# Appendix B

## Water Resources Assessment

PACIFIC ALUMINIUM

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**PACIFIC ALUMINIUM**

# Katherine to Gove Gas Pipeline

## Water Resources Assessments

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29-April-13

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**PROJECT 201001-00367 - KATHERINE TO GOVE GAS PIPELINE**

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# CONTENTS

## Appendices

# 1 INTRODUCTION

Pacific Aluminium (a business unit of Rio Tinto) owns and operates a bauxite mine and alumina refinery at Gove, 650 kilometres (km) east of Darwin in north east Arnhem Land, Northern Territory. The Gove mine and refinery produce high grade alumina which is then shipped to other locations for smelting and further processing.

Power and steam for the Gove Refinery and mining operations are currently generated from imported fuel oil. In order to reduce fuel oil consumption and improve operating costs at the Refinery, it is proposed to provide the facility with natural gas as an alternative fuel source. The lower cost natural gas will help underpin the long term operating viability of the Refinery.

The Katherine to Gove Gas Pipeline (KGGP) is proposed to deliver natural gas from the existing NT Amadeus Gas Pipeline at a point approximately 20 km south of Katherine, to the Gove Refinery. The KGGP would be a high pressure, steel pipeline approximately 603 km long with a nominal diameter of 300mm and a design operating life of 50 years. It will also include above ground facilities at specific locations along the route such as metering facilities, scraper stations, mainline valves and a compressor station. The supplied gas from the Amadeus Pipeline is sales quality so no additional processing of gas would be required. The pipeline would be constructed within a 30 m wide construction corridor and would include supporting infrastructure such as temporary work camps and equipment access tracks to facilitate construction activities.

## 1.1 Purpose of Report

This report has been prepared to Pacific Aluminium to support the draft EIS and address the relevant requirements of the EIS guidelines:

*Baseline*

- *Provide a broad description of any waterways or other wetland habitat, natural or artificial, ephemeral or permanent, including springs and mound springs, that may be impacted by the project. Include a description of catchment systems, existing surface drainage patterns, flow, likelihood of flooding and present water uses.*
- *Provide a description of relevant groundwater resources in any areas likely to be affected by the underground pipes and excavation.*
- *Provide details of the potential locations of pipeline waterway crossings including bed and bank profiles and describe selection criteria for determining the final crossing locations. Include information on the flow regime of the waterways in the vicinity of the pipeline, in particular the timing (and volume) of flows in relation to any construction work.*

*Impacts*

- *Describe how the pipeline might impact on the surface and ground water features described above.*
- *Detail the extent of de-watering that may be required for installation of the pipeline. Describe the potential impacts including the effects of localised lowering of*

*groundwater tables (ie, zone of influence), associated disturbance to wetland and aquatic flora and fauna (if any).*

- *Provide details of typical waterway crossings that would be constructed and likely impacts associated with crossing at each intended location. Consider and discuss the risks associated with the proximity of the proposed condensate pipeline to borefields or aquifer recharge zones that may supply potable water.*
- *Detail the potential impacts from wastewater generated by construction/operational water use including translocation or introduction of non-endemic aquatic fauna and flora.*

*Management*

- *Detail safeguards and management strategies used to minimise the impacts of pipeline construction and operation on the hydrological features described above. In particular, provide details on the following:*
  - o *Measures to safeguard surface and groundwater resources including options for the appropriate treatment and disposal of construction and operational wastewater, and discharge of abstracted water. Identify the preferred option and the selection criteria use.;*
  - o *Measures to ensure the beds and banks of water courses remain stable and protected from the natural forces of erosion as required, incorporating preferred methodologies of DLRM (Department of Land and Resource Management) where practicable particularly where there has been any disturbance to the bank or to the bed.*
  - o *Measures to safeguard downstream water quality including appropriate management of any acid sulphate soils excavated and wetland crossings.*

This report discusses the potential risks (if any) caused to surface water systems (major and minor watercourses) and groundwater assets as a result of the construction and operation of the KGGP. The risks and mitigation measures discussed in this report include:

- Land clearing for the right of way and topsoil stockpiling;
- Disturbances to waterways due to construction activities where the pipelines cross water courses;
- Negative changes to the hydrologic regime of watercourses as a result of surface water abstraction to meet construction water requirements (e.g. to supply water for potable water for camps, dust suppression, hydrostatic pressure testing of pipeline infrastructure);
- Increased erosion and sediment generation due to construction activities;
- Impact on water quality due to discharge of pressure test water and sewerage effluent from construction camps; and
- Fuel and chemical storage and waste disposal during pipeline construction and operation.

This report is structured to address the assessment of surface water and groundwater issues of the draft EIS.

1. Section 6 Surface Water Assessment and
2. Section 7 Hydrogeology Assessment.

## 2 ABBREVIATIONS

| | |
|---|---|
| ASS | Acid Sulfate Soils |
| BoM | Bureau of Meteorology |
| DLRM | Department of Land and Resource Management |
| EIS | Environmental Impact Statement |
| ESCP | Erosion and Sediment Control Plan |
| GDE | Groundwater Dependent Ecosystems |
| GL | Gigalitres |
| GMU | Groundwater Management Units |
| HDD | Horizontal Directional Drilling |
| KGGP | Katherine to Gove Gas Pipeline |
| RoW | Right of Way |
| SWMP | Stormwater Management Plan |
| TDS | Total Dissolved Solids |
| UA | Unincorporated Area |
| WAP | Water Allocation Plan |
| WCD | Water Control District |

# 3 AVAILABLE DATA

The assessment of surface water and groundwater issues has been based on the following:

- Climatic data obtained from the Bureau of Meteorology (BoM, 2013).
- Streamflow data from the Department of Land and Resource Management (DLRM, 2013).
- Report 'North Australian Sustainable Yields' (CSIRO, 2009).
- Report 'North Australian Sustainable Yields' (CSIRO, 2009).
- Trans Territory Underground Pipeline Wadeye to Gove in the Northern Territory – Draft EIS, (TTP, 2004).
- Impacts on Hydrology & Water Quality from the Trans Territory Pipeline Project – Appendix G of Draft EIS (EWLS, 2004).
- Report 'Water Resources of West Arnhem Land' (U. Zaar, 2003).
- Report 'Jawoyn water study' (D. George, 2001).
- Report 'Water Resources of East Arnhem Land' (U. Zaar, G. Prowse and I. Matthews, 1999).

## 3.1 Data Limitations

Available streamflow data has been sourced from DLRM and rainfall data has been sourced from BoM databases. The data available was sufficient to derive a general understanding of the surface water and groundwater resources. It was not possible during the design phase of the project to undertake detailed assessments of the volumes of water that can be obtained from individual streams or bores to enable quantitative guidelines to be developed for management of water resources during the construction period.

No detailed survey of the pipeline RoW (Right of Way) has been undertaken at the time of writing this report, so detailed descriptions of waterway crossings and locations of proposed extractions from surface waters were not able to be provided. It is however, intended to identify all bores drilled within 20km of the RoW with a view to identifying which of these may be suitable for use during the dry season survey during 2013.

It is proposed that appropriate management plans will be prepared following additional investigation and data collection.

# 4 PROJECT WATER SUPPLY STRATEGY

Construction of the gas pipeline has the potential to impact on surface water and groundwater resources due to:

- Extractions of water required for construction activities; and
- Physical changes to waterways and topography along the right of way (ROW).

Water is required for the following construction activities:

- Potable water for construction camps;
- Hydrotesting of pipeline;
- HDD (Horizontal Directional Drilling) creek crossings;
- Dust suppression;
- Compaction of trench backfill; and
- Washdown of vehicles and other miscellaneous purposes.

The projected water usage for the construction period is summarized in Table 4-1.

**Table 4-1 Projected Water Usage During Construction Period**

| Activity | Volume (ML) | Daily Demand (kL/d) |
|---|---|---|
| Camps Potable Water | 50 | 300 |
| Hydrotesting | 24-46 | variable |
| HDD | 0.77 | 23 |
| Dust suppression | 132 | 800 |
| Miscellaneous uses | Minor | <2 |

In order to satisfy the projected water usage, it is proposed to extract water from surface water sources where practicable and sustainable, with minor supplementary extraction from groundwater via existing or new bores, where practicable and sustainable.

The Australian Drinking Water Guidelines (ADWG, 1996) states that good drinking water has a TDS of less than 500mg/L, and that a TDS of 500 – 1000 mg/L is acceptable according to taste, while TDS greater than 1000mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.

The limited water quality data available for surface waters in the Roper River Basin and other river basins in West Arnhem Land indicate TDS generally less than 500mg/L, total alkalinity less than 300 mg/L and pH of 6.1-8.2. Therefore, it is anticipated that water extracted from surface water resources will require sterilisation and minimal treatment for potable use.

In general, the groundwater naturally has a low pH, caused by high levels of dissolved carbon dioxide and can be treated by aeration as is done for the Nhulunbuy water supply (U. Zaar *et. al.,* 1999). Additionally groundwater in West Arnhem Land, which represents approximately half of the pipeline route, has been assessed as suitable for potable use without treatment (U. Zaar, 2003). It is anticipated that water extracted from groundwater bores will require sterilisation and minimal treatment for potable use. Section 6.3.2 of the hydrogeological assessment provides further details of groundwater quality.

The projected construction and camp, non-potable water use includes dust suppression, access track maintenance, vehicle wash-down and other ancillary purposes. It is anticipated that water extracted for non-potable uses, excluding hydrotest water, will not require any treatment. Hydrotest water use and disposal is discussed below in 6.3.2.

If an adequate supply of water cannot be obtained locally from surface water or groundwater, it will be necessary to transport water from other sources. In particular, it may be necessary to transport potable water from Katherine and Gove if the extracted surface water or groundwater quality is not able to be easily treated to potable quality.

The strategy for water supply during the construction period has not been finalised at this time due to insufficient information on flows and water quality available from surface water and groundwater resources, as discussed in 3.1.

Additional investigations of the ‘dry’ season flow behaviour of the surface watercourses and baseflow from groundwater are to be undertaken in order to derive trigger and threshold criteria for appropriate management of extractions from surface water or groundwater sources. The additional investigations may include hydrologic and hydrogeologic modelling and the installation of temporary stream and borehole monitoring equipment to record water levels and selected quality parameters.

# 5 RELEVANT LEGISLATION

The management and protection of water resources in the Northern Territory is controlled under the *Water Act 2011 (*hereafter *The Water Act).* The *Water Act* governs the extent to which both surface and groundwater can be used, and for what purpose. For example, waste discharge to natural waters is prohibited unless licensed under the *Water Act*. Waste Discharge Licences are only available in areas where Beneficial Uses have been declared. If waste is to be discharged to a waterway in areas where no such declaration has been made, the Beneficial Uses must be determined and declared prior to licence issue. This process is normally done in full consultation with the community and as such, may be prohibitive from a timing perspective. With reference to *Subsection* (3) of the *Water Act*, Beneficial Uses mean the uses of water. The following are Beneficial Uses of water:

- Agriculture – to provide irrigation water for primary production including related research;
- Aquaculture – to provide water for commercial production of aquatic animals including related research;
- Public water supply – to provide source water for drinking purposes delivered through community water supply systems;
- Environment – to provide water to maintain the health of aquatic ecosystems;
- Cultural – to provide water to meet aesthetic, recreational and cultural needs;
- Industry – to provide water for industry, including secondary industry and a mining or petroleum activity, and for other industry uses not referred to elsewhere in this subsection; and
- Rural stock and domestic – to provide water for the purposes permitted under sections 10, 11 and 14.

Under Part 3, Division 1 of the *Water Act*, various stipulations are made for the control, protection and management of water resources. For example, under Section 22A and 22B of the *Water Act*, Beneficial uses within Water Control Districts (WCD) are described. At present the only WAP present on the KGGP route is in the Daly River Basin; forming the Daly-Roper WCD.

The Northern Territory Water Act (2011) prohibits the unauthorised taking or use of surface water and unlicensed extraction of groundwater. Under the Act, the Administrator may, on the recommendation of the Minister, by notice in the Gazette, declare that a licence is not required for the taking or use of surface water of a class, kind, description or volume, or at a rate or for a purpose, specified in the notice. Additionally, the Administrator may, on the recommendation of the Minister, by notice in the Gazette, declare that a provision of the *Act* does not apply to or in relation to a bore, or to drainage water or waste, of a class or description specified in the notice.

Section 7 of the *Water Act*, however states that:

***7 Application of Act to mining or petroleum activity***

*(1) Section 15 does not apply to an interference with, or the obstruction of, a waterway if the interference or obstruction occurs in the course of a mining or petroleum activity.*

*(2) Section 16 does not apply to waste that comes into contact with water, or water that is polluted, if:*

*(a) the contact or pollution occurs in the course of carrying out a mining or petroleum activity; and*

*(b) the waste or polluted water is confined within the mining site or petroleum site on which the activity is being carried out.*

*(3) Subject to subsection (4), Parts 5 and 6 do not apply to an action or omission by a person, or to an action or omission caused, suffered or permitted by a person to be done, or to be omitted to be done, by another person, if the action or omission occurs in the course of carrying out a mining or petroleum activity.*

*(4) Part 6, Division 5 applies to the disposal underground of waste in the course of carrying out a mining or petroleum activity on a mining site or petroleum site if the waste is not confined within the mining site or petroleum site.*

Section 15 refers to the obstruction or interference with a waterway; Section 16 refers to the prohibition of pollution; Part 5 refers to surface water works and extraction and Part 6 refers to Groundwater works and extraction.

Consequently, no licenses for extraction of surface or groundwater will be required. It should be noted; however, that this exemption does NOT extend to Section 16 which requires that a waste discharge licence be obtained prior to the discharge of any contaminated water directly into surface or groundwater.

# 6 SURFACE WATER ASSESSMENT

## 6.1 Rainfall

The area encompassing the KGGP route is located within the tropical monsoonal belt of northern Australia, with approximately 90% of all rain falling during the wet season between November and March. Annual rainfall varies from up to 1,800mm in the northern section to less than 900mm in the southern section. Rainfall and evaporation data recorded at Bureau of Meteorology (BoM) stations are summarized in Table 6-1.

**Table 6-1 Annual Rainfall and Potential Evaporation**

| Period | Darwin | | Gove | | Katherine | | Ngukurr | |
|---|---|---|---|---|---|---|---|---|
| | Rain (mm) | Pot. Evap. (mm) | Rain (mm) | Pot. Evap. (mm) | Rain (mm) | Pot. Evap. (mm) | Rain (mm) | Pot. Evap. (mm) |
| Jan | 426.6 | 186.0 | 275.0 | 176.7 | 261.9 | 161.2 | 182.8 | 182.9 |
| Feb | 374.3 | 159.6 | 283.2 | 156.0 | 246.0 | 156.0 | 176.5 | 170.8 |
| Mar | 321.3 | 176.7 | 274.5 | 155.0 | 204.2 | 173.6 | 174.8 | 173.6 |
| Apr | 101.2 | 189.0 | 228.8 | 159.0 | 44.3 | 183.0 | 55.9 | 183.0 |
| May | 21.2 | 210.8 | 89.7 | 167.4 | 5.1 | 173.6 | 10.7 | 173.6 |
| Jun | 1.9 | 204.0 | 31.1 | 156.0 | 0.4 | 147.0 | 5.1 | 159.0 |
| Jul | 1.2 | 210.8 | 18.4 | 161.2 | 1.1 | 170.5 | 1.1 | 170.5 |
| Aug | 5.0 | 223.2 | 5.5 | 189.1 | 1.7 | 201.5 | 0.7 | 207.7 |
| Sep | 15.7 | 228.0 | 5.8 | 201.0 | 6.8 | 228.0 | 1.8 | 231.0 |
| Oct | 70.2 | 248.0 | 11.4 | 223.2 | 33.2 | 244.9 | 13.5 | 272.8 |
| Nov | 139.3 | 222.0 | 44.4 | 219.0 | 88.0 | 222.0 | 42.4 | 255.0 |
| Dec | 251.3 | 204.6 | 181.2 | 207.7 | 223.9 | 189.1 | 131.6 | 226.3 |
| Annual | 1729.3 | 2462.7 | 1461.7 | 2171.3 | 1133.0 | 2250.4 | 815.5 | 2406.2 |

## 6.2 Soils and Topography

The region contains rocks from the McArthur Basin and the Arafura Basin. The oldest rocks are granitic in origin and underlie most of the region. Strata of the Kombolgie Sandstone have been deposited on top of these granites to form the Arnhem Land Plateau; this feature dominates the regional landscape. The sandstone cliffs of the Arnhem Land escarpment were formed by the undermining effect of wave erosion at their base during a period of high ocean levels.

Soils are mostly skeletal or stony on the hills and plateau, with shallow silty soils, some deep sands and alluvial soils on the floodplains. Approximately one-third of the Arnhem Plateau is bare rock.

## 6.3 Surface Runoff

The pipeline passes through the upper section of the Daly River basin, the northern part of the Roper River basin, the central portion of the Goyder River basin and the upper Buckingham River basin between Katherine and Gove. The Daly River basin drains westwards to the Timor Sea, while the Roper River drains eastwards to the Gulf of Carpentaria and the Goyder River and Buckingham River basins drain northwards to the Arafura Sea. The major drainage basins are presented on Figure 6-1 (Dwg 201001-00367-GIS-SKT-019 included in Appendix 1).The upper Daly River basin and Roper River basin are located south of the Arnhem Land Plateau and receive significantly lower annual rainfall (approx. 800-1100mm) than the northern basins draining to the Arafura Sea (approx. 1500-1800mm) (BoM, 2013), with the bulk of the rainfall occurring between October and April, as presented in Table 6-1. Potential evaporation is approx. 2200-2500mm/year over the region and is significantly greater than annual rainfall.

The streamflow characteristics of the watercourses traversed derive from streamflow records at the Department of Land Resource Management (DLRM) gauging stations. Summarised results from the DLRM are shown in Table 6-2, with gauging stations that are located close to the pipeline route shown on Figure 6-2 (Dwg 201001-00367-GIS-SKT-017 included in Appendix 1).

**Table 6-2 Streamflow Data Summary**

| Gauge ID | Stream | Period of Record | Mean Annual Discharge (ML/year) | Area ($km^2$) | Runoff (mm/year) | Max. Flow ($m^3/s$) | Min. Flow (L/s) |
|---|---|---|---|---|---|---|---|
| G8250002 | Goyder River | 1/9/67 – 1/9/02 | 788,940 | 5,440 | 136 | 1,413 | 1830 |
| G8260053 | Latram River | 1/11/63 – 1/11/85 | 25,230 | 85 | 293 | 142 | 65 |
| G8260219 | Giddy River | 1/9/71 – 1/11/86 | 44,150 | 111 | 552 | 617 | 18 |
| G9030003 | Wilton River | 1/9/67 – 1/6/78 | 505,000 | 4,480 | 112 | 2,253 | 14 |
| G9030088/9 | Waterhouse River | 1/12/60 – 1/8/04 | 239,760 | 3,110 | 73 | 1,771 | <10 |

Surface runoff is generally limited to the wet summer monsoon season (December to March), with most watercourses ceasing to flow during the mid to late dry season (July to November). Only the larger rivers are 'permanent' streams, with dry season flow being baseflow supplied from groundwater. Section 7.3.1 and Table 6-1 discuss the baseflow characteristics (estimated minimum flow) of the major river systems where surface water is proposed to be extracted for construction purposes along the KGGP route.


**Figure 6-1 Major Drainage Basins**

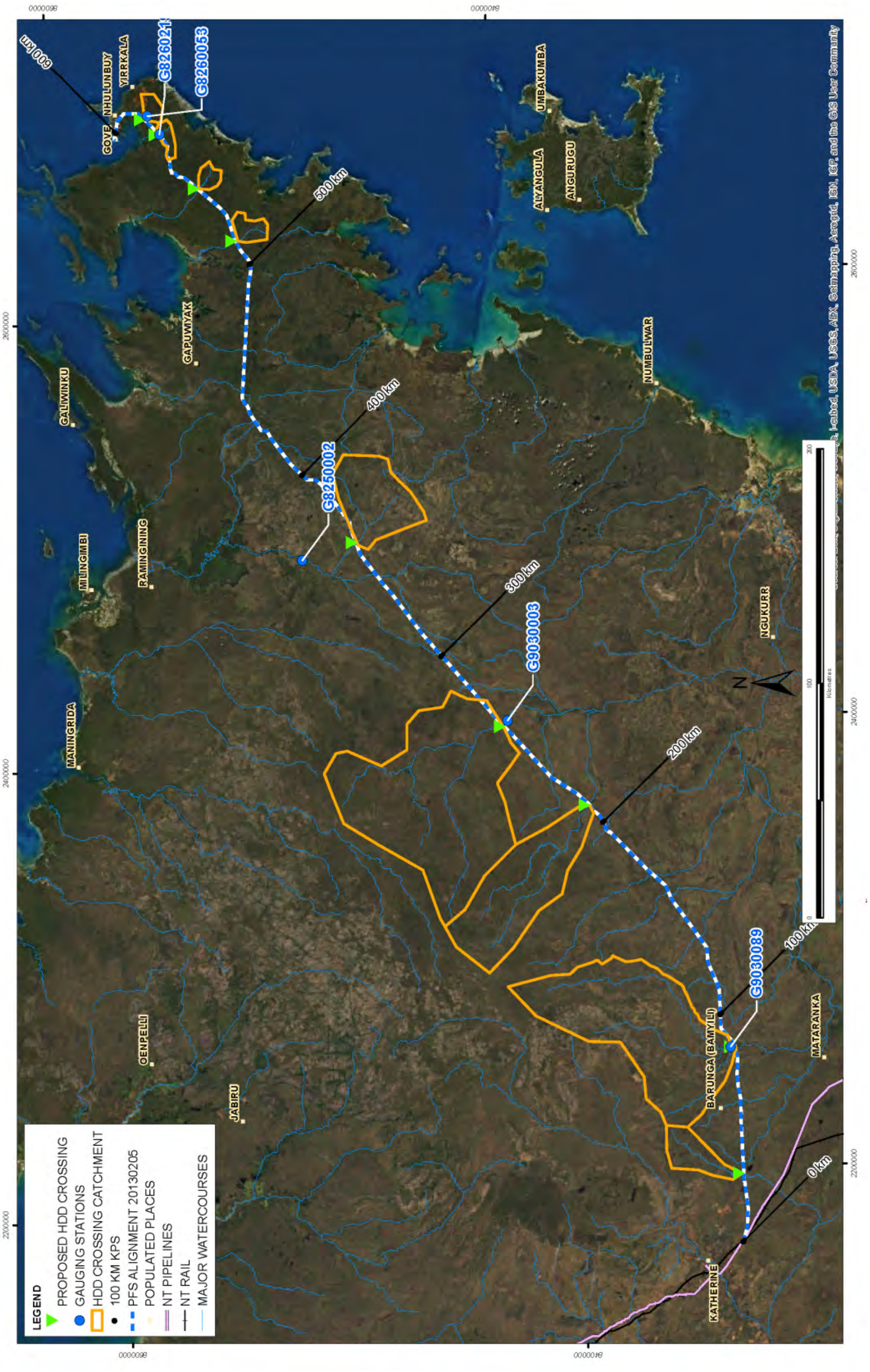


Figure 6-2 DLRM Gauging Stations and HDD Crossing Sites

The average monthly runoff depths for the gauging stations are shown on Figure 6-3. Records indicate that 70-85% of the annual runoff of the coastal rivers occurs over the December to April period, while approximately 95% of the annual runoff of the inland rivers occurs over the same period.

It is noted that the average runoff at station *G9030003* for January is dominated by the January 1976 flood period that contributed approximately 80% of the total January runoff over the period of records. Similarly, the average runoff at *G260219* for March is dominated by the March 1980 flood period that yielded 50% of the total March runoff over the period of records. It is noted that runoff for any month in any particular year may be significantly different from the average runoff, due to the variability in rainfall from year to year and also due to the relatively short period of recorded data.

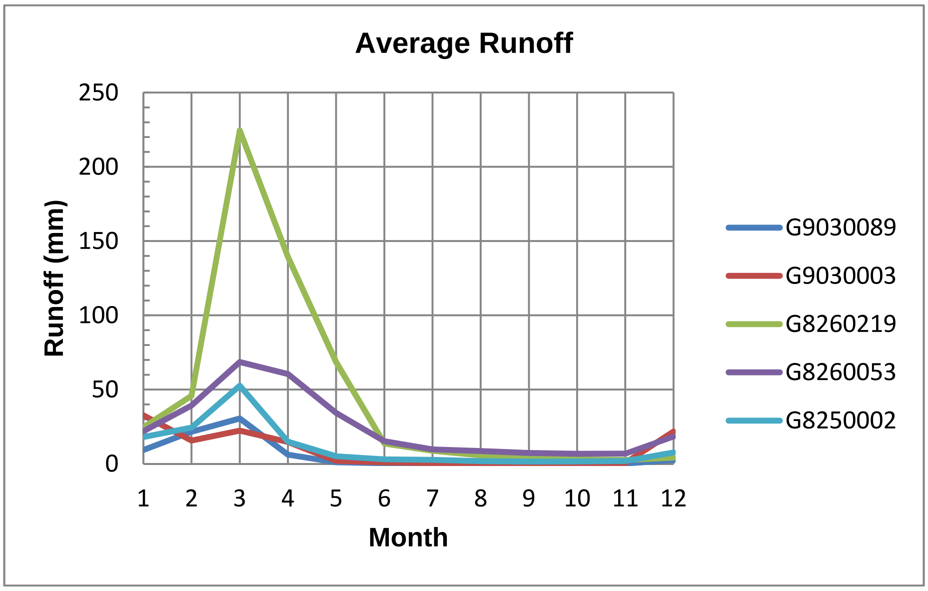


**Figure 6-3 Average Monthly Runoff**

The lag between the onset of the ‘wet’ season rainfall in November and the rise in streamflow in December is due to the build-up of soil moisture prior to catchment saturation and resultant surface runoff. Similarly, the recession of streamflow through May and June reflects the baseflow from groundwater as the soils drain.

The *‘Australian Water Resources 2005’* (NWC, 2005) mapping series shows most of the watercourses in the Arnhem Land region as ephemeral streams, with only the lower reaches of the rivers being mapped as perennial streams.  It is considered that the extent of perennial streams is significantly under-estimated, based on the information derived from streamflow records and described ‘dry’ season flow characteristics for a number of locations.

The map, *‘Water Resources of the Roper River Region’* (NTG, 2009), shows streams classified by their flow at the end of the ‘dry’ seasonand indicates that streams within the Roper River basin having catchment areas less than about 1500km$^2$ are likely to be dry at the end of the ‘dry’ season.

The identified 'permanent' rivers crossed by pipeline are listed in Table 6-3 and shown on Figure 6-2. The 'dry' season flows listed in Table 6-3 are average flow rates based on the minimum monthly runoff depths plotted on Figure 6-3 and the catchment areas above the crossing site.

**Table 6-3 'Permanent' Watercourse Crossings**

| Stream | KP* (km) | Catchment Area ($km^2$) | Minimum 'Dry' Season Flow (L/s) |
|---|---|---|---|
| King River | 29.5 | 365 | 5 |
| Waterhouse River | 83.7 | 3280 | 50 |
| Mainoru River | 209.5 | 1865 | 185 |
| Wilton River | 259.5 | 4505 | 445 |
| Goyder River | 360.5 | 995 | 560 |
| Boggy Creek | 511.5 | 135 | 130 |
| Cato River | 539.7 | 80 | 75 |
| Giddy River | 571.7 | 80 | 75 |
| Latram River | 581.0 | 85 | 220 |

** KP: Kilometre point or chainage along the pipeline route. Measured from Katherine moving towards Gove*

The eastern river basins are underlain by porous sandstone aquifers that have a much higher yield than the fractured rock aquifers underlying the central and western sections of the route. The higher yielding aquifers and slightly higher winter rainfall around Gove provide relatively higher 'dry' season flows in the coastal rivers.

It is proposed to construct the watercourse crossings during the 'dry' season between June and November when the majority of streams will not be flowing.

### 6.3.1 Water storages and drains

It is considered that a number of temporary small turkey nest dams may be constructed adjacent to watercourses for storage of water extracted from watercourses for construction water supply purposes.

All holding ponds, surface drains and other structures that are intended to store or convey water should be designed to minimise the potential for mosquito breeding. This can be achieved by incorporating a steep slope into the water, preferably greater than 30° or a 3:1 horizontal to vertical.

The dams and ponds will also require geomembrane liners to prevent seepage and potential local impacts to groundwater quality, levels and flow dynamics.

### 6.3.2 Hydrotest water

Hydrostatic pressure testing (hydrotesting) of the pipeline will be undertaken in accordance with the requirements of *Pipelines - Gas and Liquid Petroleum Field Pressure Testing (AS2885.5:2012)*. Australian Standards 2885.5:2012 focuses on assessing the structural integrity of the pipeline and does not address the potential issues with the release of poor quality hydrotest water to environmental receptors (i.e. groundwater). For example, biocides and oxygen scavengers are often required to be added to the hydrotest water to prevent corrosion of the pipeline. Disposal of hydrotest water is recommended to be in accordance with Australian Pipeline Industry Association (APIA) Code of Environmental Practice (APIA, 2009).

#### 6.3.2.1 Volumes

The pipeline has a nominal diameter DN300 with an outer diameter of 323.9mm and a wall thickness of 6.7mm; this is reduced from the original DN400 nominal diameter adopted in the EIS, yielding a volume of 76kL/km for hydrotest water. The hydrotesting of the HDD sections of the pipeline prior to installation will require relatively small, additional volumes of water (21kL) for crossings up to 300m in length.

The water required for hydrotesting may be extracted from 'permanent' watercourses as summarised below in Table 6-4. The volumes listed represent the maximum volumes without re-use, excluding allowance for evaporation and other losses.

Hydrotest water will be stored where required in a 'turkey nest' dam that may be lined with a HDPE membrane. The number and locations of the 'turkey nests' is not known at this time. It is anticipated that the 'turkey nests' will be removed following hydrotesting.

The water may require pre-treatment with bio-degradable chemicals such as biocides and oxygen scavengers to prevent the growth of algae in the pipeline and corrosion inside the pipeline.

**Table 6-4 Hydrotest Water Volumes and Potential Sources**

| Date | Stream | Pipeline Section | Length (km) | Volume (ML) |
|---|---|---|---|---|
| Jul 2014 | King River | 0 – 24 | 24 | 2.0 |
| Aug 2014 | | 24 – 79 | 55 | 4.2 |
| Aug-Sep 2014 | Waterhouse River | 79 – 144 | 65 | 4.9 |
| | Latram River | 592 – 603 | 11 | 0.8 |
| Sep 2014 | Giddy R / Latram River | 574 – 592 | 18 | 1.4 |
| | Mainoru River | 144 – 192 | 48 | 3.7 |
| Oct 2014 | Mainoru River / Wilton River | 192 – 297 | 105 | 8.0 |
| | Boggy Creek / Cato River | 457 – 574 | 117 | 9.0 |
| Oct-Nov 2014 | Goyder River | 398 – 457 | 59 | 4.5 |
| Nov 2014 | | 297 – 398 | 101 | 7.7 |

It is proposed to hydrotest the pipeline in 11 sections, varying in length from 11km up to 117km. Therefore, the volumes of water required for hydrotesting range from approximately 0.8ML up to 8.9ML. It is anticipated that hydrotest water may be re-used to test successive sections of pipeline, thereby reducing the volume of water required for hydrotesting from approximately 46ML without re-use to 24ML with maximum re-use.

It is noted that the hydrotest water volumes listed in Table 6-4 represent the volumes required with no re-use plus 20% allowance for evaporation losses.

The proposed re-use of hydrotest water may result in the transfer of relatively minor volumes of water, generally less than 5ML, from one local catchment to another local catchment. The small volumes of water transferred and short durations of released hydrotest water are considered unlikely to impact local hydrologic behaviour significantly.

#### 6.3.2.2 DISPOSAL

It is proposed to dispose of hydrotest water by land application to stable (rocky) vegetated areas to minimise direct impacts on surface water quality and wetland environments. If a suitable site for land disposal cannot be located within an acceptable distance of the pipeline or with negotiated access, the hydrotest water may be disposed via evaporation pond.

It is noted that potential evaporation over the July to November period is approximately 1150mm and average rainfall for the same period is approximately 100mm. Therefore, evaporation ponds should not exceed 1.0m in depth in order to maximise the opportunity for hydrotest water to evaporate before the onset of the monsoon rainfall season. Therefore, the surface area of any evaporation pond is expected to be less than 1 ha, based on a maximum 9ML volume of hydrotest water to be disposed from any section of pipeline, as listed in Table 6-4. As stated above in Section 5.3.1, the evaporation ponds will require geomembrane or clay liners to prevent seepage and potential local impacts to groundwater quality, levels and flow dynamics.

Research undertaken on the disposal of water used for hydrostatic testing of pipelines has revealed the following:

- The hydro-test water contains contaminants that may require treatment prior to disposal;
- The contaminants for new pipelines are mainly due to mill scale breakdown and unreacted; additives and their reaction products;
- The contaminant levels are generally not toxic;
- The characteristics of the disposal site play a role in determining the treatment required;
- Special planning is required when biocides are used and when the source water itself presents a disposal problem; and
- The discharge of hydrotest water is a one-off event and this should be considered when evaluating the potential environmental impact.

Treatment of hydrotest water for disposal may comprise one or more of the following:

- Discharge onto geofabric to trap sediment and minimise erosion;
- Holding ponds for settling of sediments; and
- Chemical treatment and absorption of organic pollutants with activated carbon.

The complexity of the treatment process depends on the characteristics of the hydrotest water, with simpler treatment generally being required for new pipelines.

The release of water to land should be carried out in a manner that ensures:

- Vegetation is not damaged;
- Soil erosion and soil structure damage is avoided;
- No surface ponding of released water occurs;
- The quality of groundwater is not adversely affected; and
- No release of water to any surface waters occurs.

**Table 6-5 Limits for the application of hydrostatic test water to land (CMIT, 2005)**

| Parameter | Limit |
|---|---|
| pH | 6.5 – 8.5 (Range) |
| Arsenic | 2.0mg/L (Maximum) |
| Cadmium | 0.05mg/L (Maximum) |
| Chromium VI | 1.0mg/L (Maximum) |
| Copper | 5.0mg/L (Maximum) |
| Iron | 10mg/L (Maximum) |
| Lead | 5.0mg/L (Maximum) |
| Manganese | 10.0mg/L (Average) |
| Zinc | 5.0mg/L (Maximum) |
| Nitrogen | 35mg/L (Maximum) |
| Phosphorus | 10mg/L (Maximum) |
| Electrical Conductivity | 2000µS/cm (Maximum) |

The hydrotest water will be released to land for disposal in accordance with a Hydrotest Water Management Plan. The land disposal area should be located more than 100m from the nearest watercourse and the hydrotest water quality for release to land is required to comply with the limits set out in Table 6-5. The disposal of hydro-test water, if undertaken in compliance of comparable conditions is not anticipated to result in adverse impacts to groundwater or surface water resources.

The areas required for storage and disposal of hydrotest water are to be located within the pipeline RoW and will be located to minimise impacts on the local environments.

## 6.4 Wastewater management

The sanitary wastewater stream will comprise both grey water and sewerage which will be treated on site and disposed of in accordance with statutory regulations, including *'Code of Practice for small on-site sewage and sullage treatment systems and the disposal and reuse of sewage effluent'*. Treated wastewater may be recycled for laundry and toilet use. Effluent disposal areas will be located with appropriate setbacks from construction camps and watercourses. The settled solids or sludge will be road transported and disposed of at sewage plants such as at Katherine, Darwin and Nhulunbuy.

Trade waste including oil and grease from workshops will be treated in dedicated treatment facilities in accordance with *'Guidelines for On-site Pre-treatment'* prior to transport off-site and approved disposal.

Vehicle wash-down water will be directed to holding tanks for removal of weed seed prior to release.

## 6.5 Impacts on Hydrologic Regime of Watercourses

Water for construction purposes and potable supply to the camps will be extracted from surface water resources where practicable and sustainable. It is noted that construction of the pipeline is programmed for the 'dry' season from July to November 2014. Therefore, it is possible that an adequate water supply may not be available from some streams for some of the construction period. The anticipated demands for potable water for the temporary construction camps and non-potable water for construction purposes and the potential surface water sources are presented in Table 6-6.

The estimated flows listed in Table 6-6 for each of the surface watercourses considered as potential sources for extraction of water during the construction period have been derived from the monthly average depths of runoff listed in Table 6-2 and the catchment areas above the pipeline crossing locations on each watercourse. The data presented in Table 6-6 lists projected volumes required by the project each month during the construction period, based on the current construction programme, as well as the corresponding monthly volume discharged in the watercourse. It is noted that the extractions are 'one off' occurrences that last for less than six months and are unlikely to affect streamflows beyond the 2014 'dry' season.

The estimated total volume of water required for the project is approximately 207ML, which is equivalent to less than 1% of the estimated total flow past the proposed extraction locations on the surface watercourses during the construction period. NT government policy generally aims to ensure that not less than 80% of the natural flow in surface watercourses is available for environmental flow requirements. Therefore, it is considered that the proposed extraction from surface watercourses will have no significant negative impacts on the hydrologic regimes and riverine ecology for most of the 'permanent' watercourses.

However, it is noted that the projected demands to be sourced from the King River and Beswick Creek represent 25-50% of the total flow in the streams for 'average' conditions during August and September. The planned extractions may have significant impacts on the river ecosystems and additional investigation is recommended for those streams. It may be necessary to obtain water for the western end of the pipeline from alternative streams or from groundwater.

It is also noted that the planned extraction from the Cato River in October 2014 exceeds 13% of the estimated discharge. It may be necessary to obtain some of the water from Boggy Creek in order to minimize impacts on hydrologic regime and river ecosystems.

It will be necessary to develop appropriate management plans for the extraction of water from surface water in order to minimize potential impacts on hydrologic regime and river ecosystems. The management plans may require the installation of temporary stream gauges to facilitate monitoring of flows in the streams.

Additional investigation of ‘dry’ season flow behavior of surface water resources and baseflow from groundwater is required to be undertaken in order to develop appropriate operating rules for sustainable extraction of water from surface water and groundwater resources. The adaptive management of water extractions is also discussed in 6.9.

**Table 6-6 Anticipated Water Demand and Surface Water Sources (ML)**

| Month | Stream | Total Demand | Estimated Flow |
|---|---|---|---|
| Jul-14 | King River | 7.51 | 70 |
| Aug-14 | | 8.08 | 33 |
| May-14 | Beswick Ck | 2 | 177 |
| Jun-14 | | 2 | 66 |
| Jul-14 | | 2 | 33 |
| Aug-14 | | 8.11 | 16 |
| Sep-14 | | 2 | 7 |
| Jun-14 | Waterhouse River | 0.08 | 1250 |
| Jul-14 | | | 625 |
| Aug-14 | | 17.12 | 295 |
| Aug-14 | Latram River | 7.32 | 730 |
| Sep-14 | | | 630 |
| Jul-14 | Giddy River | 0.08 | 700 |
| Aug-14 | | | 450 |
| Sep-14 | | 5.01 | 300 |
| Jun-14 | Mainoru River | 2 | 1750 |
| Jul-14 | | 4.08 | 950 |
| Aug-14 | | | 580 |
| Sep-14 | | 20.59 | 500 |
| Oct-14 | | 2 | 480 |
| Jul-14 | Wilton River | 2.5 | 2300 |
| Aug-14 | | 2.58 | 1400 |
| Sep-14 | | 2.5 | 1220 |
| Oct-14 | | 24.74 | 1170 |
| May-14 | Cato River | 2 | 5680 |
| Jun-14 | | 2 | 1130 |
| Jul-14 | | 4.08 | 725 |
| Aug-14 | | | 470 |
| Sep-14 | | 2 | 310 |
| Oct-14 | | 34.20 | 250 |
| Jul-14 | Boggy Ck | 2.5 | 1190 |
| Aug-14 | | 5.08 | 770 |
| Sep-14 | | | 510 |
| Oct-14 | | 2.5 | 405 |
| Sep-14 | Goyder River | 0.11 | 1470 |
| Oct-14 | | 13.13 | 1580 |
| Nov-14 | | 13.13 | 1860 |
| **Totals** | | **206.8** | **32083** |

## 6.6 Construction Impacts – Stream Crossings

### 6.6.1 Construction Program

The construction program proposes that trench excavation begin in June 2014 at Katherine and July 2014 at Gove and be completed in October 2014, with pipe laying, backfilling and restoration being undertaken progressively, within 3-4 weeks of trench excavation.

Thus, the pipe laying activities, including watercourse crossings, are to be undertaken during the 'dry' season when the minor streams are expected to have minimal flow or to be dry.

Detailed descriptions of the proposed construction methods to be used for stream crossings are provided in the Project Description chapter of the EIS.

## 6.7 Crossing Construction Techniques

### 6.7.1 Horizontal Directional Drilling

The crossings at the identified 'permanent' rivers will be constructed using Horizontal Directional Drilling (HDD) construction. HDD minimises the risk of environmental harm by sending the pipeline below particular geographical features.

The risks associated with an HDD installation during operations are generally considerable less than those of a traditional trenched crossing. In particular, the risk of the following problems is minimized or eliminated:

- Maintenance of disturbed banks or stream bed;
- Exposure of pipe during peak flow events; and
- Damage of pipe due to anchors or other third party activities.

However, increased risks associated with HDD crossings during operation include:

- Pipe is inaccessible for repairs due to depth of cover;
- Corrosion due to undetected damage to pipe coating;
- Subsidence at entry and exit points; and
- Visual leak detection is not possible.

It is understood that limited geotechnical investigations of the proposed HDD crossing sites have been undertaken.

### 6.7.2 Alternatives to HDD

If the detailed geotechnical investigation of the HDD sites reveals the existence of a rock shelf or other conditions that indicate HDD is not practicable, the following options may be assessed:

- Relocation of the crossing and deviation of the pipeline route; or

- Construction of an open trenched crossing.

The relocation of the HDD crossing and deviation of the adjoining pipeline sections may be feasible where the unsuitable geotechnical conditions are localised and a suitable alternative crossing site can be located within a short distance. This option may require negotiation of an amended RoW and approvals from the administering authorities.

It is considered that construction of an open trenched crossing is the most appropriate option where a minor deviation of the pipeline is not possible. The construction of trenched crossings is described below.

### 6.7.3 Trenched Crossings

Trenched crossings will be constructed at ephemeral stream crossing sites and where site geotechnical investigations indicate that HDD crossing of a 'permanent' watercourse is not considered practicable.

Trenching across waterways involves in-stream excavation and pipe laying conducted within a temporarily dewatered section of the waterway. Protection of the works from stream flows is achieved by installing temporary dams upstream and downstream with a bypass channel or pump.

Strategically located sumps allow dewatering in the 'dry' area where the water table is exposed. Water resulting from dewatering may be directed to on-site sedimentation ponds or carted to alternative water storage ponds to separate sediment before discharge back into the stream when deemed appropriate, or may be used for dust suppression or other construction purposes.

In the event that HDD cannot be carried out at watercourse crossings with significant flow, flow diversion will be required. This is a modification to the standard open cut method. The technique involves construction of temporary dams, upstream and downstream of the crossing, and diversion of water around the crossing point. This creates a dry construction area between the dams.

The two possible flow diversion techniques are:

- Bypass flume, where flow is diverted through flume pipes to prevent siltation, which would arise during trenching, lowering in and backfilling. This technique is less suitable for watercourses with significant flows, broad channels, low gradients or permeable substrates; and
- Dam and pump, where coffer dams or head walls are constructed above and below the trenched area and the work area is pumped dry. This is appropriate for low gradient streams with discharges of less than about 1m3/s during construction.

Either technique could be used during periods of very low water flow if practicable, with consideration of short-term weather forecasting to avoid any potential for flooding during the open trench phase of the crossing.

Rehabilitation will be undertaken in accordance with the Code of Environmental Practice (APIA, 2009) and re-contoured to match the surrounding land as soon as practicable after pipe laying and backfilling and bank erosion controls will be constructed or installed, where necessary. An effective sediment and erosion control program will be implemented to mitigate potential impacts from turbidity in runoff during the construction period and long-term operation.

### 6.7.4 Potential Impacts on Stream Hydraulics

As stated above, HDD avoids impacts on streamflow behaviour, under normal dry weather flow conditions. Localised erosion of riverbank areas may be induced by flow conditions around the HDD plant and ancillary works during flood events. As pipeline construction is planned to be undertaken during the 'dry' season, it is considered that streamflow at the HDD crossings is unlikely to be altered.

It is anticipated that the minor streams will be dry or will have minimal groundwater fed flow for most of the planned pipe laying period. Trenches in the waterway crossings will be open for the minimum period possible. Typical practice would be a maximum of two days from start of trenching until backfilling of the trench. Larger crossings would require the trench to be open for up to four days. In the very unlikely event of having to blast the trench due to the presence of hard rock, the trench may be open for up to six days.

The excavated material from the trench will be placed on the upstream side of the crossing to create a bund for temporary storage of very low streamflow. Where this is not considered practicable, the trench crossing may be undertaken in two stages with flow diverted via channels constructed around the open section of the crossing.

The short durations required for any diversion or temporary storage of streamflow will minimise the impact on streamflow behaviour.

## 6.8 Stormwater Management

The stormwater management strategy comprises works to be carried out and measures to be implemented in order to minimize the impact of the pipeline project on the quantity and quality of stormwater runoff discharged to watercourses.

The management of the quantity of stormwater runoff discharged is focused on minimization of changes in the locations and magnitudes of flows in order to prevent erosion and sedimentation along the watercourses. The soils along the pipeline route are susceptible to erosion and significant changes in channel alignment and cross-section may result from concentration of overland flows, increased flows or other changes in flow behaviour.

The management of stormwater quality is focussed on separation of runoff from potentially contaminated areas within the camps and facilities from 'clean' stormwater runoff and appropriate treatment of both streams.

The potentially contaminated stormwater is to be captured and transported off-site for treatment and disposal or is to be treated on-site prior to discharge.

The minimisation of sediments in runoff discharged from the site is the primary focus for 'clean' stormwater. The management of nutrients is not considered to be a significant issue due to the nature of the activities undertaken and pollutants normally contained in stormwater runoff.

Runoff from external areas is to be diverted around the camps and facility sites in order to minimise flows to be conveyed in the internal drainage system and to minimise hydraulic loading of treatment devices, where practicable and appropriate. The diversion of external runoff is not to result in concentration of flows, scouring or sedimentation in natural drainage lines or erosion of overbank areas and is to avoid or minimise removal of vegetation.

Surface runoff from within the camps is to be collected and conveyed via swale drains or pipes to treatment devices that may include detention basins for flow management, sediment basins, bio-retention basins or other devices for pollutant removal.

Stormwater runoff discharged is not to result in increased flow rates or concentration of flow likely to increase the level or velocity of flow or erosion/sedimentation risk downstream. Mitigation works, including energy dissipaters and erosion prevention treatments, will be installed where required.

Refuelling and storage areas that have potential to generate contaminated stormwater containing concentrated loads of hydrocarbons or process chemicals will be enclosed within bunds to contain any contaminated runoff or spills and to prevent ingress of ‘clean’ runoff from other areas. The bunded areas will be drained to internal sumps from which the captured contaminated stormwater is to be directed to an appropriate treatment process/device or removed for treatment and disposal at an approved location.

## 6.9 Management of Surface Water

The proposed strategies for management of surface water quality and quantity during the construction period are summarized below.

**Table 6-7 Management Strategies for Surface Water**

| Activity/Situation | Issues | Management Strategy |
|---|---|---|
| Water Extraction | Excessive streamflow reduction<br><br>Adverse river ecosystem impacts | Monitor upstream and downstream flows and extractions<br><br>Cease extraction if reduction in streamflow is excessive<br><br>Cease extraction if water level drops excessively at critical downstream location |
| Watercourse crossings | Flow disruption or diversion<br><br>Channel scour, bank erosion and sedimentation | Appropriate bypass works<br><br>Erosion and sediment control measures<br><br>Appropriate rehabilitation |

| | | |
|---|---|---|
| Pipeline construction | Erosion of exposed areas and stockpiles<br>Erosion of backfilled trench | Erosion and sediment control measures – silt fences, diversion drains, sediment basins<br>Rock check dams in trenches<br>Compaction of backfill |
| Hydrotesting | Water quality in receiving watercourses | Quality criteria<br>Maximize re-use<br>Land disposal only – area, application rates |
| Stormwater discharged from camps and temporary facilities | Concentrated flows<br>Erosion and sedimentation | Appropriate surface drainage works and outlets<br>Erosion and sediment control measures – sediment basins |
| Wastewater disposal | Water quality in receiving watercourses | Appropriate treatment and disposal areas |
| Contaminated wastewater | Hydrocarbons | Collection and appropriate treatment |

The following management plans will be prepared prior to the commencement of the pipeline construction and will be implemented during the construction period to minimise impacts on surface watercourses:

- Stormwater Management Plan (including Erosion and Sediment Control Plan);
- Hydrotest Water Management Plan;
- Wastewater Disposal Management Plan;
- Water Extraction Management Plan; and
- Watercourse Crossings Management Plan.

## 6.10 Proposed Mitigation Measures

The following activities are to be completed during the design phase:

- Conceptual design of sedimentation/detention basins for flow attenuation, diversion drain cross-section and profile and internal site drainage, including bunding of contamination risk areas;
- Preparation of conceptual Erosion and Sediment Control Plan (ESCP); and
- Preparation of Stormwater Management Plan (SWMP).

The following actions are to be undertaken during the construction phase:

- Implementation, review and updating, if necessary, of the ESCP;
- Maintenance and repair of ESCP devices;
- Maintenance and cleaning of vehicles and any other equipment or plant to be carried out in areas from where the resultant contaminants cannot be released to any watercourse;
- All fuels and chemicals to be stored and handled in accordance with AS 1940 and AS 3780 to minimise the potential for contamination of stormwater runoff from the site;
- Construction of stormwater management works in accordance with SWMP, subject to amendments required due to changes in facility design or other factors;
- Implementation of management measures specified in the SWMP; and
- Implementation of surface water extraction management measures.

The work to be undertaken during the operations phase comprises:

- Implementation, review and updating, if necessary, of the SWMP; and
- Implementation of a litter and solids management plan to minimise gross solids loads in runoff.

## 6.11 Conclusions

Rainfall and resultant runoff in the regional is highly seasonal, with approximately 90% of the rainfall occurring over the six month period from November to April and streamflow generally occurring in the period between December and May. The lag between the onset of the 'wet' season rainfall in November and the rise in streamflow in December is due to the build-up of soil moisture prior to catchment saturation and resultant surface runoff. Similarly, the recession of streamflow through May and June reflects the baseflow from groundwater as the soils drain.

It is considered that the project will not impact surface water resources significantly, given that:

- It is proposed to construct the pipeline and watercourse crossings during the 'dry' season between June and November when the majority of streams will not be flowing.
- The crossings at the identified 'permanent' rivers will be constructed using HDD construction that avoids impacts on streamflow behaviour, under normal dry weather flow conditions.
- Trenched crossings will be constructed at ephemeral stream crossing sites and where site geotechnical investigations indicate that HDD crossing of a 'permanent' watercourse is not

considered practicable. The short durations required for any diversion or temporary storage of streamflow for trenched crossings will minimise the impact on streamflow behaviour.

- An adaptive management strategy will be developed following additional investigation of streamflow and water quality characteristics of the surface watercourses during the 'dry' season and implemented to minimise impacts on river ecosystems resulting from extraction of water for construction of the pipeline.

# 7 HYDROGEOLOGY ASSESSMENT

The following hydrogeology assessment describes the regional hydrogeological setting along the KGGP route; with particular emphasis on establishing if groundwater is a sustainable resource to supplement the water requirements for the project. Additionally, this Section also examines the existing dataset relating to the availability and/or occurrence of groundwater, it's quality and the potential risks associated with its use.

## 7.1 Regional Hydrogeology

The Northern Territory obtains about 128 gigalitres (GL) of groundwater per annum from 55 Groundwater Management Units (GMUs). The Northern Territory's water resources are generally considered to be under relatively little pressure due to a comparatively smaller population base and low intensity of land use. However, groundwater and surface water resources in a number of local areas are recognised as being under pressure from resource development (NWC, 2011[1]).

The Water Act enables the declaration of Water Control Districts (WCD) within the Northern Territory in an effort to provide increased water management and protection. This is usually carried out in areas where there is a need to avoid stress on groundwater reserves, baseflow to surface waters (i.e. rivers)  or the preservation of wetlands (e.g. GDEs).

The proposed easement for the KGGP (Figure 7-1) traverses a total of six (6) GMUs (Figure 7-2). These GMUs are largely contained in the McArthur River and Daly River groundwater provinces. These are described in more detail in Section 7.2.

[1] National Water Planning Report Card/ Northern Territory

Figure 7-1 Proposed KGGP route from Katherine to Gove

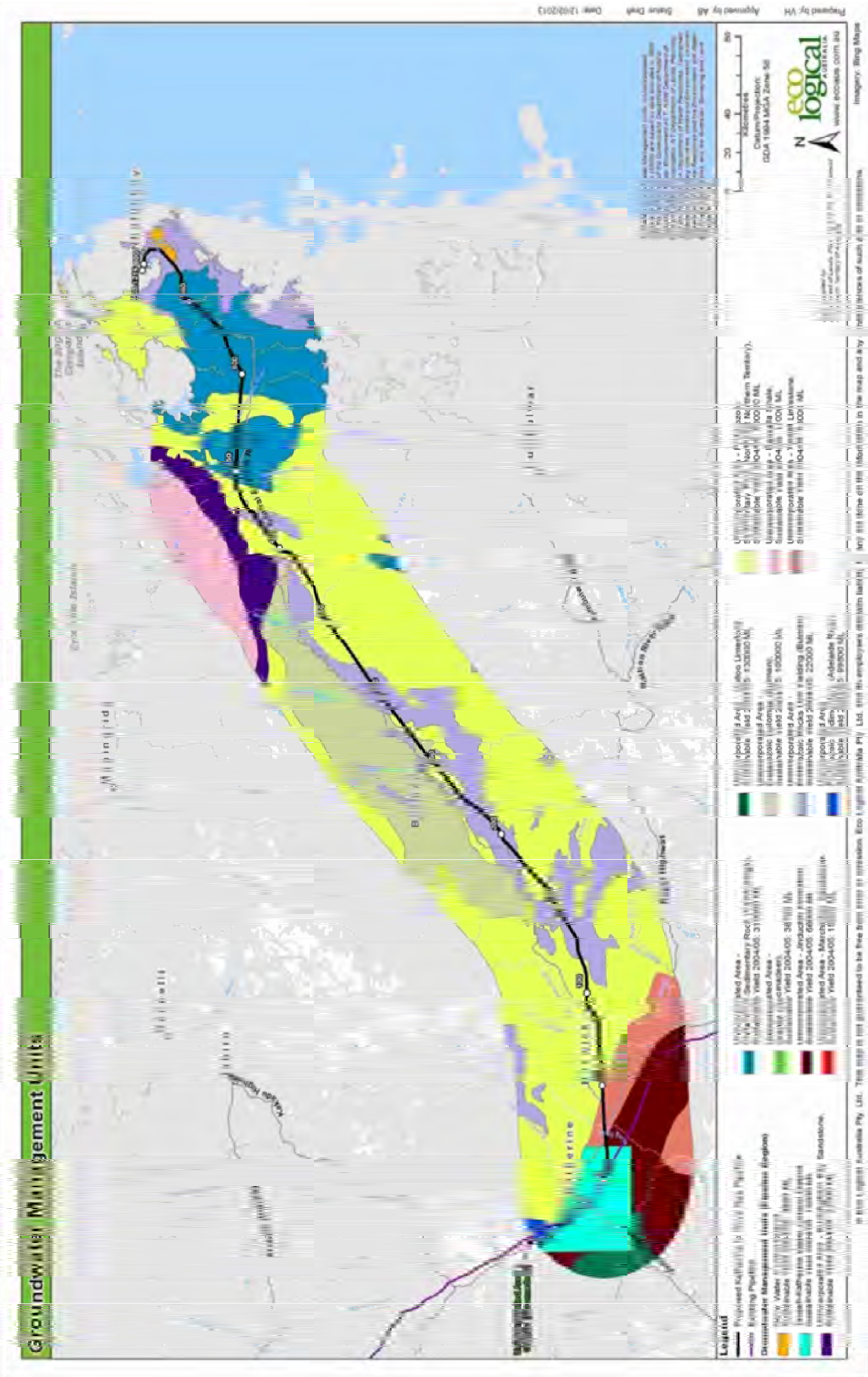


**Figure 7-2 Groundwater Management Units (GMUs) Pipeline Easement (Eco Logical, 2013)**

## 7.2 Groundwater Management Units (GMUs)

The Northern Territory obtains about 128 gigalitres (GL) of groundwater per annum from 55 Groundwater Management Units (GMUs). The Water Act enables the declaration of Water Control Districts (WCD) within the Northern Territory which provides an increased level of water management and protection.

The proposed KGGP route traverses the following six (6) GMUs (refer to Figure 7-2).

- Daly River Basin – Tindall Limestone.
- Daly River Basin – Jinduckin Formation.
- Proterozoic Sedimentary Rock (North East Northern Territory).
- Proterozoic Rocks low yielding (Bulman).
- Proterozoic Sedimentary (Adelaide River).
- McArthur Basin including Gove Water Control District (WCD).

These GMUs are largely contained in the McArthur River and Daly River groundwater provinces, and are described below. These include:

### 7.2.1 Daly River Basin –Tindall Limestone

The first approximately 50-kilometres of the proposed KGGP route is within the Daly River Basin. Three aquifers are present, all formations in the Lower Palaeozoic Daly Basin; a sequence of gently dipping carbonate rocks. The major aquifer is the Tindall Limestone, the basal formation. Individual bores can produce water up to 60 Litres/sec (L/s) and average 80 metres deep. Water quality is generally good and suitable for most purposes. The aquifer is fractured and cavernous and is hydraulically connected to the Katherine River. Springs in the river bed and bank at Katherine discharge groundwater when river levels are low; however, during flood events river water flows back into the aquifer. Distributed recharge also occurs, averaging approximately 40 to 140mm/year dependent upon whether the aquifer is confined by the overlaying cretaceous sediments or unconfined and open to direct recharge

A borefield 3km east of the town of Katherine supplements the river water. Up to 40% of the annual supply of 4,039 million litres is from these groundwater bores. Groundwater is blended with the river water to increase pH, making it less corrosive to metal. High hardness (a measure of the amount of calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$)) limits the proportion of groundwater used. The aquifer also supports a small horticultural and cropping industry.

Limestone inter-fingers with the overlying Jinduckin Formation to form less extensive aquifers. Evaporite deposits in the shales locally impart high sulfate ($SO_4^{2-}$) concentrations to groundwater. Total Dissolved Solids (TDS) reach a maximum of 4000 milligrams per litre ($mg.L^{-1}$) and elevated radium (Ra) contents have also been reported.

The uppermost formation in the basin, the Oolloo Limestone forms a major aquifer similar in properties to the Tindall Limestone. The depth to groundwater level varies during the year, in response to rainfall recharge, from 3 – 25 metres.

### 7.2.2 Daly River Basin – Jinduckin Formation

The Jinduckin Formation is located within the Daly River Basin. This comprises gently dipping Palaeozoic Jinduckin Formation of the Daly River Basin sequence. The aquifers are present in fractured and karstic limestone interbeds within a section consisting mainly of siltstone. Bores in the limestone are capable of producing moderate yields. Water quality is generally moderate and may be locally brackish due to the presence of interbedded evaporite deposits. Such groundwaters are high in sulfate ($SO_4^{2-}$), calcium ($Ca^{2+}$), sodium ($Na^+$) and chloride ($Cl^-$). Recharge comprises both distributed recharge and infiltration from rivers. The Daly and Katherine Rivers cross the area and these receive minor discharge from the aquifers. The underlying Tindall Limestone, which comprises UA NT24[2], dips beneath the Jinduckin Formation and forms the most productive aquifer.

### 7.2.3 Proterozoic Sedimentary GMUs (North East NT, Bulman & Adelaide River)

With reference to Figure 7-2, extending north-east from Beswick there are three (3) GMUs, referred to as Unicorporated Areas (UA), of which the KGGP traverses. These are Proterozoic-aged sedimentary units of  the 1) North East Northern Territory, 2) Bulman and 3) Adelaide River GMUs; with sustainable groundwater yields of 500,000 ML, 22,000ML and 99,800ML respectively. Little is known of these GMUs; however, these Proterozoic units are generally gently folded with shale and siltstone as the dominant rock type. Aquifers associated with these GMUs are fractured systems, predominantly at depths of less than 100m.

### 7.2.4 McArthur Basin

The majority of the length of the KGGP passes through the McArthur River Basin which has five GMU's and includes the Gove WCD. These include:

- Gently folded Proterozoic sandstone and shale are the dominant rocks but dolomite, siltstone and greywacke also occur. Aquifers are the fractured rock type, mostly developed shallower than 100 metres. Bore yields are mostly less than 2 L/sec but higher yields occur near major fracture zones. Several mines use groundwater for processing and undertake varying levels of dewatering. Recharge is of the distributed type, probably less than 5mm/year. Discharge occurs via springs and into riverbeds.
- Proterozoic dolomite comprising the Dook Creek Formation; a unit of the gently folded Proterozoic McArthur Basin. The aquifer associated with this formation is virtually untested but may contain a major groundwater resource. Recharge is of the distributed type, probably within

[2] Unincorporated Area (UA) designated NT24

the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds. A dry season flow of 1000 L/sec in the Goyder River is supplied from discharge from the aquifer.

- Low-Yielding Proterozoic rocks (near the town of Bulman). This formation comprises various low permeability rocks in the gently folded Proterozoic McArthur Basin. Alternating sequences of shale and siltstone are the dominant rocks but dolerite and granite also occur. Aquifers are either absent or sparsely developed low-yielding fractured rocks. Saline waters occur adjacent to the coast and tidal rivers. Recharge is likely to be very low.
- Cretaceous sedimentary rocks. This formation comprises poorly consolidated, flat lying Cretaceous sands. The aquifer is virtually untested but may contain a major groundwater resource, similar to that in the Gove Water Control District to the northeast. Water quality is good with TDS values generally less than 100 $mg.L^{-1}$.
- Recharge is of the distributed type, probably within the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds. Several of the areas streams maintain dry season flows of more than 100 L/sec.

*Gove Water Control District (WCD)*

This is a declared Water Control District, located in northeast Arnhem Land. The aquifer consists of poorly consolidated, flat lying Cretaceous sands in an outlier of the main body of the formation to the southwest. The towns of Nhulunbuy and Yirrkala obtain their water supplies from the aquifer but the major user is the Gove bauxite mine. Production bores are typically 80 metres deep and supply up to 60 L/sec each. The total supply from the borefield is 1697 Ml/year. Water quality is good with TDS values generally less than 100 $mg.L^{-1}$. Recharge is of the distributed type, probably within the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds.

## 7.3 Water supplies for proposed KGGP construction

Climatic variations throughout the year will influence the KGGP construction schedule; however, much of the construction will take place during the dry season when groundwater levels are at their lowest, and when baseflow[3] is at its minimum. This approach is favoured as a means to reduce/negate the need to undertake large-scale dewatering for the installation of pipeline infrastructure (if required).

At present the following water requirements (i.e. hydrotesting, HDD, dust suppression and potable) for the KGGP are those shown in Table 6-6. These are discussed in more detail in the following Sections.

[3] The groundwater contribution to a stream; baseflow often maintains sources water to a stream during dry season

### 7.3.1 Water requirements for KGGP pipeline infrastructure: Potential source of groundwater

Where practicable and sustainable it is understood that the main supply of water for hydrotesting of the pipeline, HDD and dust suppression is to source from surface water courses (e.g. King River, Goyder River etc) as identified and discussed in Sections 6.3 to 6.5. However, as discussed in Section 6.11, until such time as an adaptive management strategy has been developed to better our understanding on the sustainability of surface water resources to provide water for the KGGP, other sources of water needs to be considered. Not only is additional water required to supplement construction activities, a good source of potable water is required for the 750 persons working on the KGGP Project.

At present it is unaware if any source for drinking water has been defined. It is understood that the construction of the pipeline will commence concurrently at each end of the proposed pipeline network; where, access to potable water is more common. However, as camp facilities move during construction, especially away from more populated centres, the location, access and quality of water for human consumption becomes somewhat limited. Therefore it is proposed that sources of potable water may come from groundwater bores in the vicinity of the KGGP.

Information on existing groundwater bore infrastructure along the KGGP was collated from the following sources.

- Water Resources of North Eastern Arnhem Land (DLPE, 1999);
- Water Resources of the Katherine Region and South West Arnhem Land (DLPE, 2001);
- Department of Land Resource Management (DLRM) online NR Maps (Northern Territorty); and
- Advice from DLRM personnel in the Northern Territory Government and from local experts appointed by Pacific Aluminium's envirornmental consultant.

These resources were used to assess the occurrence (if any) of 'existing' and suitable groundwater bores which could be used as alternative sources of water; principally for human consumption.

With reference to Figures 7.1 to 7.6 (refer Appendix 2) and Table 7-1, a total of thirty (30) groundwater bores were identified. Reviews of these thirty (30) groundwater bores have indicated highly variable bore yields and restricted water quality results for parameters relevant for human health. For example, data abstracted from the 1999 and 2001 DLPE studies, shows that water quality results for these thirty (30) bores are incomplete (refer Table 7-1) and of little value in establishing the true potential for consumption. For example, the Australian Drinking Water Guidelines (NHMRC[4] & ARMCANZ[5], 1996) provides the necessary criteria in establishing good quality drinking water. These Guidelines provide an authoritative Australian reference on acceptable drinking water quality, covering a wide range of the microbiological, physical, chemical and radiological characteristics.

[4] National Health & Medical Research Council
[5] Agriculture and Resource Management Council of Australia and New Zealand

With regards to the present dataset it remains unclear as to wether groundwater can be used as a potable supply; however, it still may be used as a source of water to supplement construction activities. Additional field investigations will be carried out to ascertain the degree to which groundwater from ‘existing’ bores (refer Table 7-1) can be used during construction of the KGGP project.

**Table 7-1 Location, bore yield and basic water chemistry of potential groundwater bores along the KGGP easement**

| Distance along route | Bore I.D | Bore name | Northing | Easting | Depth Drilled | Date | Owner | Yield (L/sec) | pH | EC µS.cm$^{-1}$ | Iron mg.L$^{-1}$ | Total Hardness mg.L$^{-1}$ | Alkalinity mg.L$^{-1}$ | Nitrate mg.L$^{-1}$ | Fluoride mg.L$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 6.5 to 8.5 | N/A | N/A | 200 | N?A | 3.0 | 1.5 |
| 0.0 to 80 km Area of **Camp #1** | A | RN029510 | 8386800 | 212150 | 66.09 | 09/01/1994 | NT Gov't | 30 | 7.1 | 624 | 0.1 | 352 | 340 | 1 | - |
| | B | RN026355 | 8384800 | 226000 | 178 | 06/06/1989 | A.D.M.A | 15 | 7.3 | 685 | 0.1 | 387 | 384 | 1 | 0.3 |
| | C | RN026172 | 8385140 | 233870 | 178.5 | 06/07/1989 | NT Gov't | 6 | 7.7 | 510 | - | 273 | 281 | 1 | 0.2 |
| | D | RN030868 (north) | 8384200 | 239000 | 52.5 | 28/07/1996 | N Rogers | 3 | 7.4 | 469 | 5.3 | 244 | 260 | 1 | - |
| | | RN030621 (south) | 8382500 | 239500 | 62 | 26/04/1996 | H.J.J McNaught | 2 | 7.6 | 651 | 15.3 | 211 | 260 | 1 | 1.2 |
| | F | RN020527 | 8389900 | 259350 | 57 | 10/04/1980 | NT Transport | 2 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | G | RN008421 | 8392920 | 270540 | 100 | 07/01/1974 | Bamyili Settlement | 4 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | | RN008420 | 8392750 | 270760 | 108 | 20/06/1974 | Bamyili Settlement | 3 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | H | RN022705 | 8394620 | 273380 | 40 | 05/10/1984 | Bamyili Settlement | 2.2 | 7.9 | 170 | 0.1 | 76 | 103 | 1 | 0.1 |
| | I | RN004159 | 8389925 | 297010 | 161.5 | 11/30/1963 | Beswick Station | 0.7 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| 80 to 180 km | J | RN028478 | 8388950 | 299800 | 67.4 | 06/15/1993 | Beswick Council | 4 | 7.9 | 470 | 0.5 | 267 | 259 | 1 | 0.1 |
| | K | RN021563 | 8394100 | 300700 | 32 | 07/28/1982 | Beswick Station | 2 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | L | ****** No information ****** | | | | | | | | | | | | | |
| 180 to 240 km Area of **Camp #2** | M | RN008218 | 8431990 | 402550 | 91.4 | 07/13/1973 | Noranda Aust. Ltd | 5.3 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | M1 | ****** No information ****** | | | | | | | | | | | | | |
| 240 to 300 km Area of **Camp #3** | N | RN025794 | 8489814 | 425063 | 68.8 | 09/02/1991 | Aboriginal Reserve | 2 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | O | RN027810 | 8489729 | 424471 | 72.5 | 09/18/1991 | Aboriginal Reserve | 20 | 7.8 | 618 | 0.35 | 324 | 352 | 1 | 0.1 |
| | P | RN028226 | 8501660 | 438420 | 54 | 09/02/1992 | A.T.S.I.C | 3 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| 380 to 470 km Area of **Camp #4** | Q | WR 88/2 - 25899 | 8598700 | 540500 | N/A | 09/23/1988 | N/A | 1 | 5.3 | 35 | 0.1 | 7 | 5 | 1 | 0.1 |
| | Q1 | ****** No information ****** | | | | | | | | | | | | | |
| | R | WR 87/2 - 25413 | 8591500 | 593800 | N/A | 12/01/1987 | N/A | 5 | 4.9 | 35 | 0.4 | 1 | 3 | 1 | 0.1 |
| 470 to 560 km Area of **Camp #5** | S | WR 87/1 - 25414 | 8587800 | 641008 | N/A | 12/07/1987 | N/A | 15 | 7.1 | 150 | 2.7 | 20 | 55 | 1 | 0.3 |
| | T | Jan -76/8923 | 8607250 | 634150 | N/A | 10/07/1976 | N/A | 5 | 5.7 | 42 | - | 152 | 154 | 1 | 0.1 |
| | U | Jan -82/21404 | 8610000 | 635750 | N/A | 06/03/1982 | N/A | 3 | 6.2 | 81 | 0.1 | 7 | 5 | 1 | 0.1 |
| | V | WR 87/1 - 25415 | 8601000 | 665008 | N/A | 12/09/1987 | Spring Camp | 10 | 6.1 | 40 | 0.1 | 8 | 6 | 1 | 0.1 |
| | W | N/A | 8606800 | 668400 | N/A | 06/29/1995 | Garrathiya | 7 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | X | 1/89 Road Bore | 8620300 | 667800 | N/A | 08/16/1989 | Gove 6273 | 6 | 7.9 | 230 | 0.8 | 62 | 95 | 1 | 2.6 |
| | Y | WR 91/1 Dhalinybuy | 8627400 | 650900 | N/A | 08/02/1991 | East Arnhem | 5 | 6.4 | 35 | 0.3 | 8 | 7 | 1 | 0.1 |
| 540 to 600km End of pipeline | Z | O/B 3 - 31173 | 8640500 | 695600 | N/A | 08/02/1997 | Gove Mine Site | 8 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | ZA | No.16- 20391 | 8640750 | 700100 | N/A | 05/19/1980 | Gove | 27 | 5.2 | 65 | 0.1 | 7 | 5 | 1 | 0.1 |
| | ZB | N/A | 8643000 | 697100 | 76 | 03/14/1995 | Gove | 5 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |
| | ZC | WR 92/1 Gove Sth Invest | 8650700 | 692400 | 72 | 02/21/1992 | Gove | 4 | 5.0 | 175 | - | 16 | 1 | 1 | 0.1 |
| | ZD | Jan-82- 21637 | 8641350 | 680100 | 31 | 10/28/1982 | Yangumbi | 12 | *.* | *.* | *.* | *.* | *.* | *.* | *.* |

**Source for water quality:**

| |
|---|
| Water Resources of the Katherine Region an South West Arnhem Land, Technical Data, Department of Lands, Planning and Environment, Natural Resources Division, 2001. |
| Water Resources of East Arnhem Land Technical Data, Department of Lands, Planning and Environment, Natural Resources Division, 1999. |
| Australian & New Zealand Environment and Conservation Council (ANZECC). 2000. Fresh and Marine Water Quality |

## 7.4 Potential environmental risks from KGGP development

Data relating to groundwater in the area encompassing the KGGP is, to some degree, limited. Therefore, supplemental data will be collected following additional investigations in an effort to better assess the risks to groundwater quantity and quality as a result of the construction and operation of the KGGP.

The following Sections describe the potential risks to groundwater that have been identified as a result of the proposed KGGP.

### 7.4.1 Acid Sulfate Soils (ASS)

Approximately half of the KGGP crosses over meta-sedimentary rocks associated with the McArthur Basin. Given the nature of the lithology in these areas, there is a lower risk of groundwater contamination as a result of pipeline construction activities (e.g. surface spills etc). However, over the remainder of the KGGP corridor there are environmentally sensitive locales/regions. For example, at KP distances of ~500km and from ~570km to 603km along the proposed KGGP pipeline, there is the potential for the presence of Acid Sulfate Soils (ASS). As ASS generally occurs at shallow depths in coastal environments[6] there is a risk of intersecting and exposing ASS during pipeline construction. As groundwater is generally shallow in coastal environments, it is likely that dewatering will be required for the installation of pipeline infrastructure. Therefore, if ASS is present along the aforementioned sections of the pipeline there is a high-risk of ASS exposure. If exposed to atmospheric conditions, the oxidation products from ASS have to potential to damage pipeline infrastructure and release harmful metals/metalloids to the environment. This may have irreversible effects to biota and other sensitive receptors. This is described in more detail in Section 7.4.2.

Regulatory policy favours avoidance of areas underlain by ASS; however, if this is not possible then appropriate management measures are required. The Northern Territory does not have specific management guidelines for ASS; therefore, the following references will be used as a proxy for establishing a governing framework. However, each area suspected of, or containing ASS, will be assessed individually and by an experienced environmental specialist.

- Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council. 2011. National guidance for the management of acid sulfate soils in inland aquatic ecosystems, Canberra, ACT;

- Dear S.E., Moore NG, Dobos SK, Watling K.M. and Ahern C.R. 2002. Soil Management Guidelines. In *Queensland Acid Sulfate Soil Technical Manual*. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia; and

- Ahern C.R, Ahern M.R. and Powell B. 1998. *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland (1998)*. QASSIT. Department of Natural Resources, Resources Science Centre, Indooroopilly.

[6] Generally occur near coastal environments or palaeo-coastal environments (<10m Australian Height Datum (AHD), (ARMCANZ, 1999; Dear *et. al*., 2002))

### 7.4.2 Potential environmental receptors

As discussed in Section 7.3, it is proposed that water from surface water courses will be extracted for KGGP construction purposes (i.e. dust suppression); however, at present it is unknown as to how these systems will respond when water is extracted from them. A better understanding of the hydraulic connection (i.e. baseflow characteristics) between these surface water systems and groundwater is required. For example, although it can be assumed that groundwater flow supplies and maintains many of these surface water systems in the area of the KGGP route, the degree to which this is occurring for each water source is largely unknown. Therefore, where groundwater supports and maintains surface water systems, otherwise known as Groundwater Dependent Ecosystems (GDEs), there needs to be a better understanding of their function and significance. Not only is this a matter of groundwater supply (i.e. volume), but also the quality of water for the biota that rely on it and the potential for contamination from construction activities. Groundwater Dependent Ecosystems are fundamental for the preservation and maintenance of the environmental assets (i.e. biophysical assets).The nature and degree of the dependence GDEs have on groundwater can vary significantly; both temporally and spatially. GDEs often rely on groundwater for a certain period of time, and without this access, the ecological damage may be irreversible or they may take a long time to recover. At present it is understood that there is currently no over-allocation or over-use of groundwater by existing users in the regions of the KGGP; apart from the areas of the Daly-Roper and Gove WCDs. The main threats to GDEs involve expanded land clearing for agricultural and urban development.

The area traversed by the KGGP receives high annual rainfall, but much of this is quickly lost through evaporation and transpiration from riparian vegetation and all surface water. Groundwater is therefore of critical importance to the functioning of these ecosystems and should be managed accordingly.

Where surface waters (including GDEs) are to be used as a source for water for construction and hydrostatic testing, there is also potential for impact on GDEs. Potential impacts to GDEs from water extraction can be managed appropriately once these systems have been identified. Information from additional investigations will be used to generate an adaptive management strategy. Appropriate assessment to be included in adaptive management strategy for GDEs includes estimating baseflow characteristics for each GDE so that trigger criteria, for the extraction of surface water, may be established.

## 7.5 Regulatory requirements for the Take, Use or Disposal of groundwater

With regards to the legislation and management (refer Section 5) the taking, using or the disposing of groundwater (or surface water), Table 7-2 lists the Beneficial Use Declarations for all other GMUs (refer Section 7.2) present along the KGGP route. As there are no other WCDs present in the region, the GMUs represent selected major aquifer systems within gazetted WCDs across the Northern Territory. The shallow high yielding aquifers in the Daly-Roper and Gove WCDs, and an un-named, porous sandstone aquifer in the eastern McArthur Basin have identifiable conservation values in the national water quality management planning framework (EA 2001; TTP, 2004).

Although unlikely, there may be a requirement to obtain a Waste Discharge Licence under Part 7, Section 74 of the *Water Act.* This will only be necessitated if there is any intention to discharge contaminated water which would enter a waterway. In that case beneficial uses become relevant and have only been declared in two areas as listed below. If there is a requirement to discharge contaminated water in areas where the beneficial uses have not been declared, which is the case for the majority of the RoW, the formal declaration process would need to be undertaken by the relevant department, prior to the issue of such a licence.

**Table 7-2 Beneficial Use Declarations of GMUs (and associated regions) along the KGGP pipeline**

| Locations | | Beneficial Use Declarations[2] aligned with ANZEEC Guidelines |
|---|---|---|
| **GMUs[1]** | **Region** | |
| Un-named Cretaceous Sandstone, Arnhem Block Granite & Low yielding Proterozoics | Gove Area | Aquatic Ecosystem Protection and Recreational Water Quality & Aesthetics |
| Daly River Basin Daly-Roper WCD | Katherine River | Aquatic Ecosystem Protection, Recreational Water Quality & Aesthetics and Agricultural Water Use |
| Daly River Basin | Katherine River & Tributaries | Aquatic Ecosystem Protection, Recreational Water Quality & Aesthetics and Agricultural Water Use |
| McArthur River and Pine Creek Geosyncline | McArthur River Catchment Area | Environmental, Cultural and Riparian |

[1] Refer to Figure 7-2 for location of GMUs

[2] Refer to Beneficial Use Declarations http://lrm.nt.gov.au/__data/assets/pdf_file/0003/7518/bud.pdf

**Table 7-3 Legislation for the *Take, Use and Disposal* of water as referenced in the NT Water Act (2011)**

| Use of water | NT Water Act (2011) reference |
|---|---|
| Taking of surface water for use | Part 6A, Water extraction licence decisions |
| Groundwater as a supply | Part 6A, Water extraction licence decisions |
| Extraction of groundwater | Part 6A, Water extraction licence decisions |
| Waste disposal: uncontaminated | Part 5, Section 63: Grant of underground waste disposal licence |
| : contaminated* | Part 7, Section 74 & 74A: Grant of waste discharge licence |

* if hydrotest water contains, or is suspected to contain, any level of contamination then a licence with regarding Part 7, Section 74 & 74A: "Grant of waste discharge" is required.

## 7.6 CONCLUSIONS

Relevant and available information pertaining to the supplementary risks (if any) to groundwater as a result of the construction of the proposed KGGP was assessed. This pipeline extension will traverse six (6) Groundwater Management Units (GMUs); including the Roper-Daly Water Control District (WCD) and Gove WCD. The three (3) major GMUs include:

- Daly River Basin - Tindall Limestone;
- Daly River Basin – Jinduckin Formation; and
- McArthur Basin including Gove WCD.

Based on available information (i.e. TTP EIS, 2004), this desktop assessment has identified that there is a minimal risk to water quality (surface water and groundwater) as a result of the construction and operation of the KGGPproject. Current engineering design states that the pipeline will be buried to depths of 750mm below the existing terrain and to depths of 2000mm under wetlands (TTP EIS, 2004; Section 5.4.1). Apart from those areas where the pipeline is to be installed beneath wetlands, the pipeline will be constructed above the groundwater table. Although groundwater, for the most part, is well below the final construction and installation depths for most of the year, construction is to be carried out during the dry season. This approach will ensure that groundwater will not be intersected during construction, thus negating the need for dewatering operations and appropriate management of dewatering effluent. During the wet season, where water may come into contact with the buried pipeline in low lying areas, there maintains a low risk of the migration of contaminants to groundwater from the pipeline.

### 7.6.1 Identified Risks

With regards to impacts caused to groundwater sources and systems reliant on groundwater, no major risks have been identified; however, minor risks to water quality and quantity, and the biodiversity assets that rely on it, have been identified. These risks are described in more detail in Section 7.4; while Section 7.7 provides recommendations for further study to better assess the risks to groundwater as a result of the KGGP construction and operation and the development of an adaptive management strategy.

However, the fundamental concerns or potential risks caused to groundwater assets are associated with the following site activities associated with the KGGP. These include the following and are addressed in more detail below:

- Use of water sourcing from surface water courses causing over extraction;
- Allocate suitable groundwater sources (i.e. existing bores) to supplement a supply of water for construction purposes (i.e. dust suppression and hydrostatic testing) and for human consumption. However, if bores are identified these need to be investigated in terms of their yield (for supply purposes), quality (as a potable supply) and ensure abstraction of water from these bores do not have adverse environmental impacts (i.e. impacts to nearby receptors);
- Exposure of Acid Sulfate Soils (ASS); and
- Introduction of chemicals (i.e. fuel spills) to water resources from surface activities.

#### 7.6.1.1 Over extraction of surface water

Given the scarcity of data regarding flow or recharge of surface waters from groundwater (i.e. baseflow), there is the potential for the over abstraction of water from surface water systems if surface water is to be used in the construction of the camp. Such activities of abstracting water from surface water courses may potentially impact biodiversity assets that rely on natural, and not anthropogenic, fluctuations of water levels.

#### 7.6.1.2 Define supplemental sources of groundwater

The availability of water sources for construction purposes and for human consumption, along the KGGP route, is largely unknown. Water from surface water courses has been proposed to supply at least some of the water for construction; however, it is not recommended that water from surface water is consumed by camp personnel. This study has identified a series of existing groundwater bores along the KGGP; however, supplied data suggests that yields are low (i.e. generally <10 L/sec) and quality for human consumption is largely unknown.

The groundwater bores that have been identified in this study may be a good source of groundwater; however, these need to be investigated ahead of construction. The following identify the requirements for investigating these bores:

- Review the potential existing bores located within a defined corridor using the NR Mapping Tool which identifies all bores drilled in the NT;
- Ascertain if bores identified in this desktop study still exist (as current data extends back some 30 years), if they are functional and capable of producing the required yields and that the owners can provide authority for obtaining water supplies;
- Provide an estimate of the capacity of each borehole to provide the necessary quantities and qualities of groundwater for the intended uses; and
- Identify any health issues, and/or potential environmental impacts from the temporary use/consumption of the groundwater and disposal options.

If it is established that the existing groundwater bores identified as part of this study cannot be used as a supplemental source of groundwater for the KGGP, there is an option of installing new groundwater bores. However, installing new groundwater bores is not recommended as this exercise may prove to be costly and ineffective (i.e. due to the variability of the local geology and likely requirement for deep bore construction). If considered to be a viable option, the installation of new groundwater bores does not however require approval under the *Water Act* due to the Section 7 exemption discussed above.

#### 7.6.1.3 Changes to groundwater quality from the exposure of ASS

In addition to the potential risks associated with the over abstracting of water from surface water systems, the potential for exposing Acid Sulfate Soils (ASS) in low-lying areas (i.e. at KP ~500km and ~570km to 603km) as a result of pipeline construction, is quite high (refer to Appendix 3; Eco Logical, 2013). More recent ASS, Holocene in age, generally form in low-lying coastal areas (i.e. <10mAHD) and where groundwater levels are generally near to, or at, the surface. Therefore, in such instances groundwater will need to be dewatered to install pipeline infrastructure, and if ASS is present, appropriate measures will need to be carried out to manage dewatering effluent and the potentially harmful oxidation products from ASS exposure. In addition to the harmful products that could be introduced to water resources as a result of ASS oxidation, there may be damaging effects caused to the pipeline from the generation of acid.

#### 7.6.1.4 DEFINE CONSTRUCTION ACTIVITIES TO ESTABLISH RISK TO SOIL/WATER CONTAMINATION

Lastly, and although considered low risk, there is potential for surface activities to cause harmful effects to water resources. This may involve fuel spills or the release of other harmful chemicals used in the pipeline construction to water resources. However, management plans should be designed to avoid contamination from such activities by using immediate response operations.

## 7.7 FURTHER INVESTIGATIONS

Ahead of construction activities it is recommended that further investigations be carried out. It is important that more detail is collated to better define the risks (if any) associated with groundwater assets (i.e. GDEs) as a result of the construction of the pipeline. Additionally, more detail regarding the connectivity between surface and groundwateralong the pipeline route will also assist in the effective management of the pipeline during construction; especially where these resources are to be used for construction purposes.

Therefore, with regards to the potential risks and data gaps associated with using groundwater as a supplemental supply of water for the construction of the KGGP, an adaptive management strategy is required. With reference to the risks discussed in Section 7.6.1, Table 7-4 proposes management strategies to establish new sources for, and to negate the risks to, groundwater resources as a result of the construction and operation of the KGGP.

**Table 7-4 Recommended further studies ahead of the pipeline construction and management strategy option**

| Activity/Situation | Issue(s) | Management Strategy |
|---|---|---|
| Surface water extraction (i.e. GDEs) (Same for surface water strategy) | Excessive streamflow reduction<br>Adverse river ecosystem impacts | Monitor upstream and downstream flows and extractions using staff gauge<br>Cease extraction if reduction in streamflow is excessive<br>Cease extraction if water level drops excessively at critical downstream location |
| Verify suitability of existing groundwater bores along the KGGP route | To determine if groundwater is a viable source of water to supplement construction requirements | Field investigations shall include locating groundwater bores shown in Figure 1 to 6 in Appendix 2. The field investigation will involve navigation to the recorded location based on GPS coordinates, photo-location, local guide or local knowledge. At each borehole basic data will be collected on the:<br>• Existence and accessibility to the borehole;<br>• Current ownership (if changed);<br>• Water level;<br>• Physicochemical water quality (Temp, pH, Electrical Conductivity (EC), Dissolved Oxygen (DO));<br>• Pumping infrastructure present (i.e. windmill) and its functionality;<br>• Available power source;<br>• Estimated water yield;<br>• Bore casing material and diameter;<br>• Discharge method of the pump; and<br>• Potential health, safety and environmental impacts.<br>If present, the groundwater bore, headworks, pump, tanks, pipelines will be photographed for potential make-good claims. It is recommended that the owner of each groundwater bore be contacted in an effort to collate anecdotal information and permission to abstract water for the uses identified above. This may be through telephone call, email, or personal visit. A proforma borehole owner's consent form will be developed under the requirements of the Principal and used in the field study. |

| Activity/Situation | Issue(s) | Management Strategy |
|---|---|---|
| Occurrence of ASS and requirement for groundwater dewatering for pipeline installation | Exposure of ASS and PASS | Undertake an independent ASS field investigation by specialist personnel to delineate the likely (if at all) occurrence for ASS and characterise the soils accordingly. These investigations, along with geotechnical studies will identify if groundwater will be need to be dewatered to install the pipeline. A detailed report based on the findings of the field investigations (and laboratory results – if required) will be presented in an ASS Management Plan. |
| Pipeline construction | Chemical leaks and spills | Field investigations across all disciplines will have compiled sufficient site information pertaining to site conditions so that management plans can be generated to minimise the effects from chemical spills, thus contaminating groundwater (low risk) |

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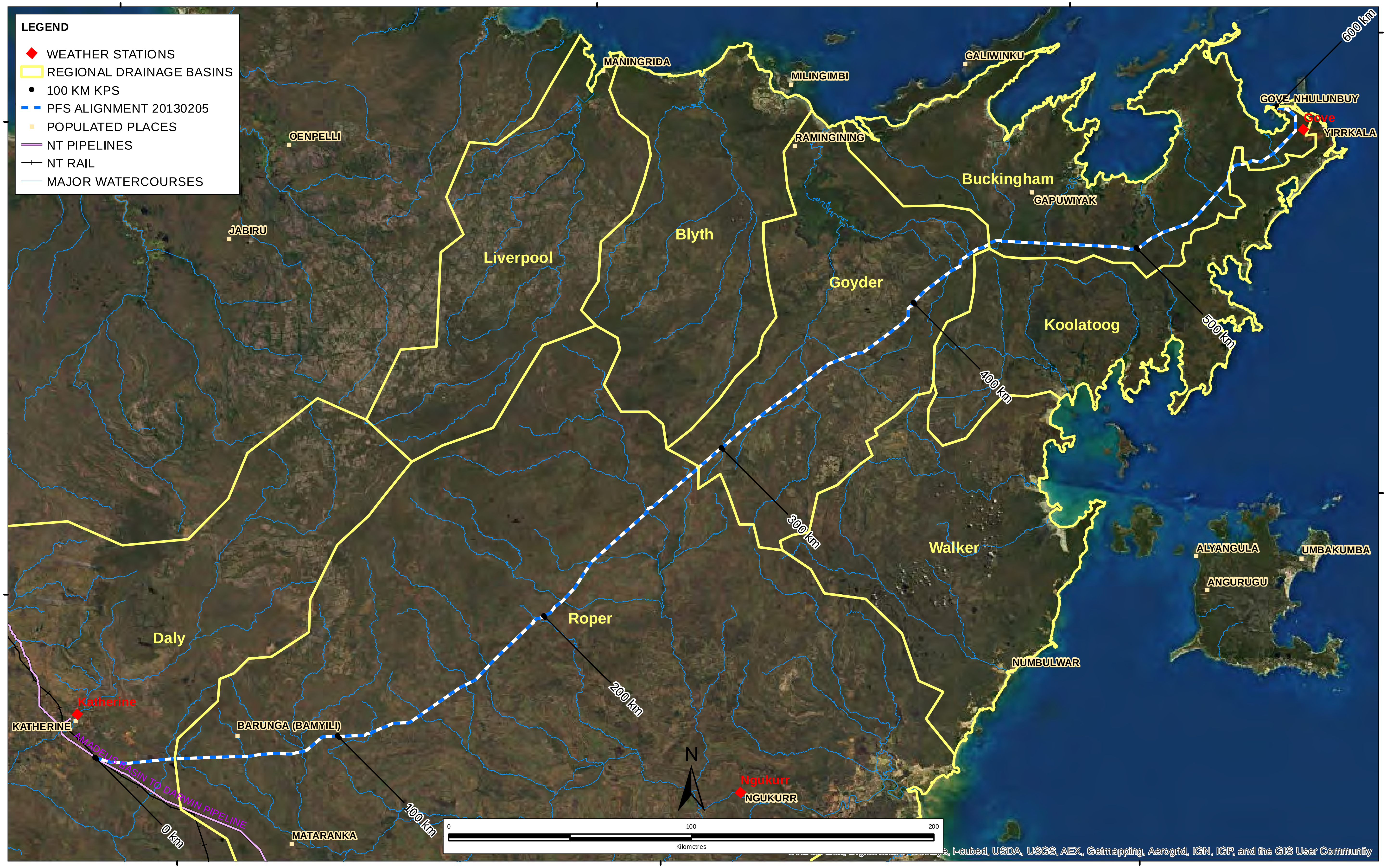
Zaar. 2003. *'Water Resources of West Arnhem Land'* Report 34/2003D –2003

# Appendix 1 – Surface Water Maps




WorleyParsons consulting practices | OneWay to Zero Harm

LOCALITY

| WORLEYPARSONS PROJECT | SCALE | DATUM |
|---|---|---|
| 201001-00367 | 1:1,500,000 @ A3 | GCS GDA 1994 MGA z53 |

| REV | REVISION DESCRIPTION | DRN | CHK | DATE |
|---|---|---|---|---|
| A1 | FOR INFORMATION ONLY | RW | AW | 18-Feb-13 |

NOTES

**INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION**

CLIENT

PACIFIC ALUMINIUM

TITLE

KATHERINE TO GOVE GAS PIPELINE PFS

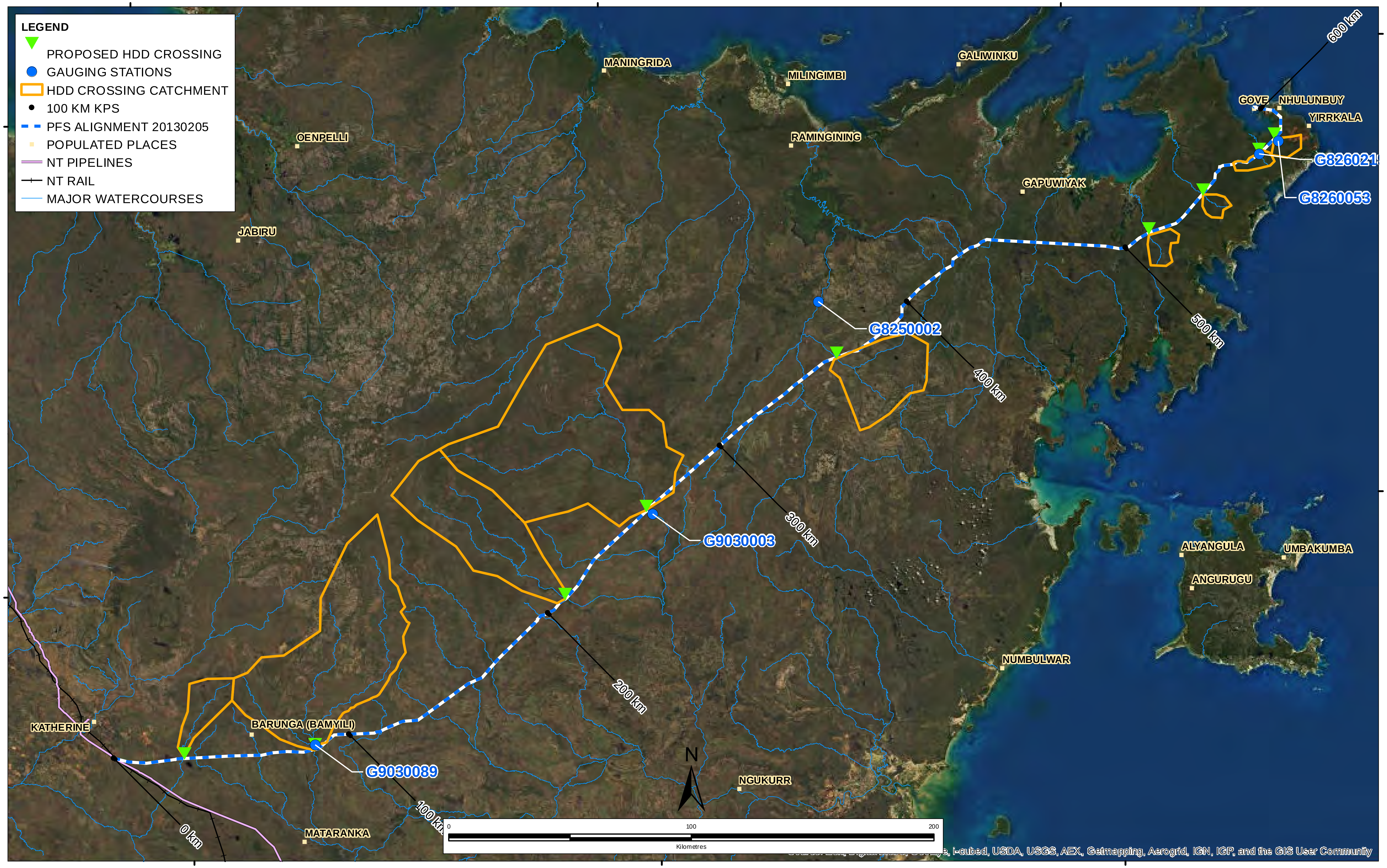
REGIONAL DRAINAGE BASINS

DRG NO: 201001-00367-GIS-SKT-019

REV: A1

PATH: ..201001-00367-GIS-SKT-019

Produced by ryan.wright@worleyparsons.com, Geomatics

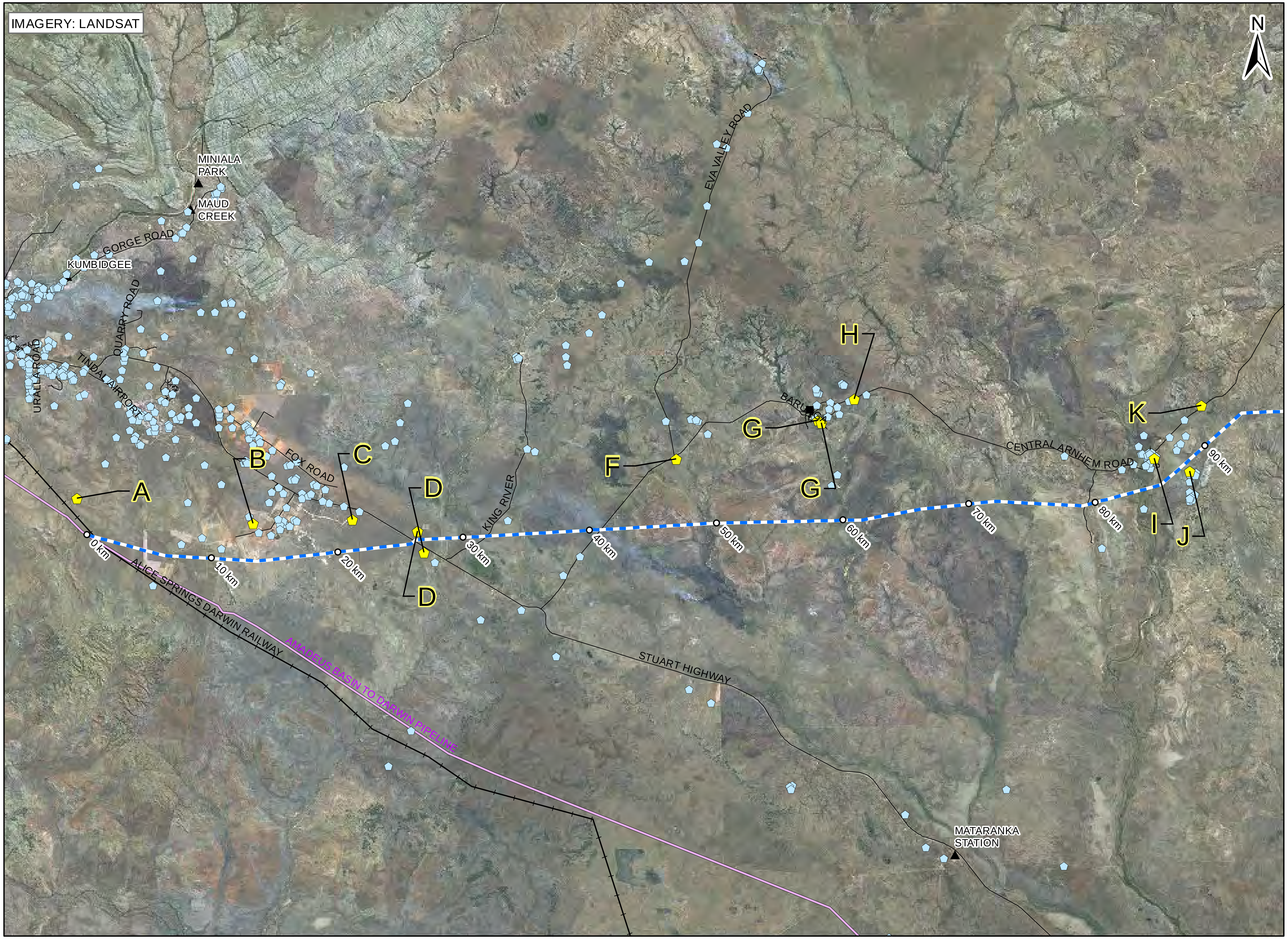



Produced by ryan.wright@worleyparsons.com, Geomatics

| WorleyParsons consulting practices / OneWay to Zero Harm | LOCALITY | | | | | | NOTES | CLIENT | TITLE |
|---|---|---|---|---|---|---|---|---|---|
| WORLEYPARSONS PROJECT: 201001-00367 | SCALE: 1:1,500,000 @ A3 | A2 | FOR INFORMATION ONLY | RW | AW | 18-Feb-13 | INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION | PACIFIC ALUMINIUM | KATHERINE TO GOVE GAS PIPELINE PFS PROPOSED HDD CROSSINGS |
| | DATUM: GCS GDA 1994 MGA z53 | REV | REVISION DESCRIPTION | DRN | CHK | DATE | | | DRG NO: 201001-00367-GIS-SKT-017 REV: A2 |

PATH: ..201001-00367-GIS-SKT-017

# Appendix 2 – Existing Groundwater Bores Along The KGGP




**LEGEND**

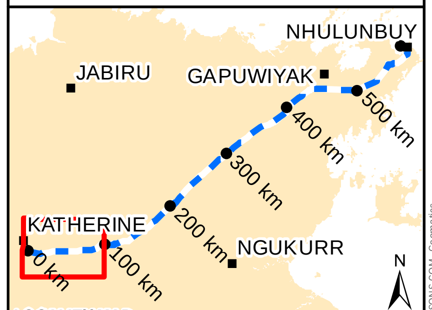
- 10KM KP
- PFS ALIGNMENT 20130205
- IDENTIFIED BORE HOLES
- NO DATA / POOR YIELD
- WATER BORE ECOLOGICAL STUDY 2000-2001
- POPULATED PLACES
- HOMESTEADS
- ROADS
- PIPELINE
- RAIL

NOTES

UNCONTROLLED COPY

PRELIMINARY UNCHECKED

INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION




LOCALITY MAP

| REV | DATE | REVISION DESCRIPTION | DRAWN | DRAFT CHK | DESIGNED | ENG CHK | REVIEWED | APPROVED | REF DRAWING No | REFERENCE DRAWING TITLE |
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| A | 20-Feb-13 | ISSUED FOR INTERNAL REVIEW | RW | TC | | | | | | |

A3 SHEET SCALE 1:300,000

20 10 0

Kilometers

OneWay to zero harm

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CUSTOMER PACIFIC ALUMINIUM

KATHERINE GOVE GAS PIPELINE

IDENTIFIED BORE HOLES
PAGE 1 OF 6

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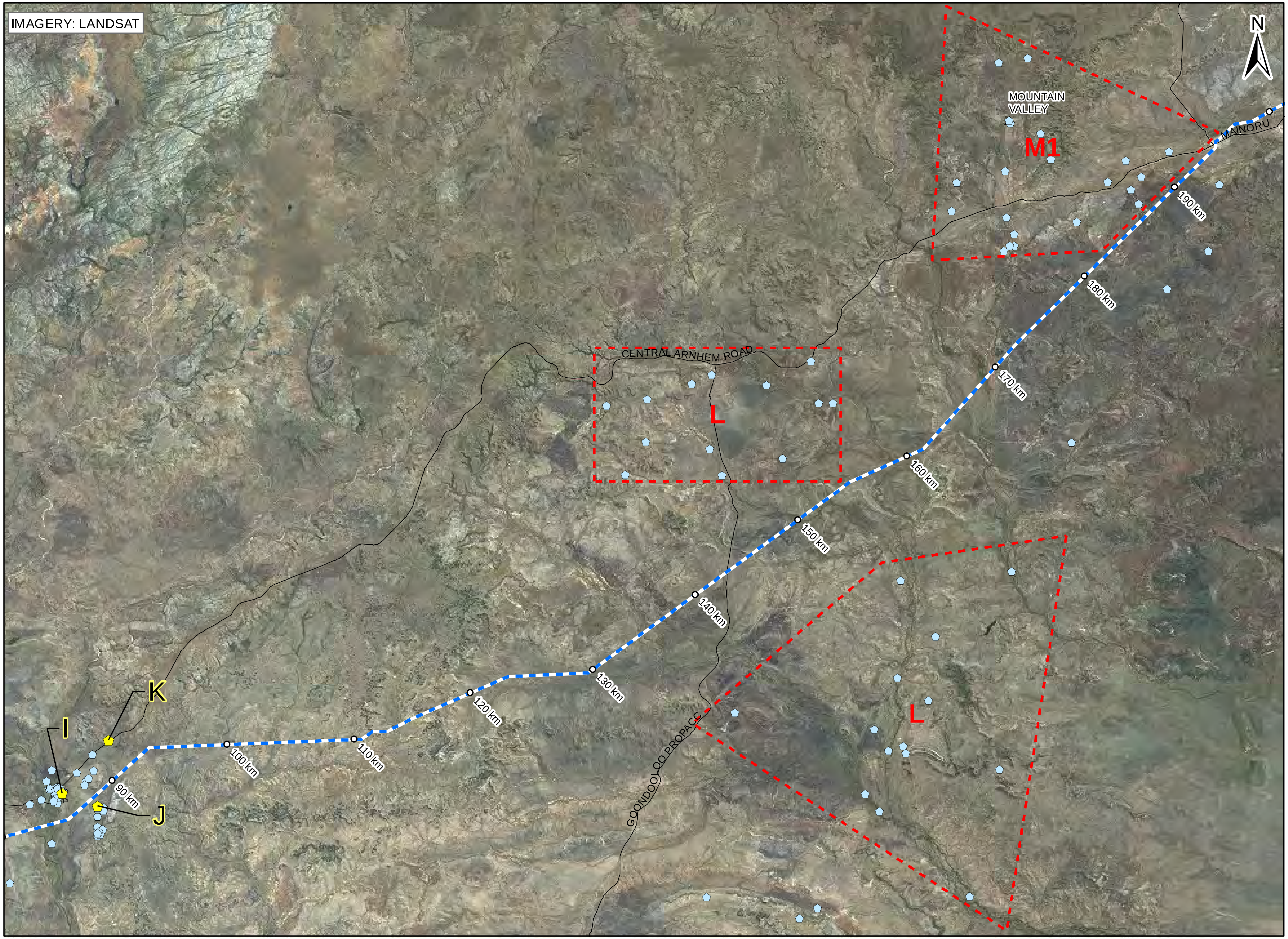


LEGEND

- 10KM KP
- PFS ALIGNMENT 20130205
- IDENTIFIED BORE HOLES
- NO DATA / POOR YIELD
- WATER BORE ECOLOGICAL STUDY 2000-2001
- POPULATED PLACES
- HOMESTEADS
- ROADS
- PIPELINE
- RAIL

NOTES

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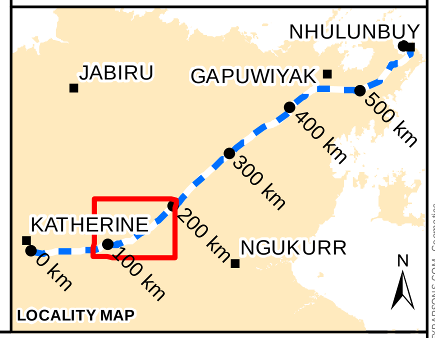


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A3 SHEET SCALE 1:300,000

OneWay to zero harm

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20 10 0 Kilometers

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CUSTOMER PACIFIC ALUMINIUM

KATHERINE GOVE GAS PIPELINE

IDENTIFIED BORE HOLES

PAGE 2 OF 6

DRAWING No 201001-00367-GIS-SKT-021

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**LEGEND**

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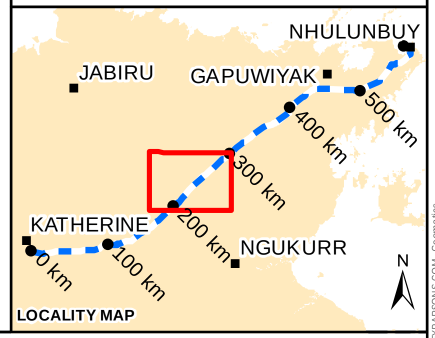


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A3 SHEET SCALE 1:300,000

OneWay to zero harm

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20 10 0 Kilometers

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KATHERINE GOVE GAS PIPELINE

IDENTIFIED BORE HOLES
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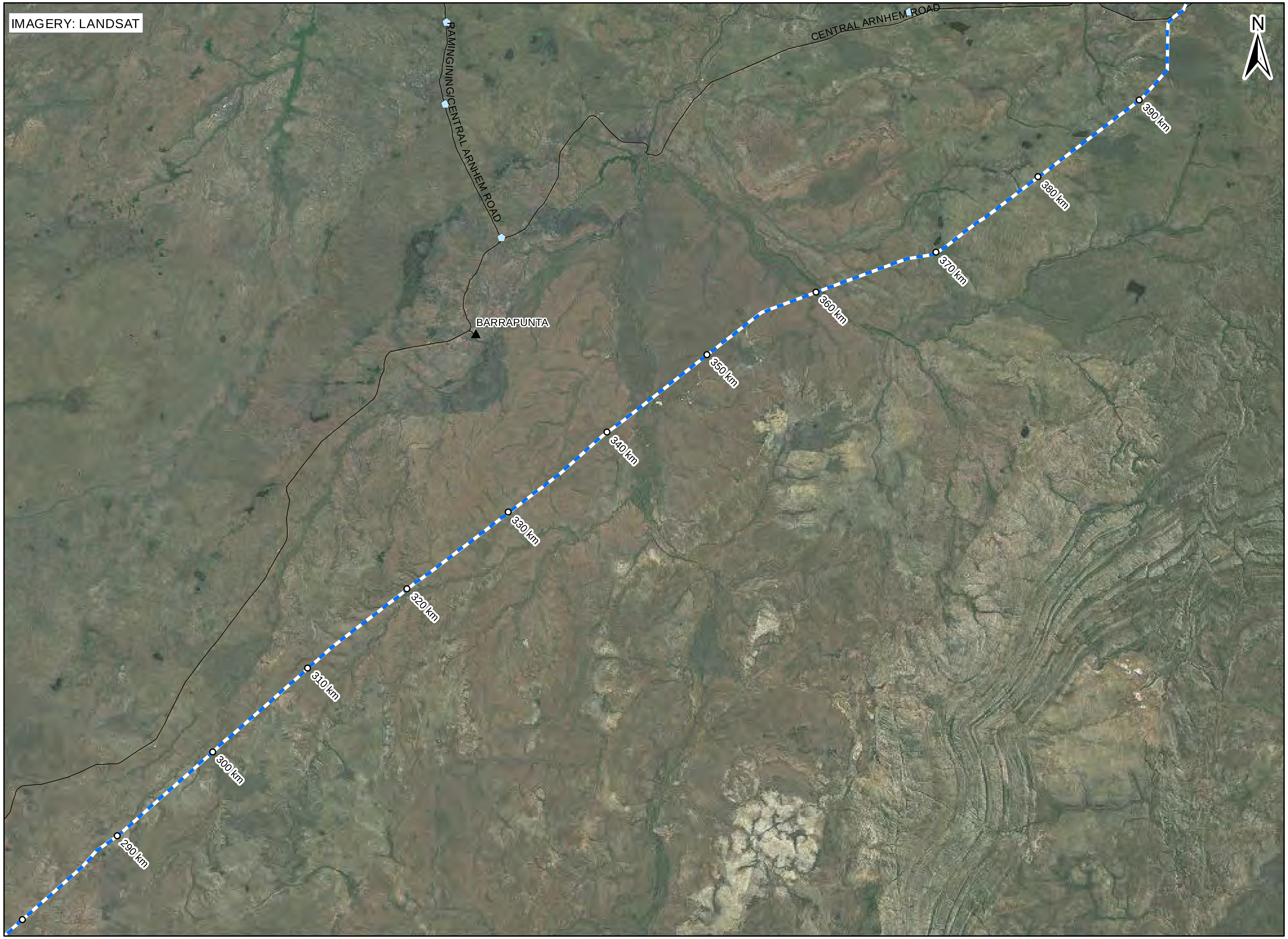


**LEGEND**

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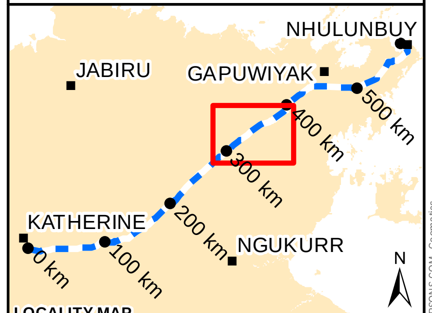

LOCALITY MAP

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A3 SHEET SCALE 1:300,000

OneWay to zero harm

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20 10 0
Kilometers

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PACIFIC ALUMINIUM

# KATHERINE GOVE GAS PIPELINE

## IDENTIFIED BORE HOLES
PAGE 4 OF 6

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LEGEND

- 10KM KP
- PFS ALIGNMENT 20130205
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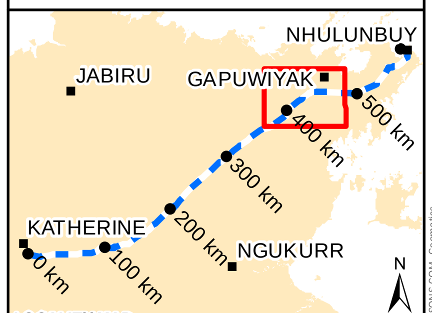


LOCALITY MAP

| REV | DATE | REVISION DESCRIPTION | DRAWN | DRAFT CHK | DESIGNED | ENG CHK | REVIEWED | APPROVED | REF DRAWING No | REFERENCE DRAWING TITLE |
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A3 SHEET SCALE 1:300,000

20 10 0
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IDENTIFIED BORE HOLES
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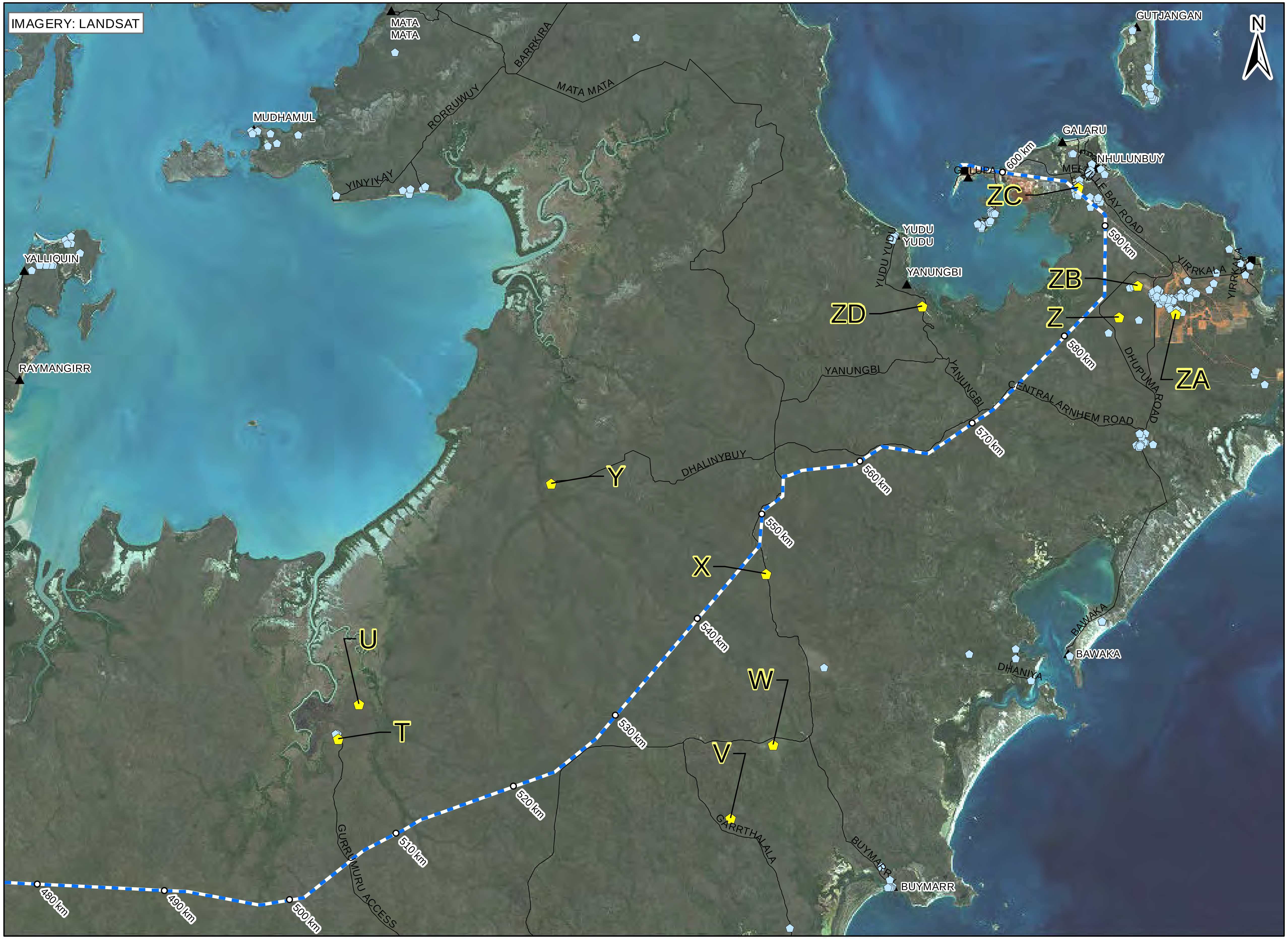


LEGEND

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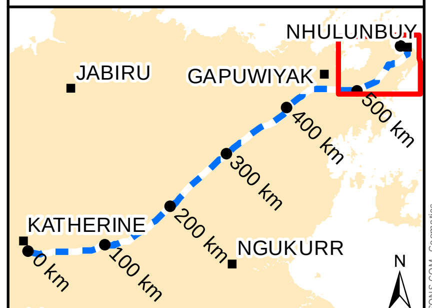


LOCALITY MAP

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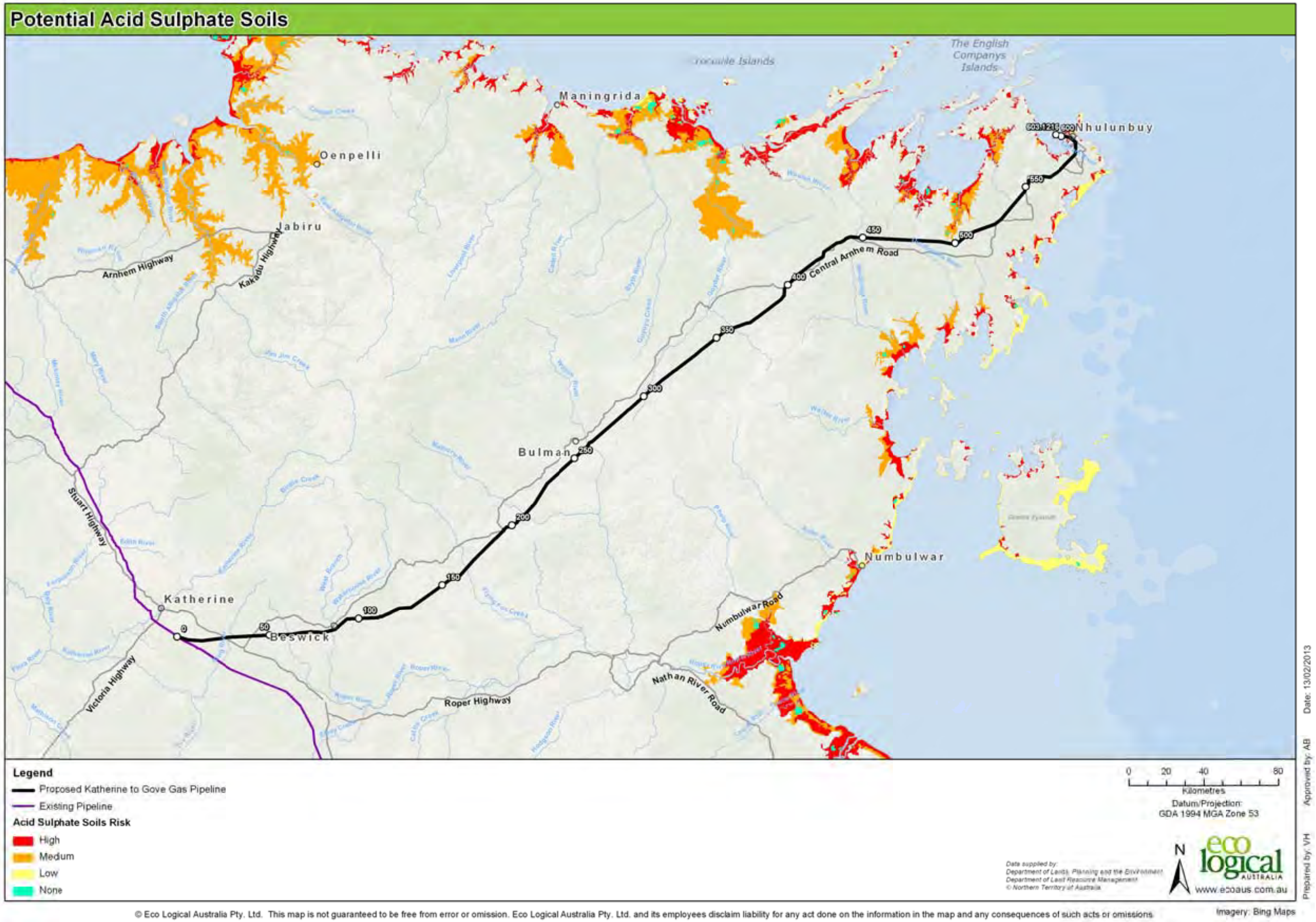
# Appendix 3 – Acid Sulfate Soils Risk Map Results




Acid Sulfate Soils (ASS) risk mapping along the KGGP (Eco Logical. 2013)