

Appendix F - TSF Dam Break Assessment

MEMORANDUM

To: Hanking Australia Investment	Date: 08 July 2021
Attn: John Zimmerman	Our Ref: PE21-00859
	KP File Ref.: PE801-00102/04-A djtm M21005
cc: Charles Hastie	From: Dave Morgan

**RE: RUSTLERS ROOST – TSF DAM BREAK AND CONSEQUENCE ASSESSMENT
REV 1**

Knight Piésold Pty Ltd (KP) has been engaged by Hanking Australia Investment (Hanking) to complete a dam break assessment for the Tailings Storage Facility (TSF), to be included as part of the pre-feasibility study for the Rustlers Roost Gold Project. As part of the assessment, the TSF consequence assessment was carried out for the facility, in order to establish severity of impact and population at risk in the event of a dam failure, and to assign minimum design criteria for the facility.

Based on Google Earth imagery and topography, there is risk of a tailings breach impacting the Adelaide River or Mary River, significant national parks, local agriculture and large environmentally sensitive floodplains. A number of sites and local access roads are at risk of being cut off and a number of unclassified buildings are located downstream of the TSF. The ANCOLD 2019 Dam Failure Consequence Category is 'High A'.

A detailed LIDAR survey will need to be conducted to model more accurately inundation mapping downstream. In addition, further design details (water balance, tailings characteristics etc.) will be required to conduct detailed dam breach modelling to establish dam breach formation and discharge flood wave modelling.

This memorandum supersedes memorandum Ref. PE21-00825 issued June 2021.

1. BACKGROUND

Rustlers Roost is a brownfields project located in the Mount Bunday region of the Northern Territory, 100 km south east of Darwin. The redevelopment will include expansion of existing pits, waste rock landforms, water storage dams and internal roads; construction of new infrastructure including an onsite processing facility, a tailings storage facility and groundwater bores for water supply.

The latest design (KP Memorandum PE21-00451) consists of a new TSF with the following characteristics:

- Total tonnage stored of 40 Mt over 10 years;
- Inundation area of approximately 292 Ha;
- Three perimeter embankments designed using the downstream method with a maximum height of 31 m; and
- Foundation geology siltstone underlying the surficial soils throughout the facility.

The site has an average rainfall of 1,455 mm and is in a low seismic zone.

2. CONCEPTUAL APPROACH

A consequence assessment was completed for the TSF in accordance with the requirements of the ANCOLD “Guidelines on the Consequence Categories for Dams” (Ref. 1). The severity rating of a facility is derived by considering the potential impacts of a significant embankment breach and resulting release of tailings slurry in terms of safety, environmental and economic factors.

The assessment is intended to be an Initial Assessment in accordance with the definition provided in Clause 2.1 of the ANCOLD guidelines (Ref. 1) as it is based on low quality topography and limited information relating to the population and communities close to and downstream of the project site. As such the assessment is intended to provide order of magnitude impacts only so as to define the consequence category of the facility for preliminary design. A more detailed and rigorous assessment must be carried out during subsequent design phases once detailed topography is available and further design details (water balance, tailings characteristics etc.) are available.

A dam breach assessment was conducted for potential dam break scenarios for both the Eastern and Western embankments assuming significant loss of containment. The layout of the facility is shown in Figure 2.1. Dam breach modelling is based on the impact should a failure occur and does not consider the likelihood of such a failure occurring. The identified flow paths were used to determine the Population at Risk (PAR), the severity of damage and loss, and hence the consequence category of the facility.

A significant failure of any of the TSF embankments would result in a release of tailings and/or water, though the extent and magnitude of the release would depend on the location of the breach, its size and the cause. For this assessment, the possible breach flow paths for each embankment at final height (when the facility is at its maximum tailings storage volume) were assessed. The critical locations were identified as the Eastern and Western walls of the TSF embankment due to the amount of the tailings capable of mobilising in the event of failure.

The potential breach flow paths for location are shown on Figure 2.2. The red line within the figure indicates the flow path 60 km downstream (based on ANCOLD guidance) due to loss of containment. Google Earth was used to identify any significant infrastructure or items of conservation along this 60 km flow path.

3. ASSESSMENT OF DAM BREAK IMPACTS

3.1 WESTERN BREACH

In the event of failure of the Western embankment of the TSF, tailings have the potential to progress down the valley towards Marrakai Creek (40 km downstream) before entering Adelaide River (47 km downstream). The following impacts may occur (based on review of available topographical survey data and aerial photography) as shown in Figure 3.1:

- Based on Google Earth imagery, there is evidence of farming and agriculture along the lower lying areas of the valley downstream of the TSF and these areas are at risk of inundation by tailings solids;

- It is likely that the tailings solids (suspended in liquor flow) will enter the Adelaide River (47 km downstream) via the existing natural drainage pathways;
- A significant environmental impact is anticipated if tailings were to reach the Adelaide River, the following items have been identified further downstream utilising the Integrated Biodiversity Assessment Tool (ref. 7):
 - Djukbinj National Park;
 - Harrison Dam Conversation Area;
 - Melacca Swamp Conservation Area; and
 - Floodplains of Adelaide and Mary River.
- Some impact to tourism and commerce along the Adelaide River is anticipated especially in the short-term if tailings were to enter the Adelaide River;
- Tailings solids and supernatant water may have adverse impacts on the groundwater quality within the immediate area, and remediation will be required;
- A number of site and local access roads are at risk of being cut off in the event of failure;
- Both tailings solids and contaminated water are likely to be released from the current mining lease; and
- If failure was to occur during a TSF raise, construction workers will be at risk.

At this stage it is not expected that the plant site or accommodation for the project will be affected by a western breach.

3.2 EASTERN BREACH

In the event of failure of the Eastern embankment of the TSF, tailings have the potential to progress down the valley towards Mary River (58 km downstream). The following impacts may occur (based on review of available topographical survey data and aerial photography) as shown in Figure 3.2:

- Based on Google Earth imagery, there is evidence of farming and agriculture along the lower lying areas of the valley downstream of the TSF and these areas are at risk of inundation by tailings solids;
- It is likely that the tailings solids (suspended in liquor flow) will enter the Mary River (58 km downstream) via the existing natural drainage pathways;
- A significant environmental impact is anticipated if tailings were to reach the Mary River with the Mary River National Park and floodplains at risk;
- Some impact to tourism and commerce along the Mary River is anticipated especially in the short-term if tailings were to enter the river system;
- Tailings solids and supernatant water may have adverse impacts on the groundwater quality within the immediate area, and remediation will be required;
- A number of site and local access roads are at risk of being cut off in the event of failure, including the existing site access road;
- The flow path travels close to an existing mine site before crossing the Arnhem Highway at a bridge crossing 21km downstream;
- There is evidence of unclassified buildings located approximately 22 km downstream of the TSF as shown on Figure 3.3. These are located on higher ground typically 100 m away from the flow path. It is assumed conservatively that these buildings will be impacted by the potential flow;
- Both tailings solids and contaminated water are likely to be released from the current mining lease; and

- If failure was to occur during a TSF raise, construction workers will be at risk.

At this stage it is not expected that the plant site or accommodation for the project will be affected by a western breach.

4. POPULATION AT RISK

As part of the estimation of the consequence category as per ANCOLD guidelines, an assessment of the indicative Population at Risk (PAR) was undertaken. There are a number of factors impacting the PAR calculation as follows:

- A number of local and site access roads are located downstream of the TSF and will be accessed daily by locals and staff;
- Once per shift, inspections by Processing Department are expected at the TSF which requires access along the embankment crest and pipeline access road;
- The process site and mine services areas are assumed to be located upstream of the TSF and will be accessed by process and mining personnel hence not impacted;
- There is evidence of camping and tourism along the Adelaide and Mary Rivers;
- A number of unclassified buildings are located along the eastern flow path and are at risk;
- The TSF construction contractor(s) are assumed to be based upstream of the TSF, however it is assumed that some workers may be present at the failure location. It is noted that these workers will only be present for a limited time, during TSF construction phases.

A breakdown of people estimated within the impact area as a whole was based on experience on similar projects within the region, and should be reviewed by Hanking to confirm suitability of the assumptions. It is not anticipated that all people will be downstream of the TSF at the same time; hence a percentage estimate of each role was approximated. A total PAR was then calculated for each dam breach location, and provides an indication of the potential PAR.

4.1 WESTERN BREACH

The indicative population at risk for the western embankment failure is summarised in Table 2.1.

Table 2.1: Indicative Population at Risk (PAR) –Western breach

Population	Number	Affected (%)	PAR
Processing Personnel ¹	50	0%	-
TSF Operation Personnel ¹	2	5%	0.1
TSF Construction Personnel ^{1,2}	25	5%	1.25
Mine Personnel ¹	20	0%	-
Public / Site Roads ¹	5	5%	0.25
Agricultural Fields ¹	5	5%	0.25
Camping ¹	5	5%	0.25
Unidentified (5% Contingency)	-	-	0.1
Total	112		2.2

Notes:

¹ The number of personnel has been estimated based on experience on similar projects within the region;

² TSF Construction Personnel only operational during TSF construction raises.

For the purposes of the hazard assessment a Population at Risk (PAR) of '≥1 to <10' was adopted for this scenario.

4.2 EASTERN BREACH

The indicative population at risk for the eastern embankment failure is summarised in Table 2.2.

Table 2.2: Indicative Population at Risk (PAR) –Eastern breach

Population	Number	Affected (%)	PAR
Processing Personnel ¹	50	0%	-
TSF Operation Personnel ¹	2	5%	0.1
TSF Construction Personnel ^{1,2}	25	5%	1.25
Mine Personnel ¹	20	0%	-
Public / Site Roads ¹	5	5%	0.25
Agricultural Fields	5	5%	0.25
Camping ¹	5	5%	0.25
Unclassified Buildings ¹	20	50%	10
Unidentified (5% Contingency)	-	-	0.6
Total	132		12.8

Notes:

¹ The number of personnel has been estimated based on experience on similar projects within the region;

² TSF Construction Personnel only operational during TSF construction raises.

For the purposes of the hazard assessment a Population at Risk (PAR) of '≥10 to <100' was adopted for this scenario.

5. SEVERITY LEVEL AND CONSEQUENCE ASSESSMENT

An assessment was conducted to determine the severity level of impacts based on ANCOLD 2019 (Ref. 2). An assessment to determine the severity level of impacts from a large-scale failure of the facility (Dam Failure Severity Level) and a spillway flow or other water release (Environmental Spill Severity Level) was conducted. The

likelihood of failure is not considered in the ANCOLD Consequence Category Assessment. The Dam Failure Severity Levels for the Western and Eastern embankments failure scenarios are presented in tables 2.3 and 2.4. The environmental spill failure scenario for the eastern and western failures are considered to be similar and are presented in Table 2.5.

Table 2.3: Severity Level – Dam Failure (Western Embankment)

Damage Type	Dam Failure Severity Level
Infrastructure (dam, houses, commerce, farms, community)	Medium
Damage to the TSF itself is expected to be repairable relatively quickly but at a cost for earthworks. Site and public roads, pipework and power supply cables may be inundated but repairs are expected to be minor. Local access tracks and farms downstream may be impacted but repairs are expected to be minor. Some impact to local tourism along the Adelaide River is anticipated with some reparations likely. The overall cost is assumed to be Moderate (\$10M - \$100M)	
Business Importance	Major
Hanking Investment Australia is a subsidiary of China Hanking Holdings Limited (CHHL). CHHL has Iron and Gold mining assets in China and Australia, with a current market cap of less than US\$1BN. As such, it is considered that failure of the TSF would be crippling to the business, therefore bankruptcy is considered possible in the event of failure.	
Extreme discontent due to environmental impact. There would likely be severe reaction from the community and some loss of business credibility hence “crippling to business” was selected.	
Interim loss of revenue due to suspension of processing.	Minor
Public Health	
It has been assumed that dust arising from tailings solids following the breach will pose a short term and/or long-term health risk to populations in the immediate vicinity of the inundation extents (to be confirmed by geochemical testing); The supernatant water and tailings area assumed to contain environmentally significant contaminants (to be confirmed during geochemical testing). It is assumed less than 100 people will be affected.	
Social Dislocation	Minor
Minor social dislocation (<100 people) would be anticipated for locals whose land may have been impacted by failure.	Catastrophic
Impact Area	
The embankment solids breach inundation has the potential to be greater than 5 km ² but smaller than 20 km ² . It is noted that if solids were to enter water ways downstream containment would be difficult and the impact area would exceed 20 km ² due to the flat low lying areas.	Medium
Impact Duration	
Impact is not expected to exceed 5 years in duration.	Catastrophic
Impact on Natural Environment	
Remediation expected to be difficult due to the high expected runout distance and impact area.	
Significant effects are expected on the Adelaide River system located 47 km downstream of the TSF.	
A number of threatened and endangered species are located within the Adelaide River system and some impact is anticipated.	
Djukbinj National Park, Harrison Dam Conversation Area, Melacca Swamp Conservation Area and Adelaide and Mary River Floodplains are at risk if failure was to occur.	

Table 2.4: Severity Level – Dam Failure (Eastern Embankment)

Damage Type	Dam Failure Severity Level
Infrastructure (dam, houses, commerce, farms, community)	Medium
Damage to the TSF itself is expected to be repairable relatively quickly but at a cost for earthworks. Site and public roads, pipework and power supply cables may be inundated but repairs are expected to be minor. Local access tracks and farms downstream may be impacted but repairs are expected to be minor. Some impact to local tourism along the Mary River is anticipated with some reparations likely. The overall cost is assumed to be Moderate (\$10M - \$100M).	
Business Importance	Major
Hanking Investment Australia is a subsidiary of China Hanking Holdings Limited (CHHL). CHHL has Iron and Gold mining assets in China and Australia, with a current market cap of less than US\$1BN. As such, it is considered that failure of the TSF would be crippling to the business, therefore bankruptcy is considered possible in the event of failure.	
Extreme discontent due to loss of life and environmental impact. There would likely be severe reaction from the community and some loss of business credibility hence “crippling to business” was selected.	
Interim loss of revenue due to suspension of processing.	Minor
Public Health	
It has been assumed that dust arising from tailings solids following the breach will pose a short term and/or long-term health risk to populations in the immediate vicinity of the inundation extents (to be confirmed by geochemical testing); The supernatant water and tailings area assumed to contain environmentally significant contaminants (to be confirmed during geochemical testing). It is assumed less than 100 people will be affected.	
Social Dislocation	Minor
Minor social dislocation (<100 people) would be anticipated for locals whose land may have been impacted by failure.	
Impact Area	Catastrophic
The embankment solids breach inundation has the potential to be greater than 5 km ² but smaller than 20 km ² . It is noted that if solids were to enter water ways downstream containment would be difficult and the impact area would exceed 20 km ² due to the flat low lying areas.	
Impact Duration	Medium
Impact is not expected to exceed 5 years in duration.	
Impact on Natural Environment	Catastrophic
Remediation expected to be difficult due to the high expected runout distance and impact area.	
Significant effects are expected on the Mary River system located 58 km downstream of the TSF.	
An endangered species is located within the Mary River system and some impact is anticipated.	
The Adelaide River and Mary River Floodplains are at risk if failure was to occur.	

Table 2.5: Severity Level – Environmental Spill (Western/Eastern Embankment)

Damage Type	Dam Failure Severity Level
Infrastructure (dam, houses, commerce, farms, community)	Minor
Damage to the TSF itself is expected to be repairable relatively quickly but at a cost for earthworks and limited to the emergency spillway. Some impact to local tourism along the Mary River is anticipated with some reparations likely. The overall cost is assumed to be Minor (<\$10M).	
Business Importance	Medium
Hanking Investment Australia is a subsidiary of China Hanking Holdings Limited (CHHL). CHHL has Iron and Gold mining assets in China and Australia, with a current market cap of less than US\$1BN. As such, it is considered that an environmental spill failure of the TSF would have significant impacts on the business, however bankruptcy is not considered possible.	
Some discontent due to environmental impact. There would likely be some reaction from the community and some loss of business credibility hence “significant impact business” was selected.	
Discharge into the facility may need be ceased in the short term until the pond can be sufficiently dewatered (if required) and special inspection completed by a Dams Engineer. Duration is anticipated to be relatively short.	Minor
Public Health	
The supernatant water and tailings area assumed to contain environmentally significant contaminants (to be confirmed during geochemical testing). It is assumed less than 100 people will be affected.	
Social Dislocation	Minor
Minor social dislocation (<100 people) would be anticipated for locals whose land may have been impacted by failure.	
Impact Area	Medium
It is expected that the impact area will be limited to the streams and creeks immediately downstream of the TSF, some impact on the immediate area is anticipated. The embankment solids breach inundation has the potential to be greater than 1 km ² but smaller than 5 km ² .	
Impact Duration	Minor
Impact is not expected to exceed 1 years in duration.	
Impact on Natural Environment	Major
Remediation expected to be achieved relatively easily due to the limited impact area.	
For the purpose of this assessment the supernatant is assumed conservatively to have elevated environmentally significant elements (to be confirmed in the next design phase) which may have some impact on the Adelaide River and Mary River systems downstream.	
A number of National parks, Wildlife reserves and conservation areas are located downstream and may be impacted by an environmental spill.	

It is noted that the Severity Level Impact of a breach of the facility is rated as “Catastrophic”. This rating was adopted as any significant breach of either embankment would be expected to flow into the Adelaide River or Mary River, which flows through a number of National parks and Wildlife conservation areas which are home to a number of threatened and endangered species. Additionally, if tailings solids are to enter these waterways, they are likely to be transported as sediment to the ocean and the potential impact area could be in excess of 20 km².

It is likely that there are a considerable number of communities downstream of the project site that rely on the aforementioned rivers for water supply, agriculture, tourism and other activities, which could be severely impacted due to contamination of the river resulting from a significant breach of the TSF. A summary of the results and derivation of the facility consequence categories are shown in Table 2.6.

Table 2.6: Assessment of consequence category (ANCOLD 2019)

Embankment (Table Ref.)	Population at Risk (PAR)	Severity of Damage and Loss	ANCOLD Consequence Category
Western Embankment (Table 2.3)	≥1 to <10	Catastrophic	High B
Eastern Embankment (Table 2.4)	≥10 to <100	Catastrophic	High A
Environmental Impact* (Table 2.5)	<1	Major	Significant

*Eastern and Western environmental impact expected to be similar therefore a single ANCOLD Consequence Category assigned.

Based on a PAR of ≥10 to <100 and Catastrophic severity of impact, a consequence category of ‘High A’ was adopted for the design of the TSF. In accordance with the ANCOLD “Guidelines on Tailings Dams” (Ref. 2) the minimum design criteria for this consequence category are summarised in Table 2.6.

Table 2.6: ANCOLD (2019) design parameters (minimum)

Dam Failure Consequence Category	High A
Dam Spill Consequence Category	Significant
Design Storage Allowance Parameters	
Design Storage allowance	10% AEP notional wet season runoff ¹ (1 in 10)
Extreme Storm Storage	1% AEP, 72-hr flood (1 in 100)
Contingency Freeboard (Wave Run-up)	10% AEP Wind
Contingency Freeboard (Additional Freeboard)	0.3
Emergency Spillway Design Parameters	
Design Flood	PMF
Wave Freeboard Allowance	Nil for given design flood
Design Earthquake Loadings	
Operating Basis Earthquake (OBE)	0.1% AEP (1 in 1,000)
Safety Evaluation Earthquake (SEE)	0.01% AEP (Median 50 th Fractile 1 in 10,000)
Maximum Credible Earthquake (MCE) for post closure	Ground motion from known active faults calculated deterministically or Probabilistically 1 in 10,000 AEP
Factors of Safety	
Long-term drained	1.5 (Effective strength)
Short-term undrained (potential loss of containment)	1.5 (Consolidated Undrained Strength)
Short-term undrained (no potential loss of containment)	1.3 (Consolidated Undrained Strength)
Post-seismic	1.0-1.2 (Post seismic Shear Strength)
Dam Safety / Inspection Frequency	
Comprehensive inspection	By Dams Engineer and Specialist (where relevant) after first year of operation then every 5 years.
Intermediate inspection	By Dams Engineer annually
Routine Inspection	Weekly to twice weekly inspection by operations personnel/ inspector.

¹ Assuming no evaporation and 100% runoff coefficient

These design criteria will be used to develop the design, construction and verification requirements for Rustlers Roost TSF.

6. CONCLUSIONS AND RECOMENDATIONS

The key conclusions from the Dam Breach Assessment for the Rustlers Roost TSF are summarised as follows:

- Based on Google Earth imagery there is evidence of farming and agriculture along the lower lying areas of the valley downstream of the TSF and these areas are at risk of inundation by tailings solids;
- It is likely that the tailings solids (suspended in liquor flow) will enter either the Adelaide River or Mary River via the existing natural drainage pathways;

- Some impact to tourism and commerce along these rivers is anticipated;
- Tailings solids and supernatant water may have adverse impacts on the groundwater quality within the immediate impact area;
- A number of site and local access roads are at risk of being cut off in the event of failure;
- A number of unclassified buildings are located downstream of the TSF, it is assumed conservatively that these buildings will be impacted by the potential flow;
- Both tailings solids and contaminated water are likely to be released from the current mining lease;
- If failure was to occur during a TSF raise, construction workers will be at risk;
- A PAR of '≥10 to <100' is expected for the assumed failure case;
- On the basis of significant impact on the environment the Severity Level would be 'Catastrophic';
- The ANCOLD 2019 Dam Failure Consequence Category is 'High A'; and
- The ANCOLD 2019 Environmental Spill Consequence Category is 'Significant'.

It may be possible to reduce the PAR from '≥10 to <100' to '≥1 to <10' if detailed modelling is completed to confirm that the unclassified buildings identified downstream are not affected. If the PAR were to reduce to '≥1 to <10' the ANCOLD Consequence Category classification would change from 'High A' to 'High B'.

The key recommendations from the Dam Breach Assessment for future work are summarised as follows:

- Dam break assessment to be revisited in subsequent design when geochemical characterisation assessment has been completed;
- Assumptions made in regards to infrastructure locations and number of personnel to be reviewed by Hanking and dam break updated to reflect any significant changes;
- Detailed dam breach modelling will be required to establish dam breach formation and discharge flood wave modelling and should be completed once further design details (water balance, tailings characteristics etc.) are available; and
- A detailed LIDAR survey will need to be conducted within the drainage corridors to the east and west of the TSF, and a hydraulically accurate Digital Terrain Model provided to model accurate inundation mapping.

We trust that this memorandum is sufficient for your current needs. Please contact us if you have any queries.

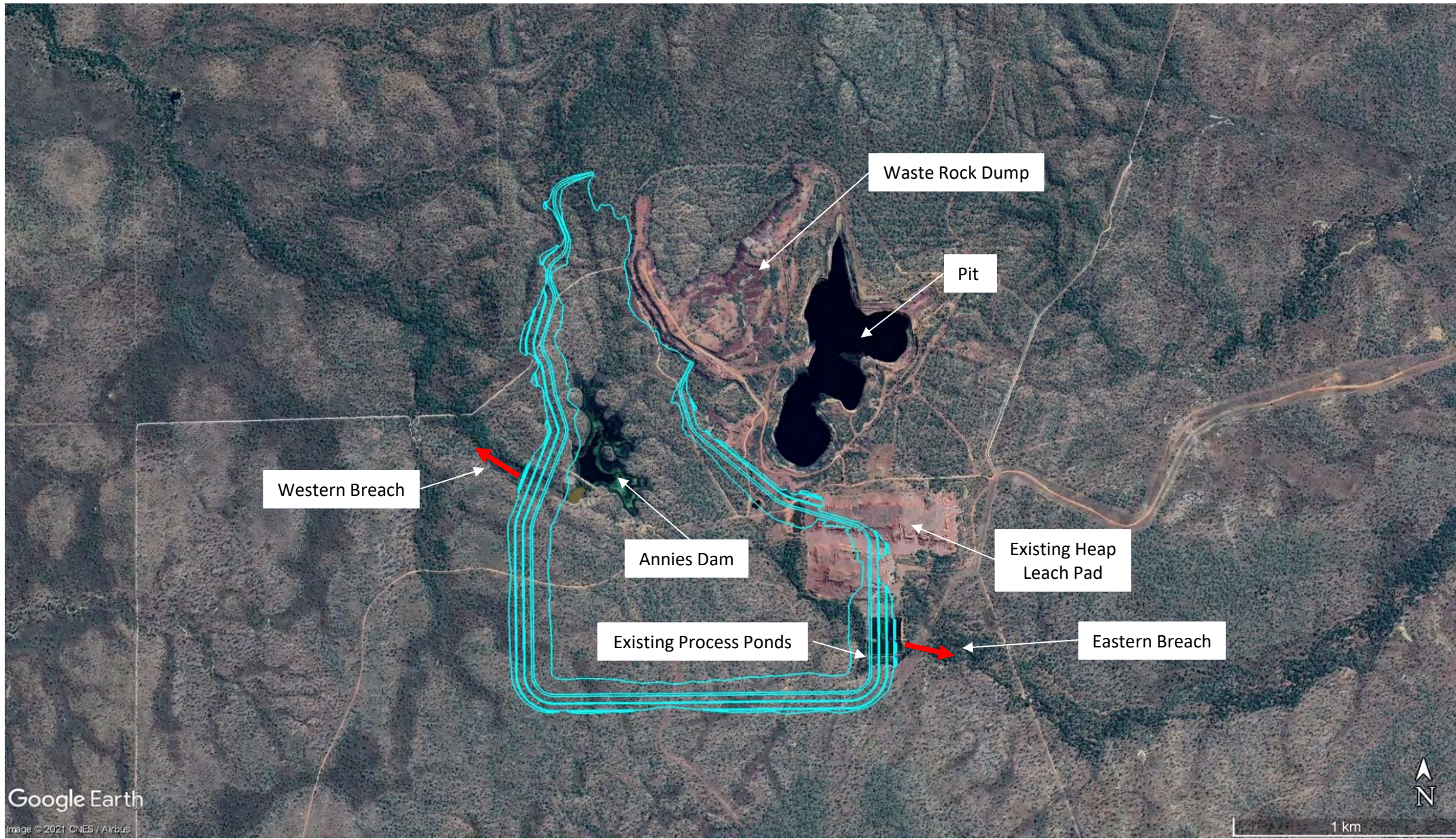
Yours faithfully
KNIGHT PIÉSOLD PTY LTD

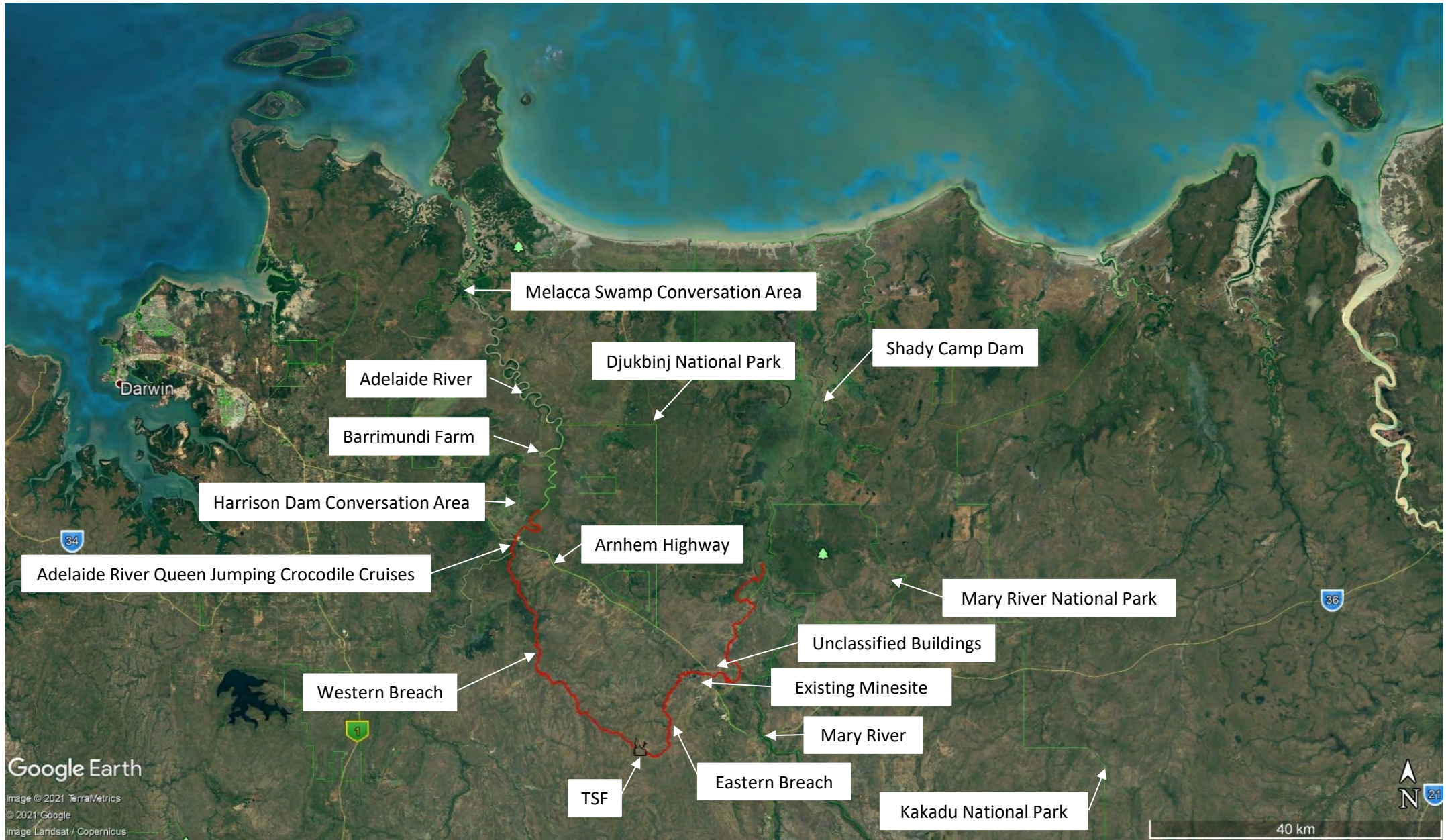

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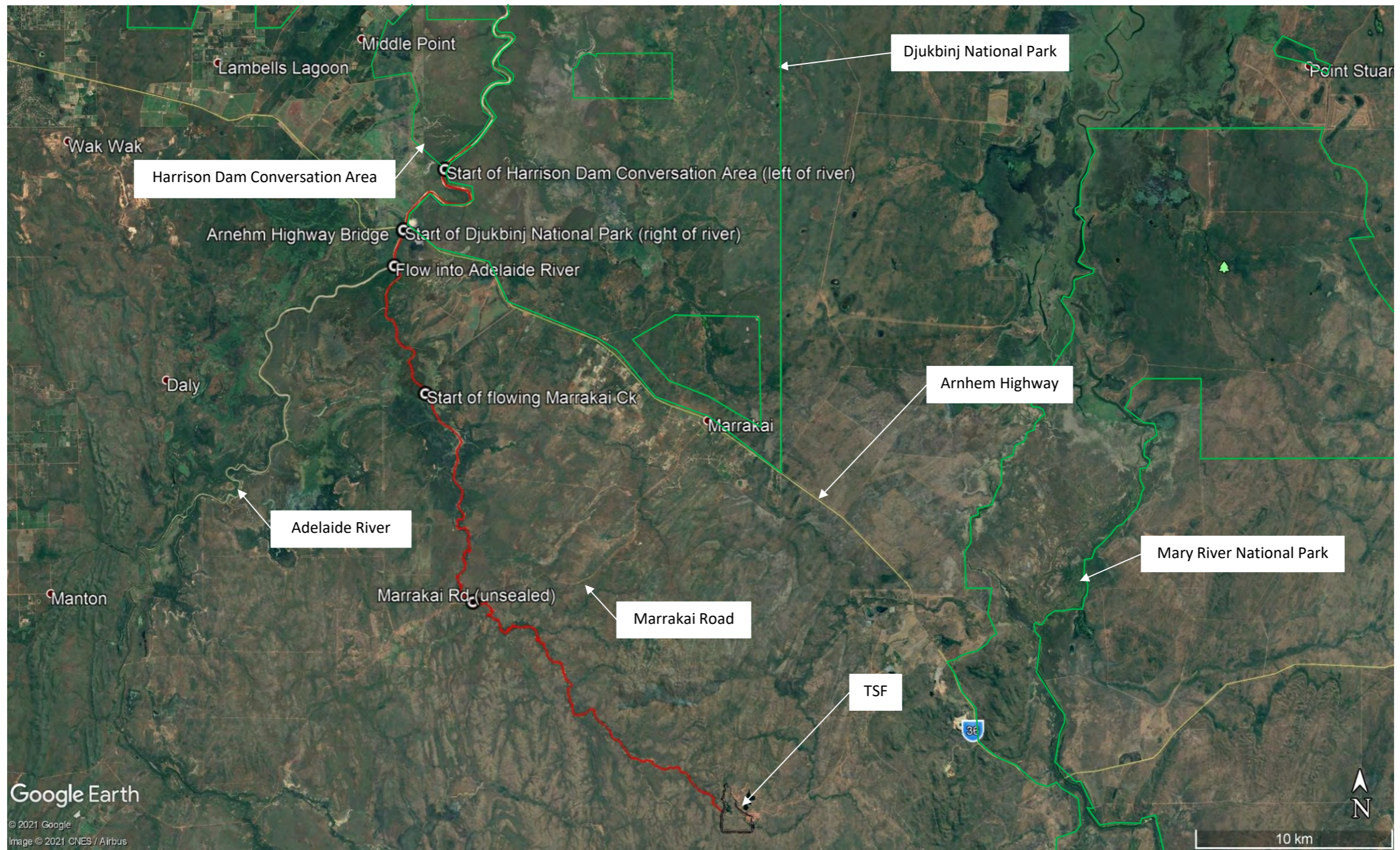
FIGURES

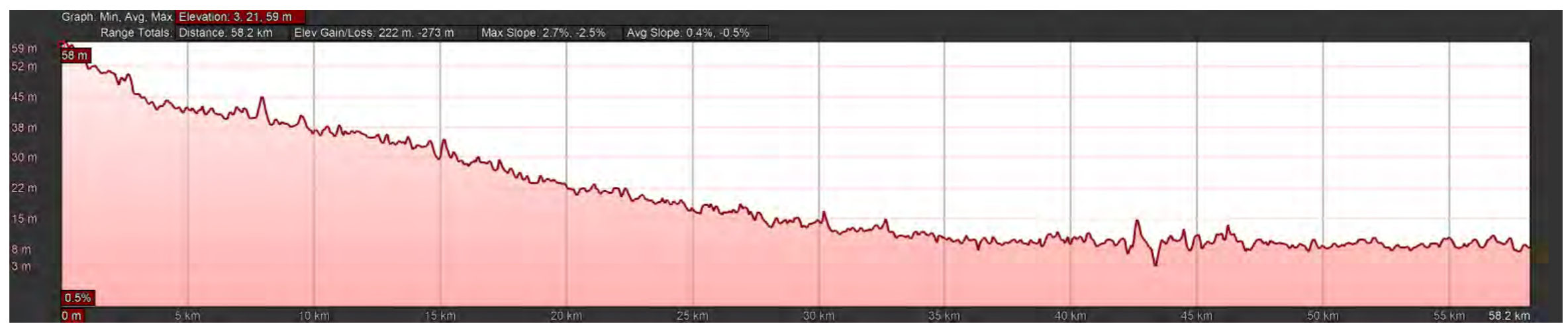
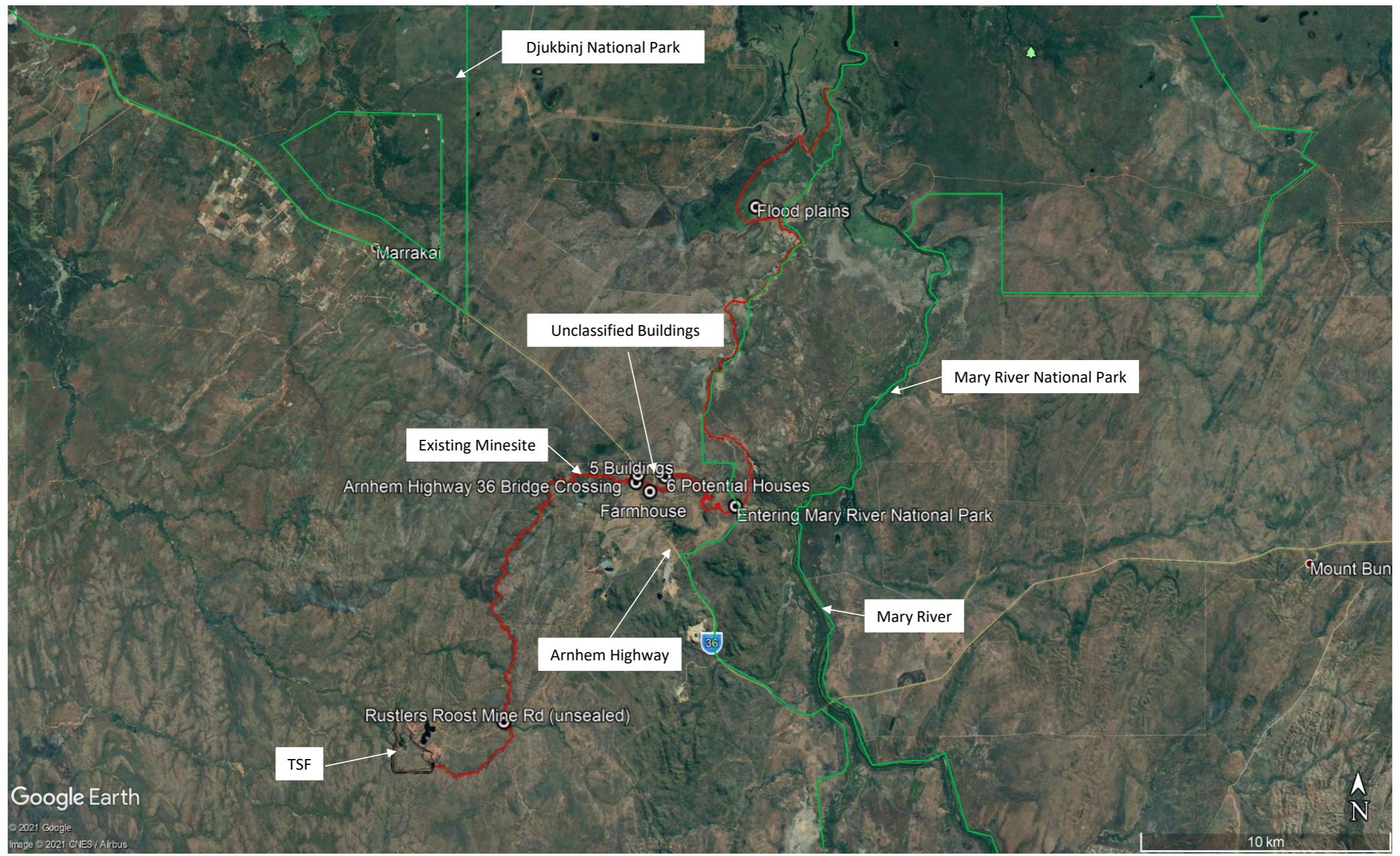




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