003), to produce the maps and reports entitled: Water Resources of the Tiwi Islands Map 2. These provide the basis for this assessment.

There are two regional aquifer systems on the Tiwi Islands (as shown in Figure 7):

- **The Van Diemen Sandstone**

(Includes any overlying laterite and alluvium). Local yield and groundwater storage depend on the thickness of the sandstone. This sandstone hosts very fresh water, (salinity, measured as electrical conductivity, EC of <100 uS/cm), and is the best aquifer available wherever it occurs. (The exceptions are bores drilled near the marine environment where saltwater intrusion may be a factor). Due to the strong seasonality of the rainfall in Tiwi Islands' monsoonal climate, the water table in the Van Diemen aquifer ranges by around 6 metres annually, (e.g. hydrograph for RN008437).

The thickness of the sandstone is greater just north of Threeways and at two locations along the Pirlangimpi Road and virtually non-existent at the lower lying parts of the Milikapiti Road and the western end of the Pirlangimpi Road.

It is the saturated part of the VDS, ranging from 10-35m, that is water bearing and normally the primary target for production bores. Any drilling of new bores should target the thickest part of the sandstone as mapped in Figure 8 Van Diemen Sandstone Thickness (after Haig et al, 2003).

- **Deep Moonkinu Member Sandstone Aquifer**

A 30-60m thick grey sandstone unit sandwiched between the mudstones of the Moonkinu Member and the Wangarlu Mudstone (see Figure 7). It is separated from the shallow aquifer by a confining layer of relatively impermeable claystone and siltstone. It occurs north of Threeways and dips gently to the north west. Three bores at Milikapiti has been constructed in the deep aquifer between 130 and 150m below sea level, one of which, in the current borefield (RN027923) airlifted 7.5 L/s of low salinity groundwater, another nearby produced no water, and another at the southern edge of town produced 2 L/s.

This aquifer has yet to be tested south of Milikapiti, but the results of two bores indicate it may produce a moderate yield.

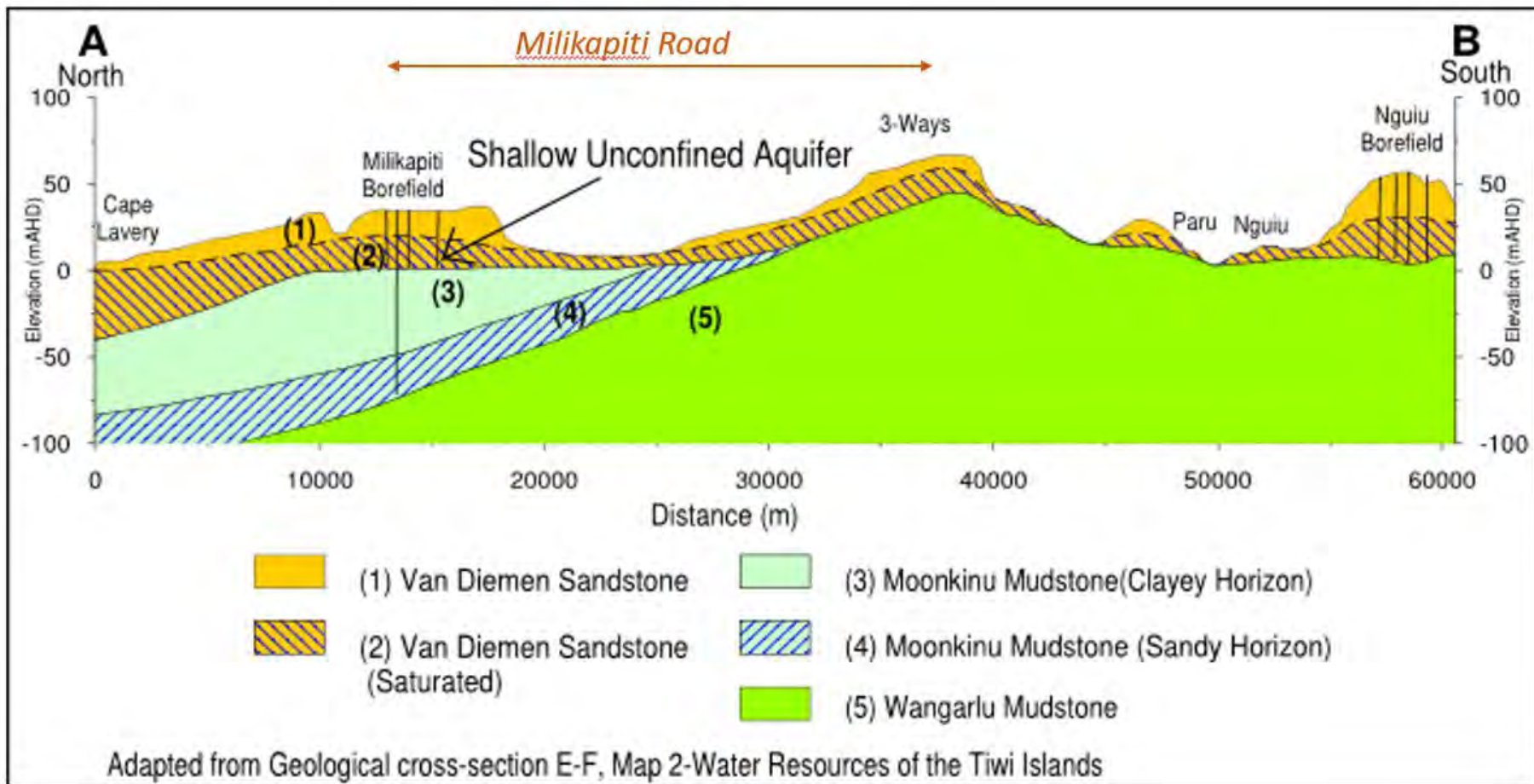


FIGURE 7 HYDROGEOLOGICAL CROSS SECTION SHOWING MILIKAPITI ROAD SECTION (AFTER HAIG ET AL, 2003)

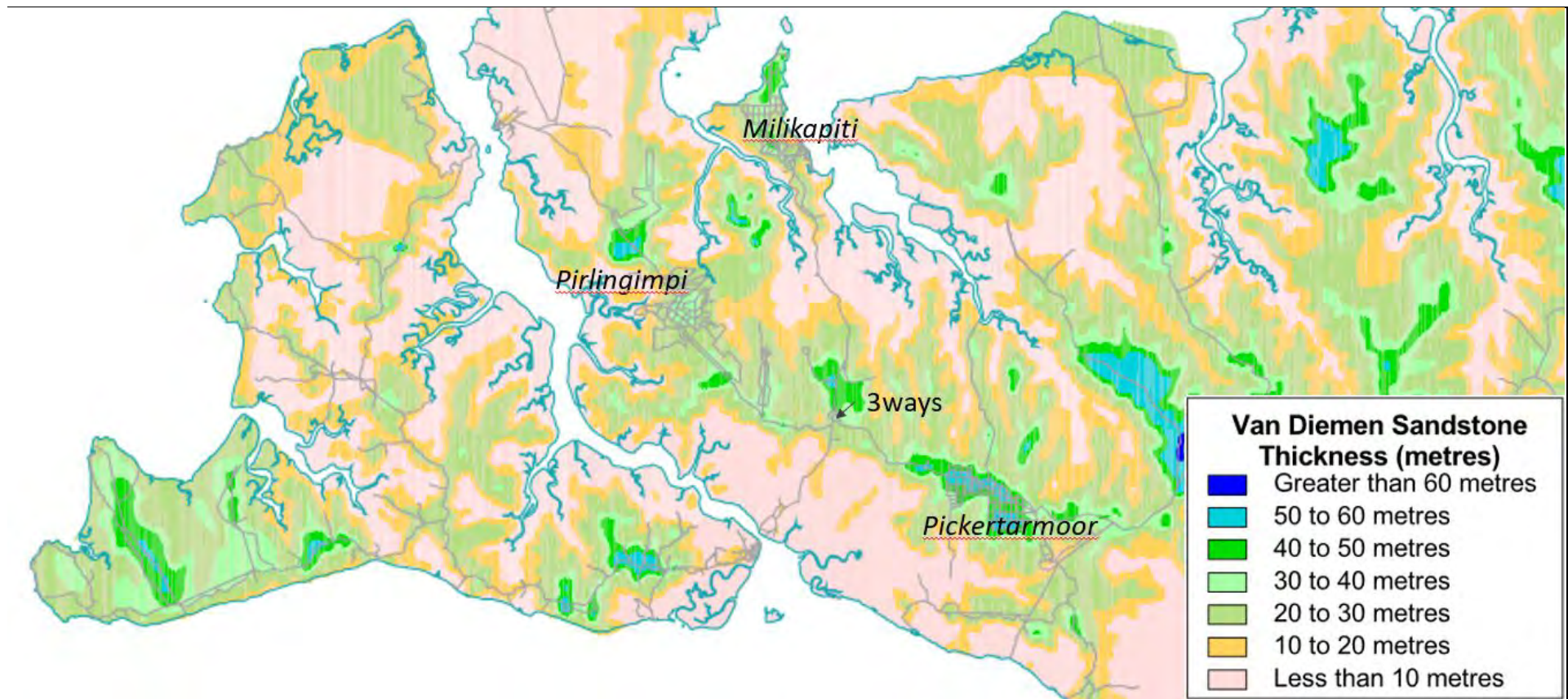


FIGURE 8 VAN DIEMEN SANDSTONE THICKNESS (AFTER HAIG ET AL, 2003)

4.1 Groundwater Salinity

A regional salinity distribution map (Haig et al 2003) is presented in Figure 9. Salinity is measured as Electrical Conductivity (EC).

In summary, the water quality is very fresh (EC's < 20 $\mu\text{S}/\text{cm}$) in the Van Diemen Sandstone inland from the coast but increases in salinity towards the coast and tidal creeks as the saltwater intrudes through the formation.

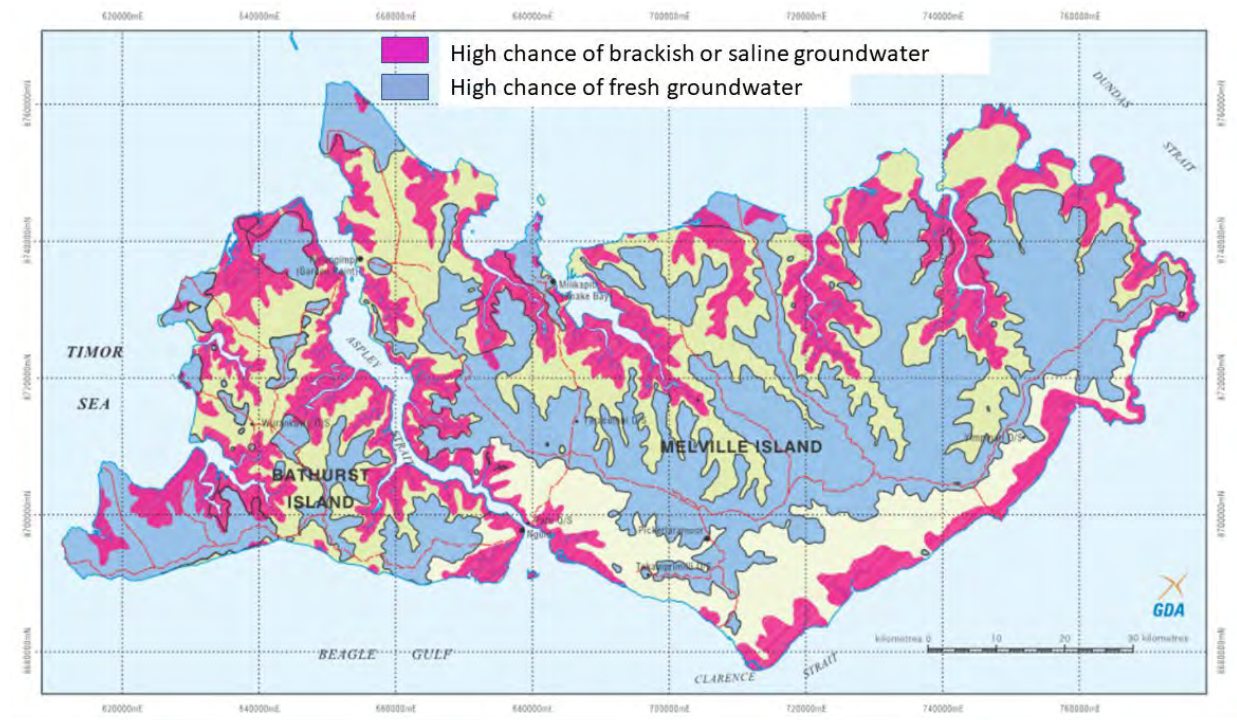


FIGURE 9 GROUNDWATER SALINITY MAP

5. ROADWORKS WATER SUPPLY STRATEGY

The approach for assessing each road of the three roads included:

- Assessment of hydrogeology;
- audit of existing bores and seeking permission for use;
- audit of potential surface water sources such as creeks and waterholes and identify those suitable for use;
- identification of prospective drilling sites to supply water where no other sources are available;
- identification of risks including to other users and groundwater dependent ecosystem; and,
- Identification of track access requirements.

Note that many of the water sources recommended in this Report have been used in the past for ad hoc roadworks previously undertaken by the PMP (pers. comm. Quentin Pope). Mr Pope and other local stakeholders stressed the ***importance of timing the water extraction from waterholes and creeks to the tail end of the wet season when the soil moisture is naturally higher requiring less water, and creeks flows are high.*** This would prevent over-draining creeks as some may dry up towards the end of the dry, particularly after a poor wet season.

The water source strategy for each road is presented in a *Water Strategy Matrix* – providing chainage, coordinates, estimated flow rates and other considerations.

5.1 Liaison

Table 1 shows the people and agencies that were consulted in the course of this work.

TABLE 1 CONSULTATION LOG

Who	Agency	What	Date
Alana O'Neill alana.oneill@powerwater.com	Power Water	Emailed to see if any existing community bores could be used. Possibly one at Pirlangimpi if I can demonstrate no impact on borefield.	26/06/2020
Dominique Michel – Environmental Officer	Tiwi Land Council	Emailed for information on whether there are any water sources surface or bores. No info available – passed me onto Murray Knyvett.	27/06/2020
Chris Smith	Tiwi Islands Regional Council	Emailed for information on whether there are any water sources surface or bores.	27/06/2020, 19/07/2020
Des Yinfoo	DENR	Phone - Discussed bore construction	27/06/2020
Quentin Pope, Bruce Holland gpope@plantationpartners.com.au	PMP, Tiwi Rangers	Site visit from Maxwell Creek Office – all known water points and bores were visited and discussed in the plantation area. Received verbal permission to use all sites visited and the two bores on Pickertaramoor Road. Requested written permission to use these bores with no response. Suggest the verbal permission will suffice in this case given the marginal flow rates and lack of potential impacts.	07/07/2020
Mari – TO at Taracumbi Outstation	TO & Taracumbi Outstation resident	Site visit to ask about access to the creek and the bore. She was ok with it but wanted her track to the house to be repaired. The bore pumps but leaks out onto the ground between bore and house.	07/07/2020
Mark Muller Mob: 0427 323 600	Ex-Operations Manager Milikapiti Farm and Nursery	Phone – for information on possible water sources around Milikapiti. Suggested the bore at 'the farm'. Request written permission to use bore 26/8/20.	08/07/2020
Mark Smirton milikapiti@tiwienterprises.com Mob: 0428 201 126	Ops Manager Milikapiti Farm and Nursery	Farm bore has been forking lately (due to drought conditions)– do not want to promise use of this at present.	09/09/2020

Who	Agency	What	Date
Scott Simpson Mob: 0438 860 677	Tiwi Enterprises	Scott will evaluate the use and capacity of the Milikapiti farm bore. (awaiting response at 10/9/20)	9/09/2020
Ray Allbright 0447 772 492	Pirlangimpi Resident, Tiwi Regional Council	Gave me contacts of grader drivers Milikapiti. Didn't know about water sources at Milikapiti.	15/07/2020
Andrew Bush	Milikapiti grader driver	Only known water source – 9 mile & Taracumbi waterfalls. Otherwise need to drill.	15/07/2020
Murray Knyvett 0409 640 549 murray.knyvett@tiwilandcouncil.com	Tiwi Land Council	Meeting at Winnellie office to go over identified water sources in detail. He will seek input from other TLC leaders and had a few other leads he would get back to me on. Strongly suggested starting works right at end of wet i.e. April. Said it's best to submit Land Use Request Forms (LURF) by clan area. Suggest considering the freshwater lagoon near the boat ramp at Milikapiti but it is full of crocs and not sure of access.	23/07/2020
Quinten Pope	PMP	After two failed wet seasons bores at the college are starting to fail – down to 42m water level. The existing bores on the Pickertaramoor Road are also probably no good at the moment.	31/07/2020
Shane Papworth	P&W	Phone conversation regarding use of one of their production bores on the road near Pirlangimpi Road. He agrees to its use if DIPL does a pumping test first (24hr) to see how the water levels respond. There are other conditions as detailed in section 7.3.	07/08/2020

5.2 Access and Water Take Permissions

The Northern Territory Administrator has signed an exemption to Section 45 *Licence to take or use water (surface water)* and Section 60 *Grant of licence to take groundwater* of the *Water Act*. This effectively exempts DIPL and its contractors from the requirement to obtain a water licence when undertaking water extraction associated with road works on public roads. Although a licence under the *Water Act* to extract water for road works is not required, approvals to use or extract water from a waterway or bore may still be required.

For all water bodies, every effort should be made to ensure that any water extraction will not reduce the supply utilised by local landowners, communities and the environment, to the point where such users are adversely affected. In order to protect the environment and ensure any other authorised use of water is not affected, all water extraction must be undertaken in accordance with the DIPL Standard Specification for Environmental Management.

5.2.1 Surface Water Take

The Contractor on behalf of DIPL should only take water from the sites which have been approved by the local landowners (via the LURF process with the Tiwi Land Council) to access the water sources identified in the Water Source Matrix. The plans for access tracks and turnaround areas to these sites should be provided to the Department with the Contractor's Environmental Management Plan that is required to be submitted by the construction contractor.

5.2.2 Groundwater Take

Use of existing bores requires the permission of the current owner and/or users which has been given for sources identified in the Water Source Matrix. The approvals should be provided to the Department with the Contractor's Environmental Management Plan that is required to be submitted by the construction contractor. The owners/operators for each bore are identified in the Water Strategy Matrix Table.

Use of existing bores requires the permission of the current owner and/or users. ***Bores within 2km of existing community borefields run by Power and Water are strictly out of bounds unless special permission is obtained.***

The owners/operators for each bore are identified in the Water Strategy Matrix table.

No bore permits are required to drill a new bore on Melville Island as it is not in a Water Control District.

5.2.3 Cultural Clearances

DIPL has obtained an Authority Certificate from the Aboriginal Areas Protection Authority for water extraction from the locations identified in the Water Source Matrix. An Authority Certificate protects sacred sites from damage by setting out the conditions for using or carrying out works proposed by a proponent on an area of land and/or sea.

These conditions relate to sacred sites in the area or in the vicinity of the proposed works, so that they are not damaged. It is a legal document issued under the *Northern Territory Aboriginal Sacred Sites Act*, and indemnifies the holder against prosecution under the Act for damage to sacred sites in the area of the Authority Certificate provided the proposed work or use has been carried out in accordance with the conditions of the Authority Certificate.

DIPL will provide the contractor with a copy of the relevant Authority Certificate. All water extraction must comply with the conditions identified in the Authority Certificate.

In addition, approvals for use of all water sources are being sought from the landowners via the Tiwi Land Council.

6. WATER SOURCES BY ROAD

6.1 Around Threeways and the Paru Road

Several bores have been drilled in the vicinity of the Threeways intersection, those at the intersection and to the south have been dry. A recent assessment of water options by TGS south of Threeways along the Paru Road undertaken in 2018 identified that the only water source option available was to extract from the road creek crossing approximately 8km south of Threeways, preferably early in the dry season. This creek crossing is known to the local community as Paru Creek.

The only nearest available and viable bores are the Taracumbi Plantation bores (RN008433, RN008437 plus storage of 150KL) which are approximately 0.7km north of the intersection on the eastern side of the road along the plantations track, yielding only 1.9 L/s each bore (yield has declined over time). These bores and adjacent storage tanks have been approved for DIPL's use by the PMP and the current user - the Tiwi Land Rangers and can be used for roadworks around Threeways within carting distance as long as Bruce Holland of the Tiwi Rangers is notified first. His contact details are available in Table 1. Note that only one bore should be used at a time here due to their proximity.

For roadworks around Threeways, it is recommended that work commences at the end of the wet (early April) and water can be drawn from the Paru Creek Crossing, and the Taracumbi Creek (at the outstation located off the Milikapiti Access Road) while flows are high, as well as, the plantation bores, utilising the storage tanks onsite. The location of these water sources is shown in Figure 10.



FIGURE 10 RECOMMENDED WATER SOURCES AROUND THREWAYS

6.2 Threeways to Milikapiti Access Road

There are three production bores within 100 metres of the southern end of the Milikapiti Access Road within 6km of Threeways. These bores yield between 1 and 2 L/s approximately. There are no bores for the next 23 km north up to the community of Milikapiti. At Milikapiti, over 50 bores have been drilled around the community over time with a high failure rate or saline water encountered. The location of these bores is shown in Figure 11. Many are used as monitoring bores and a few are currently used as production bores, with 6 bores in the Power and Water borefield, or for irrigation at 'the farm' just west of the borefield. Details of all bores in proximity to the Milikapiti Access Roads are shown in Appendix A.

The deepest bore in the study area was drilled to a depth of 151m in the Milikapiti area to intersect the deeper Moonkinu Member sandstone aquifer, but around 90% of bores are less than 50m in depth, tapping into shallow aquifers in alluvium or the Van Diemen Sandstone. Yields range from 0-10 L/s with only a handful of bores yielding >5L/s.

Around the community, the Tiwi Enterprises' Farm bore (RN027856) has been identified as a possible source (yielding 5 L/s when constructed), but permission will need to be sought (in progress). The freshwater lagoon behind the boat ramp has also been suggested but the access is difficult as there is no existing track as such, and the lagoon will dry out by the end of the dry season (pers. comm. Mark Muller, Operations Manager, Milikapiti Farm and Nursery).

TABLE 2 WATER STRATEGY MATRIX – 3 WAYS TO MILIKAPITI ACCESS ROAD (existing source - green, new bore target - blue)

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
0.7	1	Plantation bores RN008433 and RN008437	685671	8711668	3	<p>Currently an estimated 1.9 L/s is produced by these bores which are located at CH 0.7km. The yield has reduced over time either due to bore deterioration (silting up, corrosion etc) or declining heads. One option could be to redrill a bore nearby e.g. 100m away to get a better yield here.</p> <p>The bores are used intermittently and are under the jurisdiction of the PMP (<i>contact - Quentin Pope</i>) and used by the Tiwi Ranger Manager Bruce Holland. Both parties have approved the use of these bores and adjacent storage tanks.</p> <p>Recommended pump setting depth: 17m in RN008437, 10m in RN008433 (or use existing installed pump).</p>	Verbal permission to use these bores has been given by Bruce Holland and Quentin Pope. Contact either party prior to use to check.
2.8	1	New Bore Target MR1	685762	8713836		Side of road. Estimate drill depth 25m. Expect flow rate 3 L/s.	TLC approval via LURF
5.5	2	Taracumbi Creek	686515	8716376	3-4	There is a standpipe here (installed by PMP). Otherwise the creek was flowing at around 3-4L/s during the site visit and 'never dries up' according to the TO, Marie.	TLC approval via LURF required to take water from creek.
5.5	3	Taracumbi outstation bore RN032883	686452	8716413	1	This bore is currently equipped so the pump would need to be pulled. The bore is meant to be supplying the houses but is disconnected due to leaking pipes. Set pump at 7.5m (or use existing installed pump & adjust headworks for take).	TLC approval via LURF needed.
5.65 (turnoff)	1	Taracumbi Falls	686726	8716654	>50 L/s	Due to the steep and erosive banks between the road and the falls, tanks should be filled from near the road (a turnaround could be made) and layflat rolled out to the falls.	TLC approval via LURF required to take water from Falls.

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
10.6	1	New Bore Target MR2	686379	8721270		Side of road. Estimate drill depth 25m (into Moonkinu sandstone member). Expect flow rate 2-3 L/s.	TLC approval via LURF
15	2	New Bore Target MR3	684288	8724797		Side of road. Estimate drill depth 60m (into Moonkinu sandstone member – deep aquifer). Expect flow rate 3 L/s.	TLC approval via LURF
15.2 Turnoff	1	9 Mile waterhole	683850	8724740	na	This waterhole has good access and a turnaround area. Needs gravel on track to stop erosion.	LURF required to take water from creek.
19	2	New Bore Target MR4	683768	8728504.		Side of road. Estimate drill depth 130m (into Moonkinu sandstone member – deep aquifer). Expect flow rate 3 L/s.	TLC approval via LURF
24	1	New Bore Target MR5	682933	8732869		Side of road. Estimate drill depth 50m (into Van Diemen Sandstone – shallow aquifer). Expect flow rate 2 L/s.	TLC approval via LURF
31	1	Farm Bore RN027856	681231	873105	3 L/s	Farm bore currently at full capacity (current drought conditions) and can't promise it can be used. Regarding post-wet future use, I am awaiting a response from Scott Simpson Tiwi Enterprises regarding potential use after he assessed capacity and demand.	Need approval from Tiwi Enterprises.

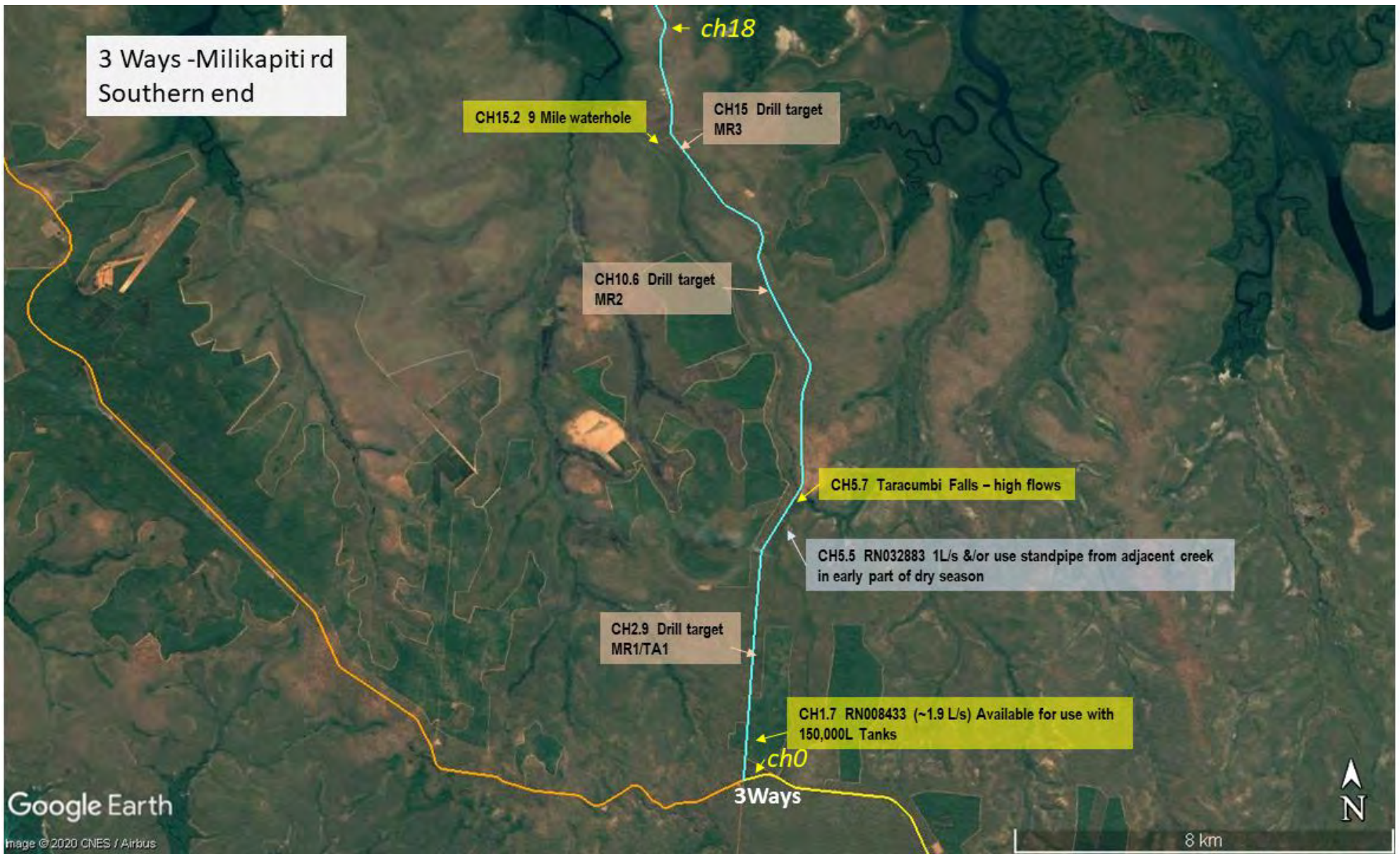


FIGURE 12 WATER SOURCE MATRIX MAP CH0-18



FIGURE 13 WATER SOURCE MATRIX MAP CH18-29

6.3 Threeways to Pirlangimpi Access Road

West of the Threeways intersection, there are no known bores for roughly 20 km. The only known water source for this first stretch of road is a waterhole at around CH 8km and ~1.5km north of the road. It is recommended a bore is drilled to fill this gap, although the flow rate is likely to be low-moderate, there are no other known options. Another target at around CH 13km (PR4 – with moderate prospects) will also be needed to fill the gap between CH10-20km where the distance to waterholes is greater.

There are several Plantation Partners bores around CH 22km, in the vicinity of Maxwell Creek Camp including a good camp production bore and several monitoring bores. None are available for use for roadworks but there are several waterholes to the north of the road that have been used in the past and would be available (pending permission from TLC). Details of all bores in proximity to the Pirlangimpi Access Road are shown in Appendix A.

Between there and approximately 3km east of the Pirlangimpi community, there are no other bores and no known water sources. Hence it will be necessary to construct new road bores at various intervals as proposed in the water strategy matrix and accompanying maps. Power and Water have given permission to use an unused production bore (RN040189- this bore should provide adequate water for the last 10 km or so of road) premised on the following conditions:

Undertake a 48 hour pumping test on the bore to confirm aquifer parameters and bore performance and to ensure viability as a water supply bore.

Power and Water's approval would also be contingent upon:

- 1. Willingness of the proponent to facilitate regular (minimum quarterly) water monitoring (Standing Water Level and salinity (EC)). Consideration should be given to installation of a continuous water level monitoring probe (e.g. a Level Troll®) for the duration of pumping activities. All collected data must be supplied to Power and Water in a timely manner.*
- 2. There being no vehicle staging/storage areas or storage of hazardous materials, fuels or chemicals at or in the vicinity of the bore.*
- 3. Confirmation by the proponent of their commitment to repair or make good any damage to the bore, and reinstatement to its original condition following cessation of use.*

Further, Power and Water will require details of:

- 1. Expected start and end date of operations, and expected frequency and volumes of extraction*
- 2. Details of the type and capacity of the pumps (L/s) to be used, and/or any headworks to be installed (is it proposed to construct a temporary standpipe?),*
- 3. Proposal to reinstate and to secure the bore post pumping.*

The full email is included in Appendix D. TGS can recommend contractors for undertaking a pumping test as required.

The details of all existing and proposed water sources are shown in the following matrix table.

TABLE 3 WATER STRATEGY MATRIX 3WAYS TO PIRLANGIMPI

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
0.7 up Milikapiti Rd	1	Plantation bores RN008433 and RN008437	685671	8711668	3	<p>Currently an estimated 1.9 L/s is produced by these bores which are located at chainage 0.7. The bores are used intermittently and are under the jurisdiction of the PMP (<i>contact - Quentin Pope</i>) and used by the Tiwi Ranger Manager Bruce Holland. Both parties have approved the use of these bores and adjacent 150 000L storage tanks.</p> <p><i>Use existing installed pump. If need to insert pump then recommended pump setting depth: 17m in RN008437, 10m in RN008433.</i></p>	Verbal permission to use these bores has been given by Bruce Holland and Quentin Pope. Contact either party prior to use to check.
5.2	2	New Bore Target PR1a	680833	8710949		On corner of access track to north. Drill depth approx. 30m – 1-2 L/s. Low-moderate prospect.	TLC approval via LURF
8.2 Turnoff. Then 2km track north of road	1	Rolla Plains Water hole on Maxwell Creek	678624	8714231	Barely flowing this year. Could cease to flow by end of dry.	Must prepare access tracks (e.g. gravel surface) to prevent erosion or degradation – they can turn to bulldust easily	LURF required to take water from creek
8.2 Turnoff then 100m north of road at gravel pit	2	New Bore Target PR6	678959	8711920		Targeted to thickest part of sandstone. In gravel pit 100m north of road. Drill depth approx. 30m – 1-3 L/s. Moderate prospect.	TLC approval via LURF
13.2	2	New Bore Target PR4	675524	8715513		Targeted to thickest part of sandstone. Near gravel pit track south of road. Drill depth approx. 40m . Moderate prospect.	TLC approval via LURF

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
19.7 <i>Turnoff. Then 5km track north of road</i>	1	White Water hole on Maxwell Creek	674679	8722521	Could cease to flow by end of dry.	Last 2.3km of track needs to be prepared for water truck to prevent erosion and bulldust. Need turnaround near waterhole.	LURF required to take water from creek.
23.8 <i>Turnoff. Then 2km track north of road</i>	1	Waterhole on Maxwell Creek	672799	8723387	Could cease to flow by end of dry.	2km of track needs to be prepared for water truck to prevent erosion and bulldust	LURF required to take water from creek.
28.2	1	New Bore Target PR7	667903	8726757		Targeted to thickest part of sandstone. Drill depth approx. 50m . 3+L/s Good prospect.	TLC approval via LURF
29.4	2	New Bore Target PR1*	667013	8727552		Targeted to thickest part of sandstone. Drill depth approx. 50m . 3+L/s Good prospect. *Optional target	TLC approval via LURF
33.5	2	New Bore Target PR2*	664966	8730946		Targeted to thickest part of sandstone. Drill depth approx. 50m . 3+L/s Good prospect. * Optional target	TLC approval via LURF
38	1	New Bore Target PR3	662629	8734176		Targeted to thickest part of sandstone. Drill depth approx. 40m . 3+L/s Good prospect.	TLC approval via LURF
42	1	Power and water Bore RN040189	660070	8737117	5 L/s	2017 bore never used. Freshwater. Need access key from Power and Water. Casing ID160mm. Set pump at 25m. Power and Water gives permission to use premised on the carrying out of a 48 hour pumping test to confirm aquifer parameters and bore performance as well as other conditions described in section 7.3)	Power and Water Approval

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
46 (a few km north of road)	1	Large waterhole approx 6km west of Pirlangimpi. Has been used for roadworks water previously.	661162	8738969	na	Track needs to be prepared for water truck to prevent erosion and bulldust.	LURF required to take water from waterhole



FIGURE 14 PIRLANGIMPI ROAD WATER SOURCE MATRIX MAP CH 0-24



FIGURE 15 PIRLANGIMPI MATRIX MAP CH 24-47

6.4 Pickertaramoor Access Road

Only two bores have been drilled along the road between Threeways and the end of Pickertaramoor Access Road tapping small freshwater supplies in the sandstone. One is a Southern Plantation production bore and the other is an investigation bore drilled for Matilda Minerals. These airlifted only 1 L/s and are available for use by DIPL (by verbal permission of PMP). It is recommended that low yielding bores have storage available such as tanks or turkeys' nests to allow maximise use.

There are several production bores around the Pickertaramoor College settlement yielding up to 4 L/s, tapping fresh water from the Van Diemen Sandstone Aquifer. Unfortunately, these provide a marginal supply to the college, and are struggle to keep up with demand in the late dry season especially after a poor wet season, (as is the case now after 2 failed wet seasons – water levels are down to 42m). The college bores cannot be used for roadworks.

Details of all bores in proximity to the Pickertaramoor Access Roads are shown in Appendix A and shown in Figure 2.

A site visit to springs and waterholes near the road was undertaken with a local resident in late August 2020. Potential water-take sites within 3km of the road were identified to the north of the road as shown in Figure 16. Access tracks would have to be made to reach these sites. Potential access to each site is described in the report (attached in Appendix F), however access tracks and extraction of water will be dependent on Tiwi landowner approval. The sites are included at the end of the water source matrix in Table 4.

In addition, a billabong, (Stewards Billabong), located approximately 15km east of the road has previously been used for roadworks, but is probably too far away in this case.

Should the identified water sources and existing bores be insufficient, it is recommended that additional one or two bores (be drilled along this road as proposed in the water strategy matrix). The bores have been sited to intersect the thickest part of the Van Diemen Sandstone (expect 1-2 L/s).

Note that after two poor wet seasons, there is anecdotal evidence that the water tables are lower than usual, and bores are performing poorly or starting to fail. **The option of using the existing road bores, and drilling any additional bores is contingent on whether the wet season is average or above average rainfall.**

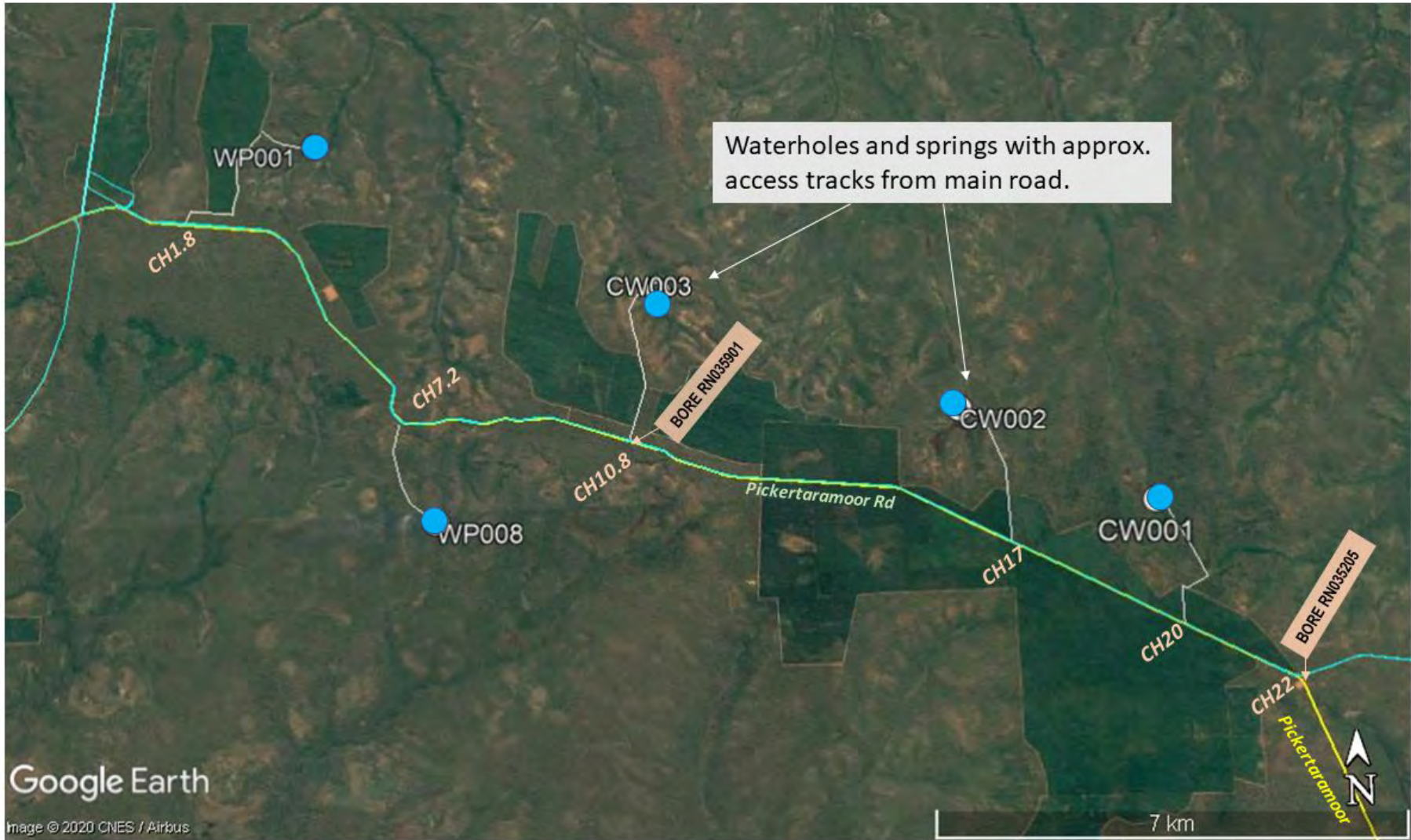


FIGURE 16 MURRAY KNYVETT'S WATERHOLES FOR POTENTIAL USE

TABLE 4 WATER STRATEGY MATRIX 3 WAYS TO PICKERTARAMOOR

(Green -existing sources, blue – new bore targets)

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
Three Ways	1	Taracumbi Outstation Creek and Paru Creek crossing – early in dry season			N/A	5km north and 8km south. Good flows/unlimited supply early in dry season.	TLC approval via LURF required to take water from creeks.
CH 0.7km on Milikapiti Road	1	Plantation bores RN008433 and RN008437	685671	8711668	3	Currently an estimated 1.9 L/s is produced by these bores which are used intermittently and are under the jurisdiction of the PMP (<i>contact - Quentin Pope</i>) and used by the Tiwi Ranger Manager Bruce Holland. Both parties have approved the use of these bores and adjacent 150 000L storage tanks. Use existing installed pump. If need to insert pump then recommended pump setting depth: 17m in RN008437, 10m in RN008433.	Verbal permission to use these bores has been given by Bruce Holland and Quentin Pope. Contact either party prior to use to check.
3.6	1	New Bore Target Picker1	688908	8710256	1-3	Targeted to thickest part of sandstone. Drill depth approx. 30m – 1-3 L/s. Moderate prospect.	TLC approval via LURF
10.4	1	Plantation Bore RN35901	694295	8707091	1	Estimated 1 L/s. Liaise with Quentin Pope regarding use of pump. Recommended pump setting is 28m. 152mm ID casing.	Use has been approved by PMP.

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
13.8	1	New Bore Target Picker 2	697448	8706166	1-3	Targeted to thickest part of sandstone. Drill depth approx. 30m – 1-3 L/s. Moderate prospect.	TLC approval via LURF
20.8	1	Plantations/Matilda Mineral Bore RN035205	704080	8702999	1	Estimated 1 L/s. Liaise with Quentin Pope regarding use of pump. Recommended pump setting is 28m. 152mm ID casing	Use has been approved by PMP.
14km east of road	?	Stewards Billabong	716241	8704443	na	Billabong unlimited water. Run layflat across swamp instead of tracks.	TLC approval via LURF
Murray Knyvett's Springs and Waterholes within 3km Pickertaramoor Road							
Chainage at turnoff on Picker Rd	Access track distance approx. km	Murrays Site Number	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
1.75	3.3	WP001	689208	8711943	unk	This spring flows into a narrow but deep creek that has very good flow rates and appears suitable for water extraction. The best access is from the firebreak approximately 900m to the west of the spring. An excess track following the ridge down from the firebreak would provide good all-weather access to the creek.	TLC approval via LURF
7.2	1.9	WP008	691185	8705753	unk	This is a large deep permanent water hole that does not appear to be flowing. There is a large swamp area on the upstream slope with several smaller waterholes present. This waterhole appears to be spring fed and suitable for water extraction. Access from the gravel pit to the north west following the ridge would be possible via the construction of an access track approximately 1.9km from the main road.	TLC approval via LURF

Chainage (km)	Preference	Recommended Water Source	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes	Permissions and Licences
10.8	2.5	CW003	694751	8709282	unk	This spring fed creek is quite deep and has a very good flow rate. The best access would be from the firebreak to the south west and would require an access track to be constructed to follow the ridge. The distance from the firebreak to the water hole is approximately 1km.	TLC approval via LURF
17.1	2.3	CW002	699408	8707194	unk	Spring with several permanent holes and good flow rates lies within a small floodplain area. The area within 50m of the spring is quite soft and wet but access to the edge of the wet area is relatively easy. There is an existing graded road from the forestry firebreak to within 300m of the spring so only a short access track would need to be constructed to use this water source.	TLC approval via LURF
20	2.4	CW001	702336	8705647	unk	A large permanent spring fed water hole was located at this point. There was a strong flow of water coming from the downstream end of the water hole. The water is located 500m north of the plantation fire break and appears to be relatively easy to access along the ridge from the firebreak. There was an old forestry track approximately halfway between the existing firebreak and the waterhole which may assist with access.	TLC approval via LURF

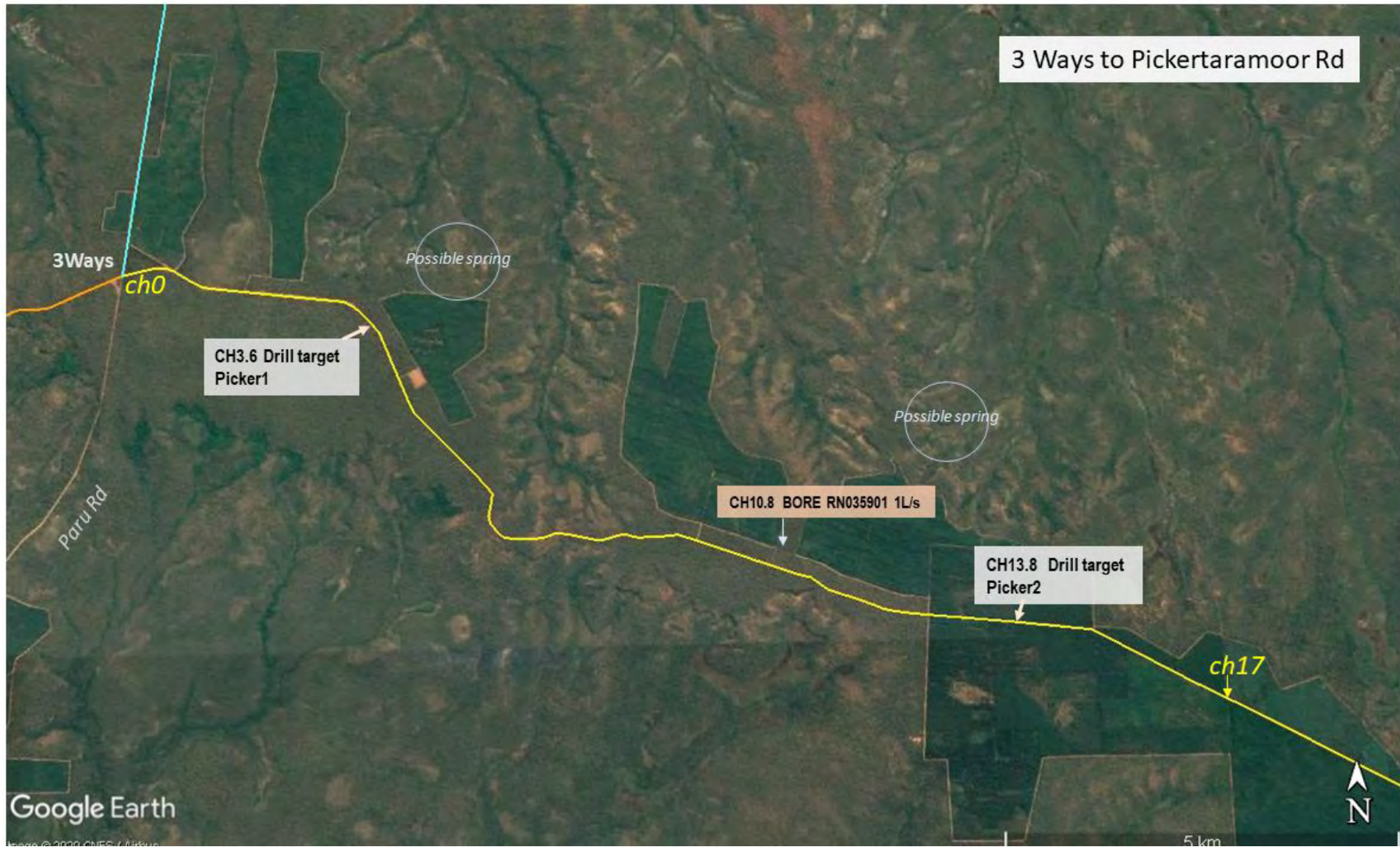


FIGURE 17 PICKERTARAMOOR ROAD WATER SOURCE MATRIX MAP CH 0-17KM



FIGURE 18 PICKERTARAMOOR ROAD WATER SOURCE MATRIX MAP CH17-26

7. NEW ROADS BORES DRILLING TARGETS

A recommended 14 investigation targets are shown in the following table. More targets than will probably be needed have been selected to allow for site preference or poor results. The likely minimum required will be 10 bores. The location is indicative and the exact spot for drilling should be refined on the ground, but as close to the road or trackside as possible to minimise disturbance.

These sites are outside all AAPA restricted work areas but **endangered plant species (particularly *Typhonium sp.*) have not been considered.**

TABLE 5 INVESTIGATION DRILLING TARGETS

<i>Target</i>	<i>Easting</i>	<i>Northing</i>	<i>Estimated Depth</i>	<i>Road</i>	<i>Feature/Target Aquifer</i>
<i>PR7</i>	<i>667903</i>	<i>8726757</i>	<i>50</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR1*</i>	<i>667013</i>	<i>8727552</i>	<i>50</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR2*</i>	<i>664966</i>	<i>8730946</i>	<i>50</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR3</i>	<i>662629</i>	<i>8734176</i>	<i>40</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR1a*</i>	<i>680833</i>	<i>8710949</i>	<i>30</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR6</i>	<i>678959</i>	<i>8711920</i>	<i>30</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>PR4</i>	<i>675524</i>	<i>8715513</i>	<i>40</i>	<i>Pirlangimpi</i>	<i>Van Diemen Sandstone</i>
<i>MR1</i>	<i>685762</i>	<i>8713836</i>	<i>25</i>	<i>Milikapiti</i>	<i>Van Diemen Sandstone</i>
<i>MR2</i>	<i>686379</i>	<i>8721270</i>	<i>25</i>	<i>Milikapiti</i>	<i>Moonkinu sandstone member (deep aquifer)</i>
<i>MR3</i>	<i>684288</i>	<i>8724797</i>	<i>60</i>	<i>Milikapiti</i>	<i>Moonkinu sandstone member (deep aquifer)</i>
<i>MR4</i>	<i>683768</i>	<i>8728504</i>	<i>130</i>	<i>Milikapiti</i>	<i>Moonkinu sandstone member (deep aquifer)</i>
<i>MR5</i>	<i>682933</i>	<i>8732869</i>	<i>50</i>	<i>Milikapiti</i>	<i>Van Diemen Sandstone</i>
<i>Picker 1</i>	<i>688908</i>	<i>8710256</i>	<i>30</i>	<i>Pickertaramoor</i>	<i>Van Diemen Sandstone</i>
<i>Picker 2</i>	<i>697448</i>	<i>8706166</i>	<i>30</i>	<i>Pickertaramoor</i>	<i>Van Diemen Sandstone</i>

- **Optional – depends on site preference.**

Bores should be drilled by the mud rotary method, with a large enough annulus to accommodate a gravel pack. 6 inch casing is adequate here.

Appendix C provides drilling specifications and options for consideration. Drilling Supervision by a qualified hydrogeologist is recommended to ensure an optimal return on the drilling investment.

8. RISK ASSESSMENT

There are two types of potential impacts from groundwater and surface water extraction on Melville Island. The first is the impact on existing users, the second is the potential adverse

8.1 Surface Water Risk Assessment

Taking water from open water bodies such as creeks, billabongs, springs and waterholes carries a number of risks as outlined in the following table:

TABLE 6 SURFACE WATER RISKS AND ACTIONS TO AVOID IMPACTS

Risk	Adverse Impact	Ameliorating Action
Over-extraction of water	Creek ceases to flow or waterhole dries up, or hydrology altered. If surface water body is in connection with underlying aquifer, groundwater tables nearby may be lowered causing bores to fork.	Only 20% of flow or volume of a waterbody should be utilised in the Top End. Do not construct dams or bunds on a natural watercourse. Where a standing water body is <500mm deep or extraction from a water body is likely to exceed 20%, an alternative water source should be sought, or if none are available, consult the Departments Environmental Services Branch for guidance.
Degrading river banks and edges of waterbodies from traffic and use of plant.	Erosion and destabilisation of banks and surrounding areas. Degradation of local vegetation and fauna. Degradation of water quality from siltation.	Protect the banks and beds of any waterhole or river used for water extraction. Keep vehicles away from the edge as much as possible by setting turnarounds away from water source and running layflat. Any damage incurred in the course of water extraction should be immediately repaired and the area rehabilitated. Access tracks should be prepared in order to prevent erosion and degradation.
Degrading water quality	Use and storage of fuels, lubricants near water bodies.	No fuels, lubricants or equipment other than pumping equipment are permitted to enter or remain at the water body. Non-permeable bunding in accordance with AS 1940 is to be provided around pump and generator equipment.

8.2 Impacts on Existing Users of Groundwater Extraction

Groundwater extraction may cause a decline in local groundwater levels. Pumping a bore causes a cone of depression to form around the bore which decreases away from the bore. If two bores are located close enough, there may be interference and impacts on the water levels of the other bore. The degree of water level decline at a given distance from the bore, (the 'zone of influence'), depends on the hydraulic properties of the aquifer, the pumping rate and the design of the well. Thus, each site needs to be considered individually when assessing potential drawdowns and potential for interfering with other bores.

The only users of water along the road are the Plantations operators, the communities at the end of each access road, one small outstation, and Taracumbi Outstation on the Milikapiti Road.

Calculations undertaken during the borefield design at Pirlangimpi in representative aquifer material, indicate that drawdowns would be negligible at distances of over 500m from a pumped bore (Power and Water, 2017). For the purposes of this study, if any bores proposed for roadworks use are within 3km of a community production bore, they will be subject to simple analytical modelling to determine what the drawdown would be given a certain pumping regime.

8.3 Impacts on the Environment from Groundwater Extraction

The main environmental consideration of groundwater extraction is in terms of ecosystems that depend on groundwater for their continued existence and ongoing ecological processes. Such ecosystems could include wetlands, springs, permanent riparian vegetation etc. These ecosystems are known as Groundwater Dependent Ecosystems or GDEs. These environmental values and features could also have Aboriginal cultural significance.

Put simply, lowering water levels by over-pumping can potentially cause springs and wetlands to dry up, and nearby streams to cease to flow. The degree of impact to GDE's will depend on the rate and duration of the groundwater extraction, distance from the feature, and the hydraulic characteristics of the aquifer at that location. Some of the water sources identified in this report are located within a few hundred metres of billabongs and creeklines. Whilst the connection between the aquifers and the surface water features have not been established, they are very likely. Therefore, caution should be applied and water levels monitored during extraction periods. **This risk can be reduced significantly by timing water extraction to the early part of the dry season.**

GDE's in Study Area

A range of terrestrial and aquatic groundwater dependent ecosystems have been identified in the study area as shown in FIGURE 19. These may include riparian vegetation, monsoonal rainforest patches, mangroves and paperbark forests etc. Some of these sites are spring fed, indeed some of the proposed sites for surface water extraction are spring-fed waterholes. Over-extraction of groundwater during the dry season may lower groundwater levels in some places, potentially jeopardising the health of groundwater dependent ecosystems. For this reason, it is important to concentrate the roadworks to the early periods in the dry when water demand will be less, and water supplies more. In general, an average wet season will replenish aquifers, waterholes, and creeks.

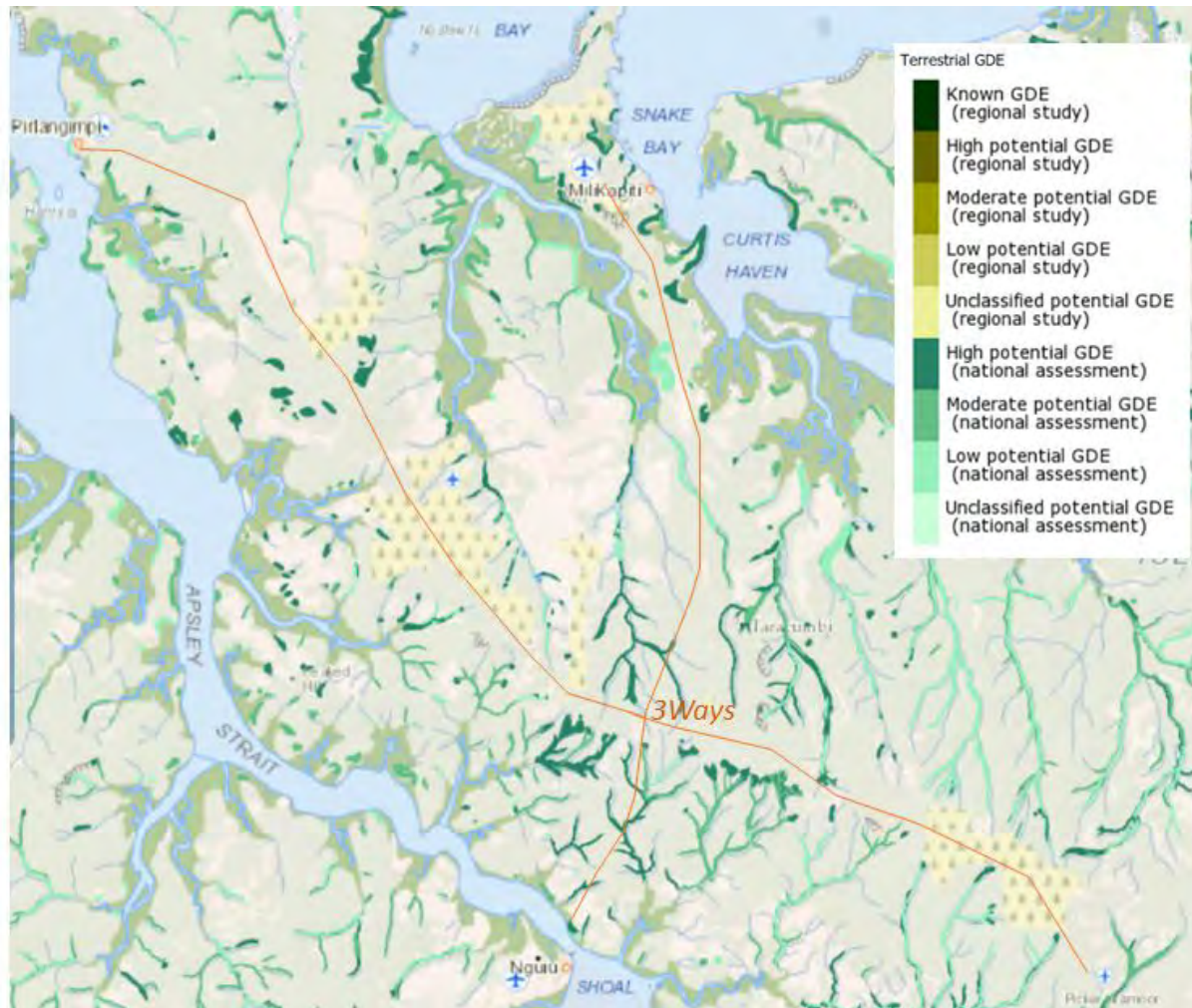


FIGURE 19 TERRESTRIAL GROUNDWATER DEPENDENT ECOSYSTEMS IN STUDY AREA (Extract from GDE Atlas on BOM Website)

TABLE 7 ROADWORKS WATER SUPPLY RISK MATRIX

Risk	Ameliorating Measures
<i>Bore pumping impacting community production bores</i>	<ul style="list-style-type: none"> • <i>Bore extraction should be kept a minimum of 500m from any domestic water supply bore including community borefields.</i> • <i>Pumping rates should be kept as low as possible to minimise drawdown. Storage infrastructure such as tanks and turkeys' nests could be used to facilitate this. As a guide to whether storage is needed - a 3L/s bore would fill a 10,000L water tank in one hour.</i> • <i>Contractors should keep an eye on water levels.</i> • <i>Bores should not be located near springs as over pumping may cause springs to dry up.</i>
<i>Over-extracting from waterholes and creeks impacting some ecosystems which depend on year-round waterholes.</i>	<ul style="list-style-type: none"> • <i>Waterholes and creeks are best accessed early in the dry season when there is plentiful water. Some will cease to flow by the end of the dry season.</i>
<i>Causing erosion on tracks accessing water points.</i>	<ul style="list-style-type: none"> • <i>Tracks should be prepared prior to use by water tanks.</i> • <i>Tracks and turnarounds should be set well back from waterholes and creeks to protect banks and vegetation.</i>

CONCLUSIONS

A comprehensive assessment of hydrogeological conditions along the Milikapiti, Pirlangimpi and Pickertaramoor Access Roads has been completed using all available data. Hydrogeology consists of two main aquifers: shallow sandstone aquifer (Van Diemen Sandstone) and a deeper sandstone aquifer (Moonkinu Member – confined to the north-western part of Melville Island). Several spring fed creeks and waterholes provide potential water sources for roadworks. Additional waterhole sites are still being explored at the time of writing.

Regarding groundwater resources for roadworks, there are very few bores along the roads, but the few that exist have been inspected and recommendations provided as to their potential for use in the network of functioning road bores.

A water supply strategy has been formulated based on the above assessment to achieve the water supply demands for all sections of the road. This provides a clear plan for investment in bore infrastructure and gives some certainty for future planning works.

The next steps are to apply to the Tiwi Land Council for permission to site road bores, and to extract surface water from various sources. These applications were submitted on 27 August 2020.

Although interim approvals have been received from the respective owners for access to surface and ground water sources, the users are still required to submit Land User Request Forms (LURF) via Tiwi Land Council.

Several strategic drilling locations have been recommended of moderate to good prospect. These locations are based on the best knowledge available of the hydrogeological conditions.

As more bores are drilled, providing more understanding of hydrogeological conditions, the drilling target locations should be reviewed.

The specifications for bore drilling and construction provided serve as a guide and should be reviewed on a site by site basis. For any new bores, the most cost efficient approach is to drill six inch pilot (or scout) holes with air if possible (although this may not be possible in the soft sediments) to decide whether there is enough water to warrant bore construction.

Appendix A

Details of Existing Bores in Study Area

Details of Bores within 10km Buffer of Milikapiti Road

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner	Notes
Southern End of Road												
RN008437	0.7	25	150	18-24.7	5	9.7	15	Production	685662	8711690	Plantations	150,000 storage tanks
RN008433	0.7	52	150	10.3-25	5	8.7	29	Production	685671	8711668	Plantations	Might not pump as much as originally
RN032883	5.5	29.1	154	8-12	1.7	4	64	Outstation production	686453	8716409	Tiwi Council	Equipped but leaking at pipeline to house
Milikapiti Community Bores												
RN007950	27.0	10			0	0		Investigation	681530	8737661		
RN023982	26.9	10			0	0	78	Monitoring	681930	8737661		
RN007938	27.0	10.3			0	0		Investigation	681530	8737661		
RN007959	27.0	12.2			0	0	49	Investigation	681530	8737661		
RN007942	27.0	12.2			0	0	380	Investigation	681530	8737661		
RN007943	27.0	12.2			0	0	270	Investigation	681530	8737661		
RN005598	26.3	12.7			0	0	51	Investigation	681830	8737050		
RN024198	26.1	16.8			0	0		Production	681284	8736760		
RN024190	26.0	21.4			7.8	0	49	Production	681330	8736661	Power and Water	Current borefield prod bore PB07
RN024191	26.5	22			0	4		Investigation	681465	8737175		
RN024197	26.3	23			0	0		Investigation	681261	8736995		
RN027856	26.4	23.3			5	2.33	35	Production	681245	8737088	Tiwi Regional Council	The Farm bore
RN024194	26.2	23.7			0	0	55	Monitoring	681347	8736902		
RN024195	26.1	23.8			2	0		Monitoring	681337	8736756		

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner	Notes
RN023988	25.7	24			0	0		Investigation	681023	8736342		
RN024199	26.2	24			0	0		Monitoring	681328	8736896		
RN023981	26.1	23.8			0.1	4	40	Monitoring	681658	8736787		
RN027921		13.1			6.7	0		Monitoring	681930	8737661		
RN023987	26.5	25			0	0	50	Investigation	681245	8737105	Tiwi Regional Council	The Farm
RN027854	25.7	25.2			2	11.21	35	Monitoring	681804	8736441		
RN023984	26.2	26.7			0	0		Production	681249	8736884	Power and Water	Current borefield prod bore PB06
RN005553	25.8	26.8			0	0		Unknown	682529	8736641		
RN024196	26.2	27			0	0	275	Monitoring	681240	8736839		
RN024192	26.0	29			0	0	120	Production	681430	8736711		
RN023983	26.1	29.2			0	4	46	Production	681430	8736811	Power and Water	Current borefield prod bore PB02
RN027858	34.7	30.1			2.5	0	1905	Production	680930	8745361		
RN027859	25.7	30.4			1.4	0	30	Production	681812	8736439	Power and Water	Not equipped
RN023985	25.9	32			0	7.5		Investigation	681352	8736606		
RN027855	26.5	32.3			3	7.34	34	Production	680990	8737061	Power and Water	Current borefield prod bore PB09
RN023989	25.9	32.4			0	0		Investigation	681220	8736584		
RN023986	26.4	33			0	0		Investigation	681014	8737058		
RN027920	25.8	35.1			0.6	0	35	Production	680856	8736421		
RN027851	30.4	53			3	23.49	35	Monitoring	678671	8740576		
RN027853	28.7	53			2.8	27.01	35	Monitoring	678706	8738879		
RN027922	27.6	54.3			3.6	30.14	40	Production	679380	8737911		
RN027857	26.6	58.3			1.2	0	140	Production	680274	8737082	Power and Water	

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner	Notes
RN027923	26.1	130.2			7.5	11.2	190	Production	681231	8736765	Power and Water	Current borefield prod bore PB02 Moonkinu aquifer
RN027852	26.1	139			0	0		Investigation	681130	8736761		Moonkinu aquifer
RN023980	25.3	151			2	34.3	255	Observation	682330	8736070	Power and water	Moonkinu aquifer
RN007950	27.0	10			0	13.11		Investigation	679930	8743761		
RN023982	26.9	10			0	0	78	Investigation	681530	8737661		

Details of Bores within 10km Buffer of Pirlangimpi Road

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner
RN032884	11.3	30.6			4	5.61		Monitoring	676153	8717417	PLANTATIONS
RN032885	14.3	37.5			4	6.65		Monitoring	674555	8720187	PLANTATIONS
RN032886	16.5	46.3			4	6.52		Monitoring	672762	8721472	PLANTATIONS
RN032887	17.8	45.2			5	1		Investigation	671730	8722248	PLANTATIONS
RN035334	17.8	46			10	2.5		Production	671724	8722256	PLANTATIONS
RN035905	18.7	19			0.2	7		Investigation	671097	8722907	PLANTATIONS
RN035902	18.9	17			0.2	11		Investigation	670647	8722762	PLANTATIONS
RN035903	19.1	27			1	11.5		Production	670822	8723277	PLANTATIONS
RN035904	19.4	16			0.5	7		Investigation	670464	8723273	PLANTATIONS
RN040189	36.5	33			5.5	9.21		Monitoring	660052	8737113	Power & Water
RN040187	37.8	56.2			1.2	9.39		Monitoring	658769	8737705	Power & Water
RN040188	38.4	24.7			8.5	5.8		Monitoring	658724	8738575	Power & Water
RN032888	38.8	23.5			3.5	6.1		Monitoring	658077	8738392	O.B. NO 5 melville Island
RN035894	38.8	27			0.3	11		Production	658081	8738404	PLANTATIONS
RN040224	38.9	23.5			5	0		Monitoring	657923	8738489	Power & Water
RN040222	39.1	25			2	0		Monitoring	658201	8738963	Power & Water
RN040220	39.2	27			3.3	2.3		Monitoring	657648	8738569	Power & Water
RN040221	39.4	34			9	0		Monitoring	659006	8740179	Power & Water
RN040228	39.5	0						Unknown	657795	8739149	Power & Water

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner
RN040223	39.5	25.5			4	0		Monitoring	657795	8739153	Power & Water
RN040226	39.6	17			0	0		Monitoring	657276	8738751	Power & Water
RN038616	39.8	38			0.75	10.8		Production	655428	8737106	Tiwi Aboriginal Land Trust
RN038615	39.9	36			1.5	8.8		Production	655750	8737560	Tiwi Aboriginal Land Trust
RN038613	39.9	38			0.6	10.5		Production	655318	8737112	Tiwi Aboriginal Land Trust
RN040182	39.9	31			4	9		Monitoring	656837	8738803	Power & Water
RN038614	39.9	36			2.5	9		Production	655698	8737580	Tiwi Aboriginal Land Trust
RN032889	39.9	29.3			3.5	10.2		Monitoring	656842	8738809	O.B. NO 6 melville Island
RN035208	40.0	19			0.5	10.23		Investigation	655244	8737124	MATILDA MINERALS
RN040225	40.0	30			1.8	0		Monitoring	657126	8739176	Power & Water
RN035206	40.1	0						Investigation	655112	8737122	MATILDA MINERALS
RN040227	40.3	29			2.5	0		Monitoring	656465	8739008	Power & Water
RN040186	40.4	41			4	9.21		Monitoring	656023	8738655	Power & Water
RN040184	40.7	21			2	7.3		Monitoring	656936	8739946	Power & Water
RN040183	40.8	31.5			1	17.4		Monitoring	656335	8739520	Power & Water
RN040185	40.8	31			1.2	16.06		Monitoring	656001	8739272	Power & Water
RN004972	41.1	3.6			0	0		Unknown	655330	8738862	unk
RN005619	41.1	15.5			0	0		Unknown	655530	8739162	unk
RN004973	41.6	0			0	0		Unknown	654630	8738862	unk

Details of Bores within 10km Buffer of Pickertaramoor Road

Bore No.	Km to 3ways	Depth (mbgl)	Casing diameter (mm)	Screened interval (mbgl)	Airlift yield L/s	SWL (mbgl)	EC (uS/cm)	Purpose	Easting	Northing	Owner
RN035901	9.6	38			1	0		Production	694295	8707091	PLANTATIONS
RN035205	20.2	25.8			1	13.27		Investigation	704079	8702992	MATILDA MINERALS
RN009879	23.4	45			1	0		Investigation	705228	8698460	TIWI COLLEGE (TIWI ABORIGINAL LAND TRUST)
RN009878	23.4	49			1.5	0		Production	705228	8698460	TIWI COLLEGE (TIWI ABORIGINAL LAND TRUST)
RN009877	23.4	49			2.26	0		Production	705359	8698616	TIWI COLLEGE (TIWI ABORIGINAL LAND TRUST)
RN037318	23.7	52			3	1.3		Production	705741	8698696	TIWI COLLEGE (TIWI ABORIGINAL LAND TRUST)
RN037317	23.8	50			4	15.5		Production	705753	8698611	TIWI COLLEGE (TIWI ABORIGINAL LAND TRUST)
RN041285	24.2	75			1.2	8		Production	706022	8698231	Tiwi Land Council
RN035204	32.4	33			4.35	9.91		Investigation	717418	8705572	MATILDA MINERALS

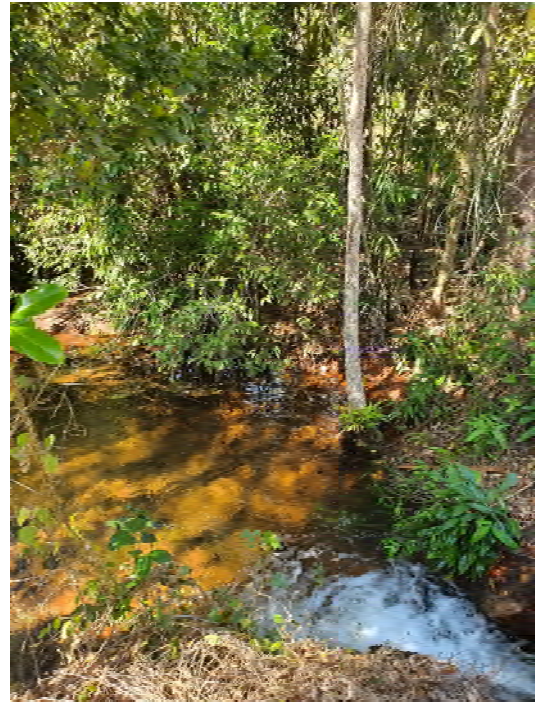
Appendix B

Photos of Water Sources and Drilling Target Sites

Milikapiti Road



Taracumbi Outstation Bore RN32883



Taracumbi Creek at Outstation – Estimated Flow 3-4L/s



Taracumbi Creek at outstation Standpipe



Taracumbi Waterfall

Milikapiti Road Continued



Proposed drill site TA1



Proposed drill site MR2



Proposed Drill site MR1



Proposed drill site MR3



Proposed drill site MR4

Milikapiti Road Continued



Proposed drill site MR5



9 Mile Waterhole

Pirlingimpi Road



Proposed drill site PR2



Proposed drill site PR4



Proposed drill site PR3



Proposed drill site PR6

Pirlingimpi Road Continued



Proposed drill site PR7



Bore RN40189 – 3km east of Pirlingimpi

Appendix C

Drilling Specifications

Bores must be drilled and constructed to meet the minimum requirements for water bores including steel collars, adequate grouts and seals, etc (NUDLC, 2012). A Class 1 Licenced driller is suitable for this area as no artesian or multiple aquifer conditions are expected.

DRILL DEPTHS

Drill depths are provided per site in the Water Strategy Matrix. Generally, if duplicate bores are being drilled adjacent to existing bores, they should consider the original bore depth and construction and follow and/or improve on the design where possible.

DRILLING METHOD

Mud rotary drilling is generally recommended on Melville Island due to loose sands and sandstones.

CASING

A range of casing options are offered depending on budget and the expected substrate conditions.

- Stainless steel is the most expensive but is strong and corrosion-resistant.
- PVC is much less costly but can only be inserted into stable, open holes ('pushing' casing in is not an option). It is non-corrosive, light and easy to handle. PVC-U casing is low in compressive strength relative to steel casing. Class 12 PVC-U should be suitable for water heads in the bore of up to 56m (in unconsolidated material). For greater heads, a class 18 PVC-U should be used. I recommend using glues and screws for joins if using PVC.
- Mild steel has been used for previously constructed road bores, and is good where strength is required, but is subject to corrosion and a relatively short life span depending on groundwater chemistry.
- As expected yields are <6 L/s, 150mm diameter casing is recommended. Should higher yields be encountered (up to 11 L/s), a 200mm diameter casing should be used.

SCREENS

- Wire-wound stainless steel screens are optimal but are high-cost and can be vulnerable to damage when installing. Generally, a 6m length is used but it depends entirely on the aquifer as to where and how much to screen. Aperture size should be chosen based on the expected formation (eg. 0.5mm where fine sands are expected, 2mm or more for firm formation or for coarse gravel).
- Machined or hand slots in casing are acceptable as screens.

- In-line casing – (screens and blank casing of the same diameter welded together and inserted as one string), is the usual bore construction, but in some cases, unstable sections may need to be cased off and smaller diameter screens telescoped in.

Other general design points to take into consideration include:

GRAVEL PACKING

Will generally be required on Melville Island due to sands and soft sandstones. A 2-3mm gravel pack should be sufficient.

MINIMISATION OF IMPACTS TO SITE

The area cleared for drilling should be minimal as possible. Vegetation, in particular trees, should be retained. Creeklines should not be damaged by earthworks, and any extraction of local sandy material for backfill should be done in such a way as damage to natural drainage systems does not occur. At the completion of drilling, the site should be restored as much as possible to previous condition, in particular, earthworks should be undertaken to remove channels, mud pits, etc to original surface conditions.

SUPERVISION

Drilling supervision by an experienced hydrogeologist would be a worthwhile investment to achieve the best possible outcome when drilling and constructing bores. The hydrogeologist can also work with the driller in the planning stages to agree on the best materials and approach.

CONSTRUCTION EXAMPLE

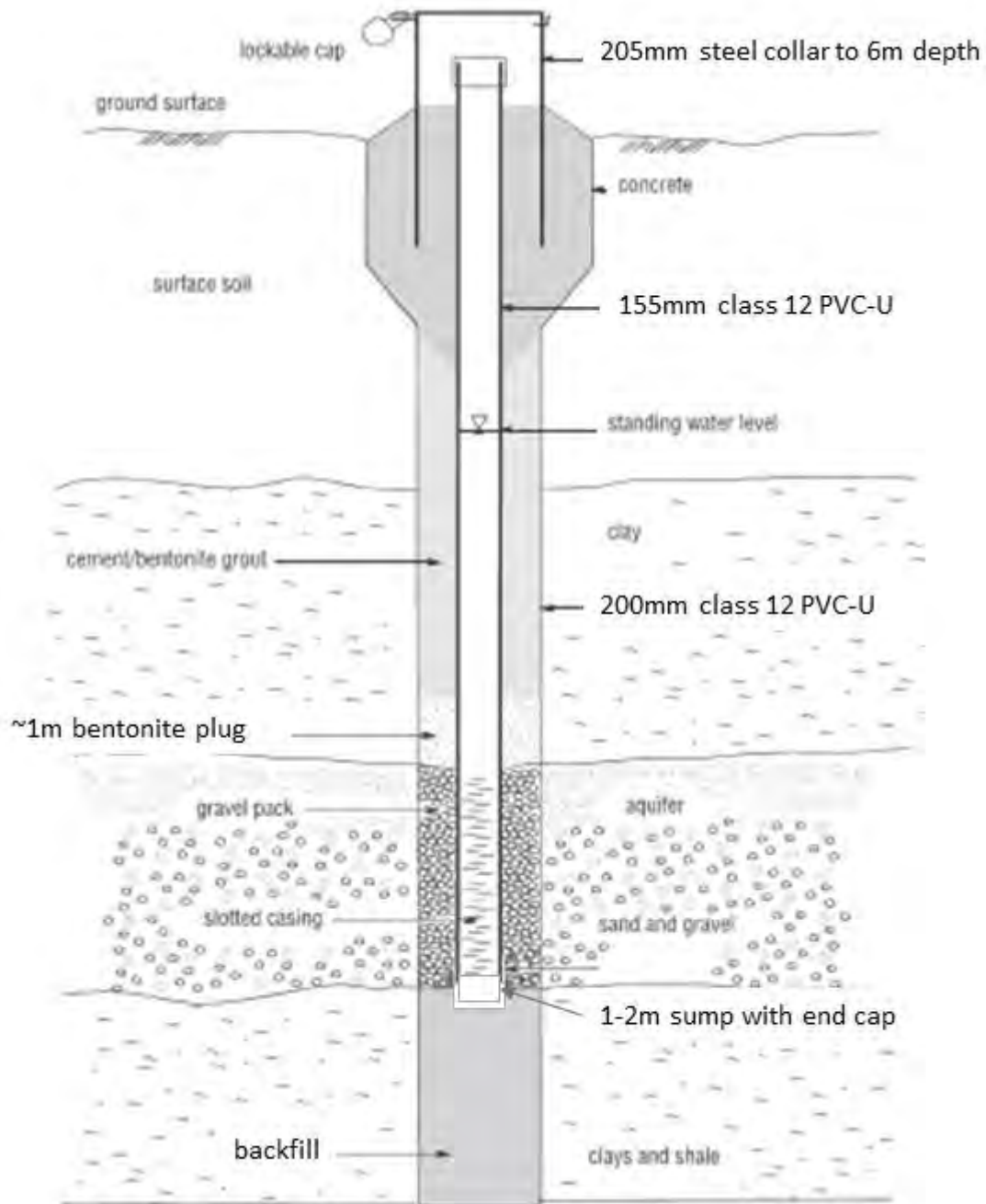
The following outlines a typical approach for drilling an **investigation (pilot or scout) hole**.

<ul style="list-style-type: none">• <i>Air rotary drill a 254mm hole to a depth of ~5.7m.</i>
<ul style="list-style-type: none">• <i>Install a temporary 6m x 205mm steel or PVC collar and grout.</i>
<ul style="list-style-type: none">• <i>Air (or mud if necessary) rotary drill a 152mm hole to depth. Record lithology, penetration rates, depth of water intersections, airlift yield and salinity for each water intersection downhole.</i>
<ul style="list-style-type: none">• <i>If adequate yield available >2L/s, consult with hydrogeologist on screen placement and optimal bore design to maximise yield. Ream out and construct bore as per specifications below.</i>
<ul style="list-style-type: none">• <i>If yield too low, backfill bore with natural cuttings (or use bentonite if multiple aquifers require separation).</i>
<ul style="list-style-type: none">• <i>Remediate site.</i>

The following outlines a typical approach for **constructing either inline steel or PVC production bore**.

<ul style="list-style-type: none">• <i>Air rotary drill a 254mm hole to a depth of ~5.7m.</i>
<ul style="list-style-type: none">• <i>Install a 6m x 205mm steel collar to allow stickup of 0.5m. Grout annulus and allow overnight to cure.</i>
<ul style="list-style-type: none">• <i>Air (or mud if necessary) rotary drill a 200mm hole to depth. Record lithology, penetration rates, depth of water intersections, yield and salinity downhole. Ascertain productive zone for screening. Depth hole.</i>
<ul style="list-style-type: none">• <i>Insert casing string with a bottom cap and regularly placed centralisers.</i>
<ul style="list-style-type: none">• <i>Unless the formation is clean hardrock, insert gravel pack fully across the screened section and a minimum of 1m above and 1m below. Insert a 1m bentonite plug above the gravel pack. Either grout to surface or backfill to at least 6m below surface then grout to surface.</i>
<ul style="list-style-type: none">• <i>Airlift for one hour or until water runs clear – measure final airlift yield using a bucket and stop-watch or a v-notch if >10L/s.</i>
<ul style="list-style-type: none">• <i>Depth hole to record final construction depth.</i>
<ul style="list-style-type: none">• <i>Construct headworks with a steel flange/bolts/lock so as to protect bore from damage from bushfires, vandalism, and being hit by vehicles. Install a 1m square by 0.3m thick concrete block around bore. Tag the bore with it's registration number.</i>
<ul style="list-style-type: none">• <i>Remediate site.</i>

The following diagram illustrates the fundamental elements of a suitable roads production bore.



Appendix D

Land Use Request Forms Submitted to Tiwi Land Council August 2020



Tiwi Land Council

LAND USE REQUEST FORM

TLC Use Only

This form seeks Tiwi Land Council approval for land, water and natural resource access and/or modification.

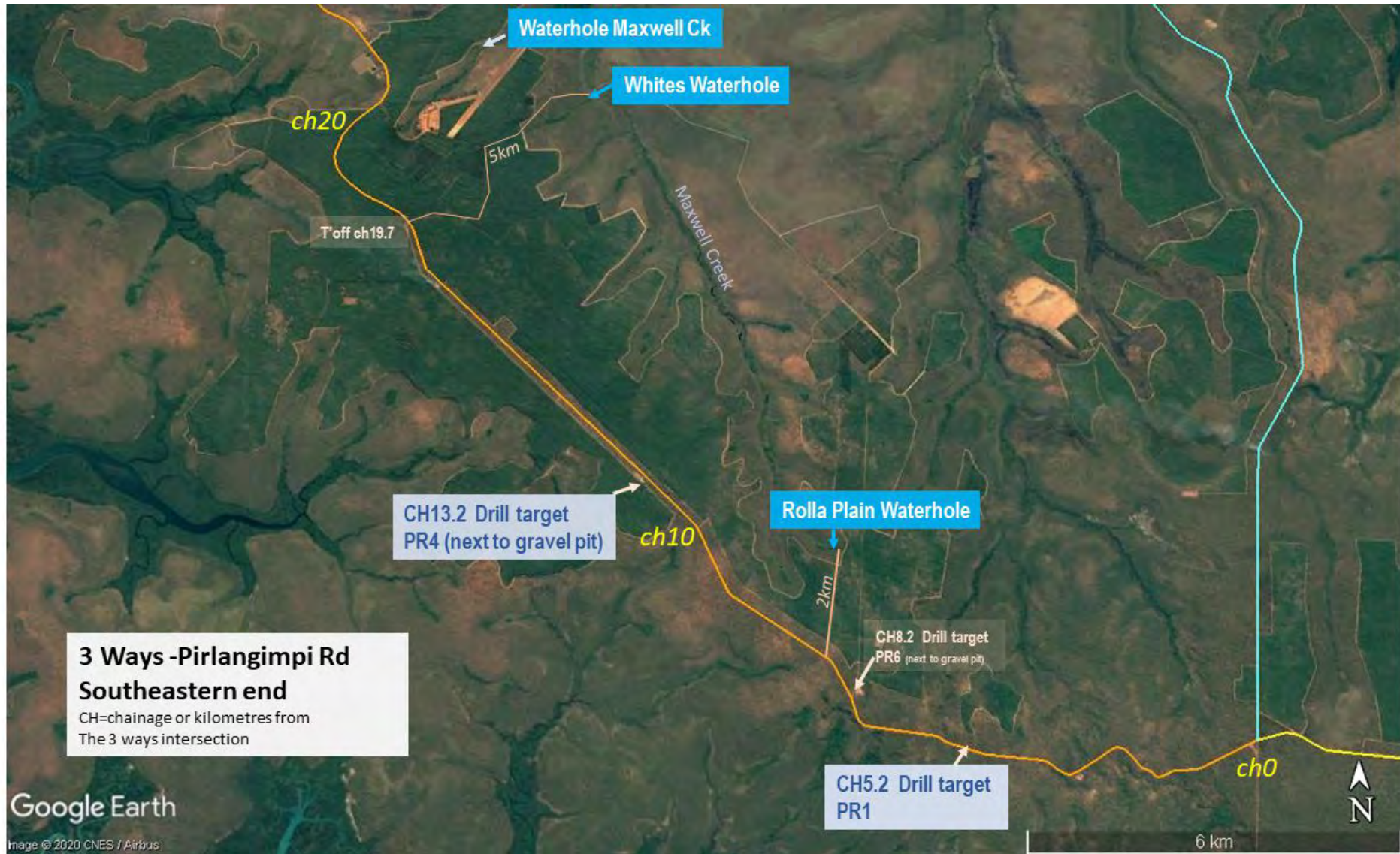
Land Owner Group	Munupi		
Location Details	Pirlangimpi access road		
Proposed Activity	<ol style="list-style-type: none"> 1. Taking water from waterholes for road upgrade works from 2021 onwards 2. Drill new water bores alongside road 		
Person/Organisation Requesting (Proponent)	Maria Woodgate, Consulting Hydrogeologist on behalf of <i>Division of Transport and Civil Services, NT Department of Infrastructure, Planning and Logistics</i>		
Details of Activity: Please provide details such as land disturbance (eg clearing), need for sand/gravel or other materials, access to watering points, need to barge equipment from the mainland etc.			
<p>The road upgrades planned for the dry season of 2021, 2022 and beyond will require water (in the order of 250 kL/day).</p> <p>The proponent would like to seek temporary access to the following identified fresh water supplies:</p> <ol style="list-style-type: none"> 1. 3 waterholes along Maxwell Creek and the large waterhole 6km east of Pirlangimpi along the Blue water Creek. (see attached map) <p>The proponent would also like to get approval to drill at the following roadside sites:</p> <ol style="list-style-type: none"> 2. 5 to 7 (depending on results) new bore drilling sites along the main access road as close to the road as possible. Coordinates and maps attached. 			
Time Frame	April -October 2021 and years thereafter.		
Map and/or Sketch attached (Please ✓ the appropriate box) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			
Comments; include an assessment of risk to land & water (for example soil erosion, weeds, pollution) and Landowners. Include any proposed bringing in of plant and equipment, and any Landowner consultation already carried out:			
<ul style="list-style-type: none"> • The 3 waterholes are already used sometimes for water for roadworks by Plantation Partners. • The drill rig will have to clear a pad of approximately 30x 50m to drill. Trees will not be felled & disturbance will be kept to a minimum, and the site will be rehabilitated immediately afterwards. • The attached photo shows a bore on the Pirlangimpi road a few years after drilling when the vegetation has regrown. 			
The Tiwi Land Council gives the Proponent permission to undertake the above activities.			
	Name	Signature	Date
Landowner Trustee, Delegate or nominated proxy			
Tiwi Land Council Executive Member			
Tiwi Land Council Environment Manager			
Proponent	Maria Woodgate for DIPL		27/8/2020



Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only

INVESTIGATION DRILLING TARGETS

<i>Target</i>	<i>Easting</i>	<i>Northing</i>	<i>Estimated Depth</i>	<i>Road</i>	<i>Feature/Target Aquifer</i>
PR7	667903	8726757	50	Pirlangimpi	Van Diemen Sandstone
PR1*	667013	8727552	50	Pirlangimpi	Van Diemen Sandstone
PR2*	664966	8730946	50	Pirlangimpi	Van Diemen Sandstone
PR3	662629	8734176	40	Pirlangimpi	Van Diemen Sandstone
PR1a*	680833	8710949	30	Pirlangimpi	Van Diemen Sandstone
PR6	678959	8711920	30	Pirlangimpi	Van Diemen Sandstone
PR4	675524	8715513	40	Pirlangimpi	Van Diemen Sandstone



Bore on Pirlangimpi Rd 3 years after drilling.



Tiwi Land Council

LAND USE REQUEST FORM

TLC Use Only

This form seeks Tiwi Land Council approval for land, water and natural resource access and/or modification.

Land Owner Group	Wulirankuru		
Location Details	Milikapiti access road, 3 ways area		
Proposed Activity	<ol style="list-style-type: none"> 1. Taking water from waterholes for road upgrade works from 2021 onwards 2. Drill new water bores alongside road 		
Person/Organisation Requesting (Proponent)	Maria Woodgate, Consulting Hydrogeologist on behalf of <i>Division of Transport and Civil Services, NT Department of Infrastructure, Planning and Logistics</i>		
Details of Activity: Please provide details such as land disturbance (eg clearing), need for sand/gravel or other materials, access to watering points, need to barge equipment from the mainland etc.			
<p>The road upgrades planned for the dry season of 2021, 2022 and beyond will require water (in the order of 200kl/day).</p> <p>The proponent would like to seek temporary access to the following identified fresh water supplies:</p> <ol style="list-style-type: none"> 1. Taracumbi Falls, Taracumbi Creek at Outstation, Paru Rd creek crossing, 9Mile waterhole (see attached map) <p>The proponent would also like to get approval to drill at the following roadside sites:</p> <ol style="list-style-type: none"> 2. 5 new bore drilling sites along the main access road. Co-ordinates and maps are attached. 			
Time Frame	April -October 2021 and years thereafter.		
Map and/or Sketch attached (Please ✓ the appropriate box) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			
Comments; include an assessment of risk to land & water (for example soil erosion, weeds, pollution) and Landowners. Include any proposed bringing in of plant and equipment, and any Landowner consultation already carried out:			
<ul style="list-style-type: none"> • The 3 waterholes are already used sometimes for water for roadworks by Plantation Partners. Extraction would be limited to early in the dry season except for Taracumbi Falls which flows all year around. • The drill rig will have to clear a pad of approximately 30x 50m to drill. Trees will not be felled & disturbance will be kept to a minimum, and the site will be rehabilitated immediately afterwards. • The attached photo shows a bore on the Pirlangimpi road a few years after drilling when the vegetation has regrown. 			
The Tiwi Land Council gives the Proponent permission to undertake the above activities.			
	Name	Signature	Date
Landowner Trustee, Delegate or nominated proxy			
Tiwi Land Council Executive Member			
Tiwi Land Council Environment Manager			
Proponent	Maria Woodgate for DIPL		27/8/2020



Tiwi Land Council LAND USE REQUEST FORM

LURF No.

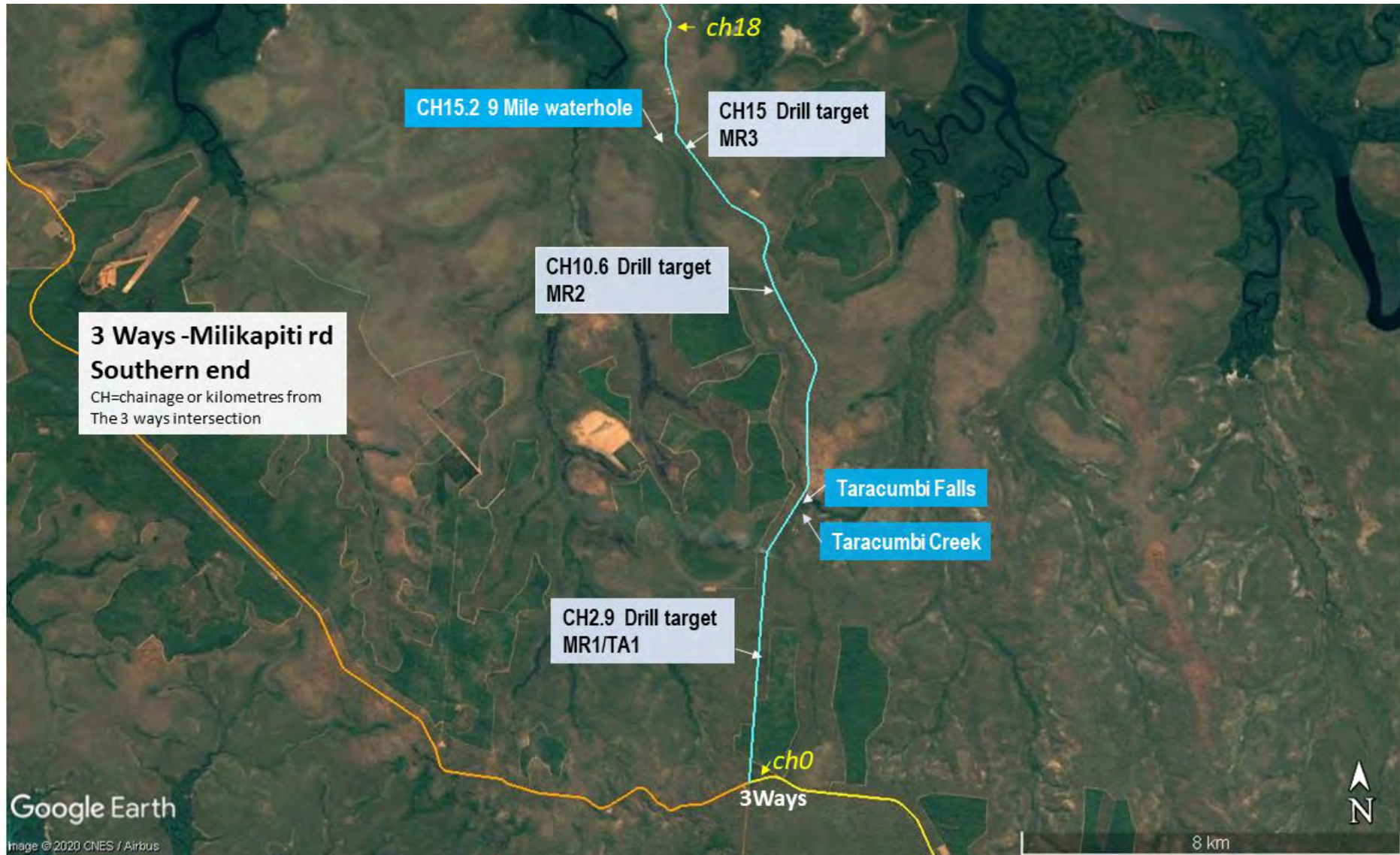
TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only

TABLE 1 INVESTIGATION DRILLING TARGETS

<i>Target</i>	<i>Easting</i>	<i>Northing</i>	<i>Estimated Depth</i>	<i>Road</i>	<i>Feature/Target Aquifer</i>
MR1	685762	8713836	25	Milikapiti	Van Diemen Sandstone
MR2	686379	8721270	25	Milikapiti	Moonkinu sandstone member (deep aquifer)
MR3	684288	8724797	60	Milikapiti	Moonkinu sandstone member (deep aquifer)
MR4	683768	8728504	130	Milikapiti	Moonkinu sandstone member (deep aquifer)
MR5	682933	8732869	50	Milikapiti	Van Diemen Sandstone



Bore on Pirlangimpi Rd 3 years after drilling.



Tiwi Land Council

LAND USE REQUEST FORM

TLC Use Only

This form seeks Tiwi Land Council approval for land, water and natural resource access and/or modification.

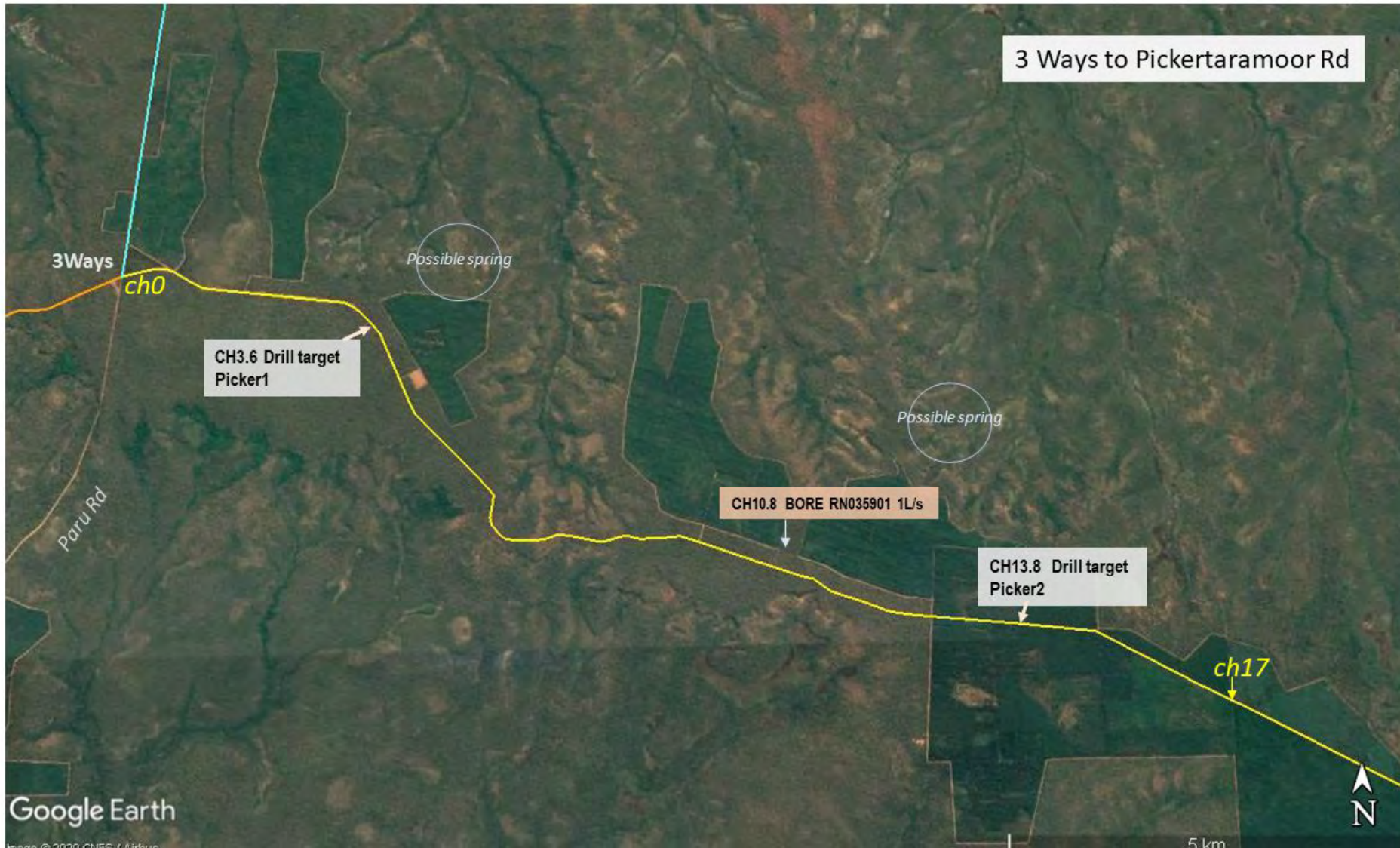
Land Owner Group	Mantiyupwi		
Location Details	Pickertaramoor Road		
Proposed Activity	1. Drill new water bores alongside road for road upgrade works.		
Person/Organisation Requesting (Proponent)	Maria Woodgate, Consulting Hydrogeologist on behalf of <i>Division of Transport and Civil Services, NT Department of Infrastructure, Planning and Logistics</i>		
Details of Activity: Please provide details such as land disturbance (eg clearing), need for sand/gravel or other materials, access to watering points, need to barge equipment from the mainland etc.			
<p>The road upgrades planned for the dry season of 2021, 2022 and beyond will require water (in the order of 200kl/day).</p> <p>The proponent would also like to get approval to drill at the following roadside sites:</p> <p>1. 2 new bore drilling sites along the main access road. Co-ordinates and maps are attached.</p>			
Time Frame	April -October 2021 and years thereafter.		
Map and/or Sketch attached (Please ✓ the appropriate box) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			
Comments; include an assessment of risk to land & water (for example soil erosion, weeds, pollution) and Landowners. Include any proposed bringing in of plant and equipment, and any Landowner consultation already carried out:			
<ul style="list-style-type: none"> The drill rig will have to clear a pad of approximately 30x 50m to drill. Trees will not be felled & disturbance will be kept to a minimum, and the site will be rehabilitated immediately afterwards. The attached photo shows a bore on the Pirlangimpi road a few years after drilling when the vegetation has regrown. 			
The Tiwi Land Council gives the Proponent permission to undertake the above activities.			
	Name	Signature	Date
Landowner Trustee, Delegate or nominated proxy			
Tiwi Land Council Executive Member			
Tiwi Land Council Environment Manager			
Proponent	Maria Woodgate for DIPL		27/8/2020



Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only





Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only

TABLE 1 INVESTIGATION DRILLING TARGETS

<i>Target</i>	<i>Easting</i>	<i>Northing</i>	<i>Estimated Depth</i>	<i>Road</i>	<i>Feature/Target Aquifer</i>
<i>Picker 1</i>	<i>688908</i>	<i>8710256</i>	<i>30</i>	<i>Pickertaramoor</i>	<i>Van Diemen Sandstone</i>
<i>Picker 2</i>	<i>697448</i>	<i>8706166</i>	<i>30</i>	<i>Pickertaramoor</i>	<i>Van Diemen Sandstone</i>



Tiwi Land Council LAND USE REQUEST FORM

LURF No.

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Bore on Pirlangimpi Rd 3 years after drilling.



Tiwi Land Council

LAND USE REQUEST FORM

TLC Use Only

This form seeks Tiwi Land Council approval for land, water and natural resource access and/or modification.

Land Owner Group	Mantiyupwi		
Location Details	Pickertaramoor Road		
Proposed Activity	1. Access springs and waterholes for road upgrade works.		
Person/Organisation Requesting (Proponent)	Maria Woodgate, Consulting Hydrogeologist on behalf of <i>Division of Transport and Civil Services, NT Department of Infrastructure, Planning and Logistics</i>		
Details of Activity: Please provide details such as land disturbance (eg clearing), need for sand/gravel or other materials, access to watering points, need to barge equipment from the mainland etc.			
<p>The road upgrades planned for the dry season of 2021, 2022 and beyond will require water (in the order of 200kl/day).</p> <p>The proponent would also like to get approval to take water (if there is sufficient flow or volume at the time)</p> <p>1. 5 spring/waterhole sites north and south of the Pickertaramoor Rd. Co-ordinates and maps are attached.</p>			
Time Frame	April -October 2021 and years thereafter.		
Map and/or Sketch attached (Please ✓ the appropriate box) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			
Comments; include an assessment of risk to land & water (for example soil erosion, weeds, pollution) and Landowners. Include any proposed bringing in of plant and equipment, and any Landowner consultation already carried out:			
<ul style="list-style-type: none"> The water tank would need to access the springs. Temporary access tracks and turn around areas would need to be established. Turn arounds and tracks will be kept away from the waterholes as much as practicable. Disturbance of vegetation will be minimised with no trees to be harmed. Watercourse will be protected from damage to the extent possible by keeping tracks away from the banks and lowlying areas. Water extraction will not occur if flows have ceased or levels drop too low. 			
The Tiwi Land Council gives the Proponent permission to undertake the above activities.			
	Name	Signature	Date
Landowner Trustee, Delegate or nominated proxy			
Tiwi Land Council Executive Member			
Tiwi Land Council Environment Manager			
Proponent	Maria Woodgate for DIPL		9/9/2020



Tiwi Land Council LAND USE REQUEST FORM

LURF No.

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Tiwi Land Council LAND USE REQUEST FORM

LURF No.

TLC Use Only

TABLE 1 LOCATION OF SPRINGS

Access track distance off Picketaramoor Rd approx. km	Murrays Site Number	Easting	Northing	Estimated Flow Rate L/s	Access and Other Notes
3.3	WP001	689208	8711943	unk	This spring flows into a narrow but deep creek that has very good flow rates and appears suitable for water extraction. The best access is from the firebreak approximately 900m to the west of the spring. An excess track following the ridge down from the firebreak would provide good all-weather access to the creek.
1.9	WP008	691185	8705753	unk	This is a large deep permanent water hole that does not appear to be flowing. There is a large swamp area on the upstream slope with several smaller waterholes present. This waterhole appears to be spring fed and suitable for water extraction. Access from the gravel pit to the north west following the ridge would be possible via the construction of an access track approximately 1.9km from the main road.
2.5	CW003	694751	8709282	unk	This spring fed creek is quite deep and has a very good flow rate. The best access would be from the firebreak to the south west and would require an access track to be constructed to follow the ridge. The distance from the firebreak to the water hole is approximately 1km.
2.3	CW002	699408	8707194	unk	Spring with several permanent holes and good flow rates lies within a small floodplain area. The area within 50m of the spring is quite soft and wet but access to the edge of the wet area is relatively easy. There is an existing graded road from the forestry firebreak to within 300m of the spring so only a short access track would need to be constructed to use this water source.
2.4	CW001	702336	8705647	unk	A large permanent spring fed water hole was located at this point. There was a strong flow of water coming from the downstream end of the water hole. The water is located 500m north of the plantation fire break and appears to be relatively easy to access along the ridge from the firebreak. There was an old forestry track approximately halfway between the existing firebreak and the waterhole which may assist with access.

Appendix E

**Report by Murray Knyvett (TLC) on Potential
Spring Water Sources near the Pickertaramoor
Road**

Surface Water Resources – Pickertaramoor Road

28th August 2020

Murray Knyvett assisted by Dennis Dunn

A field assessment of potential water sources was conducted to confirm natural surface water points along the Pickertaramoor road between “Three Ways” and the Pickertaramoor turnoff. Eight potential water sources were identified with approximate GPS coordinates from satellite images (figure 1) and all of them were confirmed to have surface water. Coordinates listed below are the confirmed locations for these water points. Not all the surface water that was confirmed is suitable for extraction, however there may be more potential following a wet season with higher rainfall. Potential access to each site is described below however access tracks and extraction of water will be dependent on Tiwi landowner approval.



The eight potential water points that were assess for water extraction for roadworks.

CW001 S 11 42'10.0 E 130 51'22.8

A large permanent spring fed water hole was located at this point. There was a strong flow of water coming from the downstream end of the water hole. The water is located 500m north of the plantation fire break and appears to be relatively easy to access along the ridge from the firebreak. There was an old forestry track approximately halfway between the existing firebreak and the waterhole which may assist with access.



View of the water hole from the southern side looking north.



View of access from the southern edge of the water hole looking south up the ridge towards the firebreak.

CW002

S 11 41'18.3

E 130 49 46.8

Spring with several permanent holes and good flow rates lies within a small floodplain area. The area within 50m of the spring is quite soft and wet but access to the edge of the wet area is relatively easy. There is an existing graded road from the forestry firebreak to within 300m of the spring so only a short access track would need to be constructed to use this water source.



One of several permanent spring fed water holes.



Flow rates for late dry season are still quite strong.



One of the deeper permanent water holes.



The top hole in the spring system is larger and shallower than the others but feeds into the smaller water holes.

WP007

S 11 43 03.64 E 130 47 55.83

Surface water was located at this position however the water does not appear to be flowing and consists of a shallow swampy area that is difficult to access. This water point would not be suitable for significant water extraction for roadworks.



Shallow swampy water hole not suitable for large volume water extraction.

WP002

S 11 40 07.69 E 130 46 46.33

This site had some small surface water holes that were quite shallow and appeared to have no flow. This site is not suitable for water extraction.



Shallow swampy water hole not suitable for water extraction.

CW003

S 11 40 13.3

E 130 47 11.8

This spring fed creek is quite deep and has a very good flow rate. The best access would be from the firebreak to the south west and would require an access track to be constructed to follow the ridge. The distance from the firebreak to the water hole is approximately 1km.



Good flow rates would make this spring suitable for water extraction.



Permanent flowing water in one of the larger pools.

WP004

S 11 40 18.36 E 130 47 19.22

This water hole contained shallow swampy water with no flow. This site is not suitable for water extraction.



Buffalo have been using this area as a source of water.



Buffalo were observed grazing around the shallow swamp that has no suitable water for extraction.

WP008

S 11 42 08.85 E 130 45 14.81

This is a large deep permanent water hole that does not appear to be flowing. There is a large swamp area on the upstream slope with several smaller waterholes present. This waterhole appears to be spring fed and suitable for water extraction. Access from the gravel pit to the north west following the ridge would be possible via the construction of an access track approximately 1.9km from the main road.



Large permanent water hole that appears suitable for water extraction.



Smaller water hole on the upstream side of the main waterhole.

WP001

S 11 38 47.81

E 130 44 08.27

This spring flows into a narrow but deep creek that has very good flow rates and appears suitable for water extraction. The best access is from the firebreak approximately 900m to the west of the spring. An excess track following the ridge down from the firebreak would provide good all-weather access to the creek.



The spring flows into a deep but narrow creek and appears to be suitable for water extraction.

Appendix F

Relevant Written Correspondence

Email from Shane Papworth Power & Water, 23/8/2020

Hello Maria,

As discussed on the phone, for a variety of reasons Power and Water is normally reluctant to facilitate access to our bores. However in this instance I've spoken to our Operations Manager and he has advised that he has no objections to the temporary use of this bore by DIPL to facilitate road construction activities.

However, as discussed with you, Power and Water's approval would be premised on the willingness of your client to, prior to the commencement regular pumping operations, undertake a 48 hour pumping test to confirm aquifer parameters and bore performance. Bore performance testing would be prudent regardless, to ensure viability as a water supply bore.

Power and Water's approval would also be contingent upon:

1. Willingness of the proponent to facilitate regular (minimum quarterly) water monitoring (SWL and salinity (EC). Consideration should be given to installation of a continuous water level monitoring probe for the duration of pumping activities. All collected data must be supplied to Power and Water in a timely manner.
2. There being no vehicle staging/storage areas or storage of hazardous materials, fuels or chemicals at or in the vicinity of the bore.
3. Confirmation by the proponent of their commitment repair or make good any damage to the bore, and reinstatement to its original condition following cessation of use.

Further, Power and Water will require details of:

1. Expected start and end date of operations, and expected frequency and volumes of extraction
2. Details of the type and capacity of the pumps (L/s) to be used, and/or any headworks to be installed (is it proposed to construct a temporary standpipe?),
3. Proposal to reinstate and to secure the bore post pumping.

Can you please confirm these conditions will be acceptable, and if so, subject to the provision of the requested information, then Power and Water will be able to facilitate formal approval.

Thanks,

Shane

From: Adrian David Costar <Adrian.Costar@powerwater.com.au>

Sent: Tuesday, 4 August 2020 5:29 PM

To: Shane Papworth <Shane.Papworth@powerwater.com.au>

Cc: Scott Evans <Scott.Evans@powerwater.com.au>; Peter Poole <Peter.Poole@powerwater.com.au>

Subject: RE: Melville Island bore use request

Hi Shane,

I am unsure of PWC protocols re water use. However if access was granted I don't think it would be too much to ask to conduct a pumping test (constant rate discharge; continuous pumping over 24-48 hours) – rather than relying on theoretical parameters/values. I note both bores (RN040220/production & RN040189/observation) do not have pumping test data according to the database. I also note the Theis equation is not offered in the letter.

I will discuss further with Scott.

Regards, Adrian

Adrian Costar (BSc. Hon.)

Senior Hydrogeologist | Water Services

Power and Water Corporation

Ben Hammond Complex

Iliffe Street, Woolner

GPO Box 1921, Darwin NT 0801

Tel 08 8924 5327 | Mobile 0402 881 525

powerwater.com.au

adrian.costar@powerwater.com.au

From: Shane Papworth <Shane.Papworth@powerwater.com.au>

Sent: Tuesday, 4 August 2020 4:50 PM

To: Adrian David Costar <Adrian.Costar@powerwater.com.au>

Cc: Scott Evans <Scott.Evans@powerwater.com.au>; Peter Poole <Peter.Poole@powerwater.com.au>

Subject: FW: Melville Island bore use request

Hi Adrian,

Here's one I might ask you to have a look at. I'd already spoken to Maria informally & advised her that as a general rule we usually prefer, for a variety of reasons, that road builders and others source their water elsewhere. But not being particularly familiar with this site or bore I said to send it in & we'll have a look at it.

Thanks,

Shane

From: David Annesley <David.Annesley@powerwater.com.au>

Sent: Wednesday, 1 July 2020 8:10 PM

To: Alana O'Neill <Alana.O'Neill@powerwater.com.au>

Cc: Joanna Ellis <Joanna.Ellis@powerwater.com.au>

Subject: RE: Melville island bores for roadworks

Hi please note there will be a massive demand at Pirlangimpi as the subdivision works start up and run for the next 5 to 6 months

Catch up later this week. Regards David Annesley

Sent from Workspace ONE Boxer

On 1 Jul 2020 2:56 pm, Alana O'Neill <Alana.O'Neill@powerwater.com.au> wrote:

Hi Maria,

Regards bores at Melville; as far as using one of our assets for temporary use RN040189 does look best placed, although we do have hesitation on its use as it is on the fringe of our delicate (yet to be proven) new borefield at Pirlangimpi. We have just equipped this borefield so this dry season and the following will be a true test on the capability of this borefield, of which we have already had to downsize flow rates due to lower (than originally modelled) GW levels. We would ask that DIPL demonstrates to PWC that using monitoring bore RN040189 would not pose a risk of interference to our borefield, especially if the work is planned for the dry when GW levels will be low due to natural discharge. DIPL would need to model potential impact before use, as well as monitor flow rates and surrounding GW levels throughout use.

I spoke to Jo Ellis regards this, and she mentioned that there are bores (of higher salinity) near the coast that were drilled for the barge/port operators a while back, an option to see if this is suitable and perhaps less risk of impact on our bores? (These are low flow and saline & Port Melville do not recommend them for use - MW)

Kind regards,

Alana O'Neill

Hydrogeologist | Asset Management | Water Services

Power and Water Corporation

Ben Hammond Complex

Iliffe Street, Woolner

GPO Box 1921, Darwin NT 0801

Tel 08 8924 5189 | **Mobile** 0401 114 578

powerwater.com.au

alana.o'neill@powerwater.com.au