Rustlers Roost and Quest 29 Open-Cut Mine Redevelopment

Draft Environmental Impact Statement (EIS)

Section 7.5 - Aquatic Ecosystems

Prepared pursuant to the Environment Protection Act 2019

October 2021

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Document Version:	Rev 0
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Key Project Terms

Term	Definition
Adaptive Management	Systematic process for incrementally improving management practices by learning from the outcomes of past and current practices.
Carbon in Leach	This process uses a dilute alkaline cyanide solution to leach (dissolve) gold from the ore material. Activated carbon removes gold out of dilute cyanide solution by adsorption (sticking). The leaching agent and activated carbon are added together in a slurry of ore and water.
Development Envelope	Defined as the maximum area within which the Project footprint could occur. The development envelope for the Project encompasses 790 ha, inclusive of Rustlers Roost, Quest 29, the accommodation camp and haul road.
Environmental Aspect	An element of the Primary Gold's activities, products or services that can interact with the environment.
Environmental Impact	Change to the environment whether adverse or beneficial, wholly or partially resulting from the Primary Gold's environmental aspects. Environmental impacts can be caused directly or indirectly from a Project activity or cumulatively with other non-Project related activities in a set area.
Environmental Factor	The NT EPA listed environmental objectives to identify environmental matters that have value to the Northern Territory and that need to be protected; and to state the objective to be achieved for each matter. The NT EPA has prepared these environmental objectives and organised these in structured divisions of the environment, called environmental factors.
Existing Disturbance Footprint	Defined as the direct disturbance area from known historical activities associated with the Rustlers Roost, Quest 29, accommodation camp and haul road areas. For Rustlers Roost and Quest 29 this is taken from the existing Mine Management Plans. The existing direct disturbance footprint encompasses 169.4ha within the development envelope.
Heap Leach Pad	Existing areas where historic mining placed ore for processing via a leaching solution to dissolve and capture the mineral. The pads contain the remaining material.
Maximum Vegetation Clearing Extent	The maximum extent of native vegetation clearing proposed for the Project based on mapped vegetation extent layers which account for historic anthropogenic disturbances to the development envelope (e.g. historic mining and pastoral activities). This area constitutes a total of 368.86 ha.
Project	The Project includes the expansion of existing pits, waste rock landforms, water storage dams and internal roads in both the Rustlers Roost and Quest 29 MLs. Two new pits will be constructed at Rustlers Roost and new infrastructure includes an onsite processing plant, a tailings storage facility, a landfill, laydown area, magazine, administration office, accommodation camp and groundwater bores for water supply. The Project is inclusive of an expanded connecting haul road between the non-contiguous extraction areas and an accommodation camp.
Project Area	The Project area is defined as wholly including ML1083 (Rustlers Roost), ML 29783 (Quest 29), ML 29814 (accommodation camp) and the connecting haul road. The entire Project area covers 1,143.25 ha.
Direct Disturbance Footprint	Defined as the direct disturbance area based on the current proposed infrastructure and material placement inclusive of Rustlers Roost, Quest 29, the accommodation camp and haul road. This area covers both historically disturbed and undisturbed areas. The disturbance footprint encompasses 532.84 ha within the Project area.
Significant Impact	A significant impact of an action is an impact of major consequence having regard to: (a) the context and intensity of the impact; and (b) the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact.
Study Area	Refers to the area of survey or investigation for a specific study. This area may be beyond the Project area or development envelope.
Tailings Storage Facility	A specially engineered and constructed impoundment into which tailings (residue) from the ore processing plant is deposited for placement in perpetuity. The storage facility is constructed with confining embankments consisting of earthen material (e.g. rock and soil) and capped following closure.
Waste Rock Dump	An engineered and constructed impoundment into which overburden from the mining process is placed for safe storage in perpetuity.

Acronyms, Abbreviations and Units

Abbreviation, Acronym or Unit	Definition
$m	Million dollars
%	Percentage
+ve	Assessment of positive
µS	Microsiemens
4WD	Four-wheel drive
AADT	Average Annual Daily Traffic
AAS	Atomic Absorption Spectrophotometer
AAPA	Aboriginal Areas Protection Authority
AARL	Anglo American Research Laboratory
ABS	Australian Bureau of Statistics
AE	Aquatic Ecosystems
AEP	Annual Exceedance Probability
AFANT	Amateur Fishermen's Association of the Northern Territory
AHD	Australian Height Datum
ALA	Atlas of Living Australia
ALARP	As Low As Reasonably Practicable
AMD	Acid and Metalliferous Drainage
ANC	Acid Neutralising Capacity
ANCOLD	Australian National Committee on Large Dams
ANFO	Ammonium Nitrate
ANZG	Australia and New Zealand Government
ARI	Average Recurrence Interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
ASRIS	Australian Soil Resource Information System
ASX	Australian Stock Exchange
AS/NZS	Australian/New Zealand Standards
AUSRIVAS	Australian River Assessment System
BESS	Battery Energy Storage System
BoM	Bureau of Meteorology
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
Bq	Becquerel
BUD	Beneficial Use Declaration
CAD	Computer-Aided Design
CAPEX	Capital Expenditure
CCTV	Closed Circuit Television
CE	Community and Economy
CEO	Chief Operating Officer
CH_4	Methane

Abbreviation, Acronym or Unit	Definition
CIL	Carbon in Leach
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide Equivalent
COPC	Contaminant of Potential Concern
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSL	Compact Soil Liner
CSM	Conceptual Site Model
C&D	Construction and Demolition
C&I	Commercial and Industrial
DAWE	Department of Agriculture, Water and Environment (Cth) (current)
DEPWS	Department of Environment, Parks and Water Security (NT) (current)
DGV	Default Guideline Value
DIDO	Drive-in Drive-out
DITT	Department of Industry, Tourism and Trade (NT) (current)
DIWA	Directory of Important Wetlands of Australia
DO	Dissolved Oxygen
DotE	Department of the Environment (Cth) (former)
DotEE	Department of the Environment and Energy (Cth) (former)
EC	Electrical Conductivity
EH&S	Environment, Health and Safety
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
EP Act	*Environment Protection Act 2019*
ERA	Energy Resources of Australia
ERP	Emergency Response Plan
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development
GDE	Groundwater Dependent Ecosystem
GGAP	Greenhouse Gas Abatement Plan
GHG	Greenhouse Gas
GJ	Gigajoule
GL	Gigalitre (1,000 Megalitres)
GPS	Global Positioning System
GRP	Gross Regional Product
GST	Goods and Services Tax
g/t	Grams Per Tonne
GV	Guideline Value
GWP	Global Warming Potential
ha	Hectare

Abbreviation, Acronym or Unit	Definition
HDPE	High Density Polyethylene
HEC-HMS	Hydrologic Modelling System
HFC	Hydrofluorocarbons
HP	Hydrological Processes
HSE	Health, Safety and Environment
IAP2	International Association for Public Participation
IBC	Intermediate Bulk Container
ID	Identification
IECA	International Erosion Control Association
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Provider
ISO	International Organisation for Standardisation
IWEQ	Inland Water Environmental Quality
JORC	Joint Ore Reserve Committee
kL	Kilolitre
km	Kilometre
km^2	Square Kilometre
kV	Kilovolt
L	Litre
L/s	Litre Per Second
LED	Light Emitting Diode
LiDAR	Light Detection and Ranging
LNG	Liquefied Natural Gas
LOM	Life-of-Mine
LPG	Liquefied Petroleum Gas
M	Million
m	Metre
m^2	Metre squared
m^3	Cubic metre
mAHD	Metres Australian Height Datum
mBGL	Metres Below Ground Level
MCP	Mine Closure Plan
MEDLI	Model for Effluent Disposal Using Land
mg	Milligram
ML	Mining Lease (Granted)
MLA	Mining Lease Application
mm	Millimetre
MMP	Mining Management Plan
MNES	Matter of National Environmental Significance
MP	Management Plan
mRL	Metres Reduced Level
Mt	Million Tonnes

Abbreviation, Acronym or Unit	Definition
Mtpa	Million Tonnes Per Annum
MW	Megawatt
N_2O	Nitrous Oxide
NAF	Non-Acid Forming
NAPP	Net Acid Producing Potential
N/A	Not Applicable
NGER Act	*National Greenhouse Energy Reporting Act 2007*
NLC	Northern Land Council
NMD	Neutral Mine Drainage
NORM	Naturally Occurring Radioactive Material
NOI	Notice of Intent
NO_2	Nitrogen Dioxide
NSESD	National Strategy for Ecologically Sustainable Development
NT	Northern Territory
NTG	Northern Territory Government
NTU	Nephelometric Turbidity Unit
NT Act	*Native Title Act 1993*
NVIS	National Vegetation Information System
OPEX	Operational Expenditure
PAF	Potentially Acid Forming
PASS	Potential Acid Sulfate Soil
PER	Public Environmental Report
PET	Plecoptera, Ephemeroptera and Trichoptera
PFC	Perfluorocarbon
PGO	Primary Gold Limited, a wholly owned subsidiary of Hanking Australia Investment Pty Ltd
PMF	Probable Maximum Flood
PMLU	Post Mining Land Use
PMST	Protected Matter Search Tool
PPL	Perpetual Pastoral Lease
Q	Quarter
RL	Reduced Level
RMP	Risk Management Plan
RO	Reverse Osmosis
ROM	Run of Mine
RRMPL	Rustlers Roost Mining Pty Ltd
RSWL	Reduced Standing Water Level
SA	Statistical Area
SD	Saline Drainage
SDS	Safety Data Sheet
SEP	Stakeholder Engagement Plan
SEIFA	Socio-Economic Indexes for Areas
SF_6	Sulfur Hexafluoride
SGV	Site-Specific Guideline Value

Abbreviation, Acronym or Unit	Definition
SIGNAL	Stream Invertebrate Grade Number – Average Level
SoBS	Site of Botanical Significance
SoCS	Site of Conservation Significance
SSAN	Security Sensitive Ammonium Nitrate
SSC	State Suburb Code
SSTV	Site-Specific Trigger Values
STP	Sewage Treatment Plant
SWGs	Stock Water Drinking Guidelines
SWL	Standing Water Level
t	Tonne
TAMS	Territory Asset Management Services
TARP	Trigger Action Response Plan
TBD	To Be Determined
TE	Terrestrial Ecosystems
TEC	Threatened Ecological Community
TEQ	Terrestrial Environmental Quality
Th	Thorium
TN	Total Nitrogen
ToR	Terms of Reference
TP	Total Phosphorus
TPWC Act	*Territory Parks and Wildlife Conservation Act 1976*
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
TSSC	Threatened Species Scientific Committee
U	Uranium
UC	Uncertain
V	Volt
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WCD	Water Control District
WDL	Waste Discharge Licence
WMP	Water Management Plan
WONS	Weed of National Significance
WRD	Waste Rock Dump
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

7.5 Aquatic Ecosystems

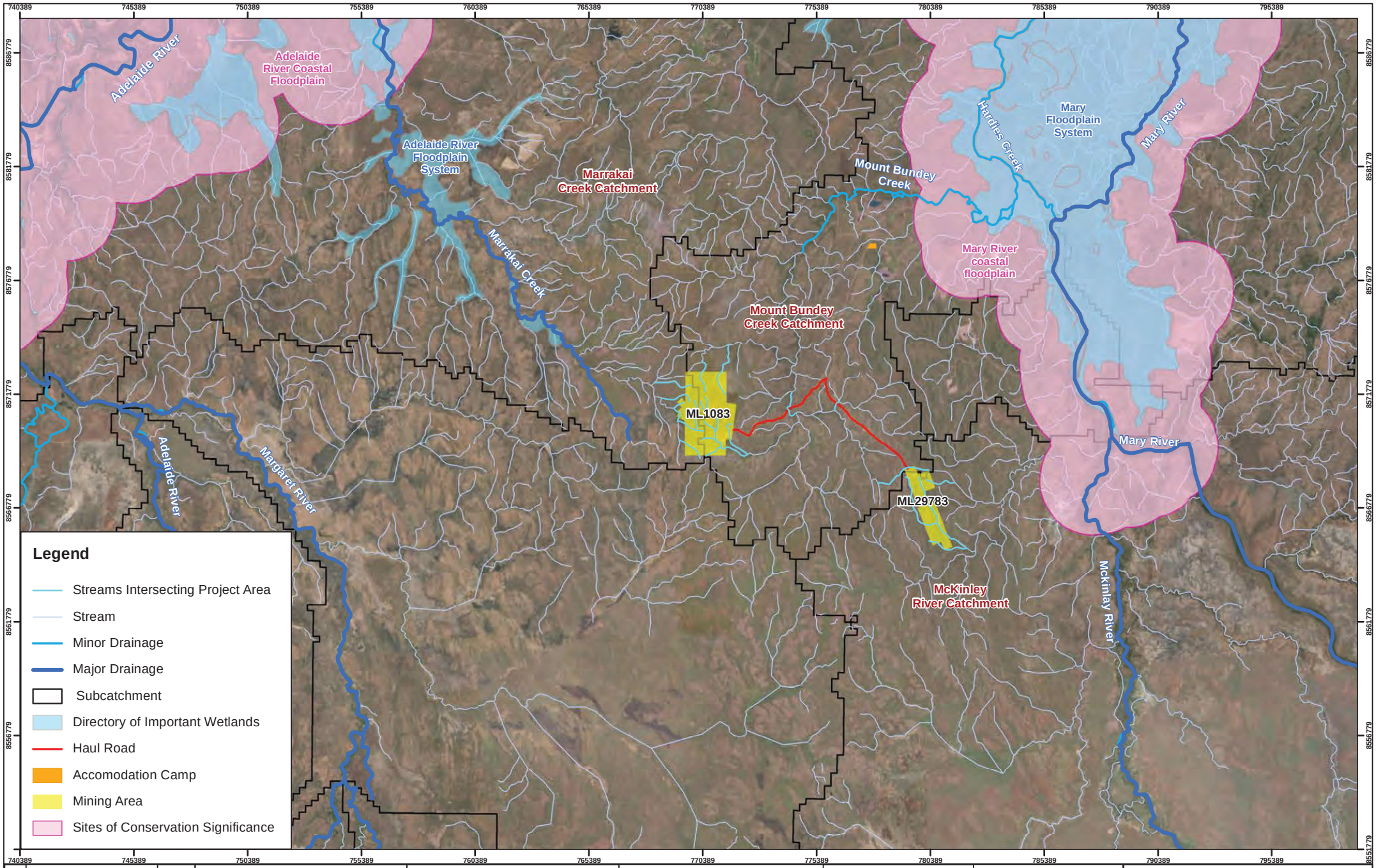
NT EPA Environmental Factor	Aquatic Ecosystems
NT EPA Environmental Objective	*Protect aquatic habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.*
Relevant Policy and Guidance	▪ Cyanide Management: Leading Practice Sustainable Development Program for the Mining Industry (Australia Government 2008); ▪ Guidelines for Fresh and Marine Water Quality (95%). Australia and New Zealand Government (ANZG 2018); ▪ Land clearing guidelines: Northern Territory Planning Scheme (DENR 2020); ▪ Northern Territory: Sampling and Processing Manual. Australian River Assessment Scheme (AUSRIVAS) (date unknown); ▪ Minimum Construction Requirements for Water Bores in Australia (NUDLC 2020); ▪ Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016a); ▪ Hazardous Materials Management, Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016b); ▪ Tailings Managements: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016c); and ▪ Water Stewardship, Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016d).

This section identifies aquatic ecosystems relevant to the Project and the region in which it is placed. This section has utilised existing desktop information and aquatic fauna survey data. Potential impacts of the Project have been identified and assessed in accordance with the risk assessment framework identified in Section 6. Actions to avoid or minimise potential impacts have subsequently been identified in accordance with the environmental decision-making framework.

7.5.1 Environment Values

The following sections discuss surveys related to aquatic ecosystem data collection and provide a description of the existing environmental baseline for the values relevant to the Project area and surrounds.

The Project area is located in two drainage basins being the Adelaide River Basin and the Mary River Basin, both systems contain downstream coastal wetlands of national and international significance (Figure 7-38). The western portion of the Rustlers Roost Project includes Annie's dam (Plate 7-15) and the proposed TSF, drains to the Adelaide River via small tributaries connecting with Marrakai Creek (Figure 7-39). The eastern section of the Rustlers Roost Project area, including the main pit (Plate 7-16), drains towards the Mary River system with tributaries connected to Mount Bundey Creek (refer to Figure 7-40). The Quest 29 Project area is almost exclusively connected to the Mary River system via tributaries flowing into the McKinlay River. Only the northern section of the Quest 29 Project area, containing the BHS pit and the heap leach ponds (Plate 7-17), drains into a Mount Bundey Creek tributary (refer to Figure 7-40). A haul road that allows transport of mined ore from the Quest 29 site to the processing facility at Rustlers Roost will result in three crossings of Mount Bundey Creek and a smaller tributary. The accommodation camp will be located at ML 29814 adjacent to Toms Gully Mine approximately 7 km to the north of the Rustlers Roost and Quest 29 Project area. The camp drains into Coulter Creek, a low order stream and tributary of the Mount Bundey Creek (refer to Figure 7-41).



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Notes:

N

0 1,625 3,250 6,500

Meters

1 cm = 1,500 meters

GCS GDA 1994 MGA Zone 52

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FIGURE 7-38

Regional Overview of Aquatic Features

DRG Ref: 1001087-EIS-07-7.6

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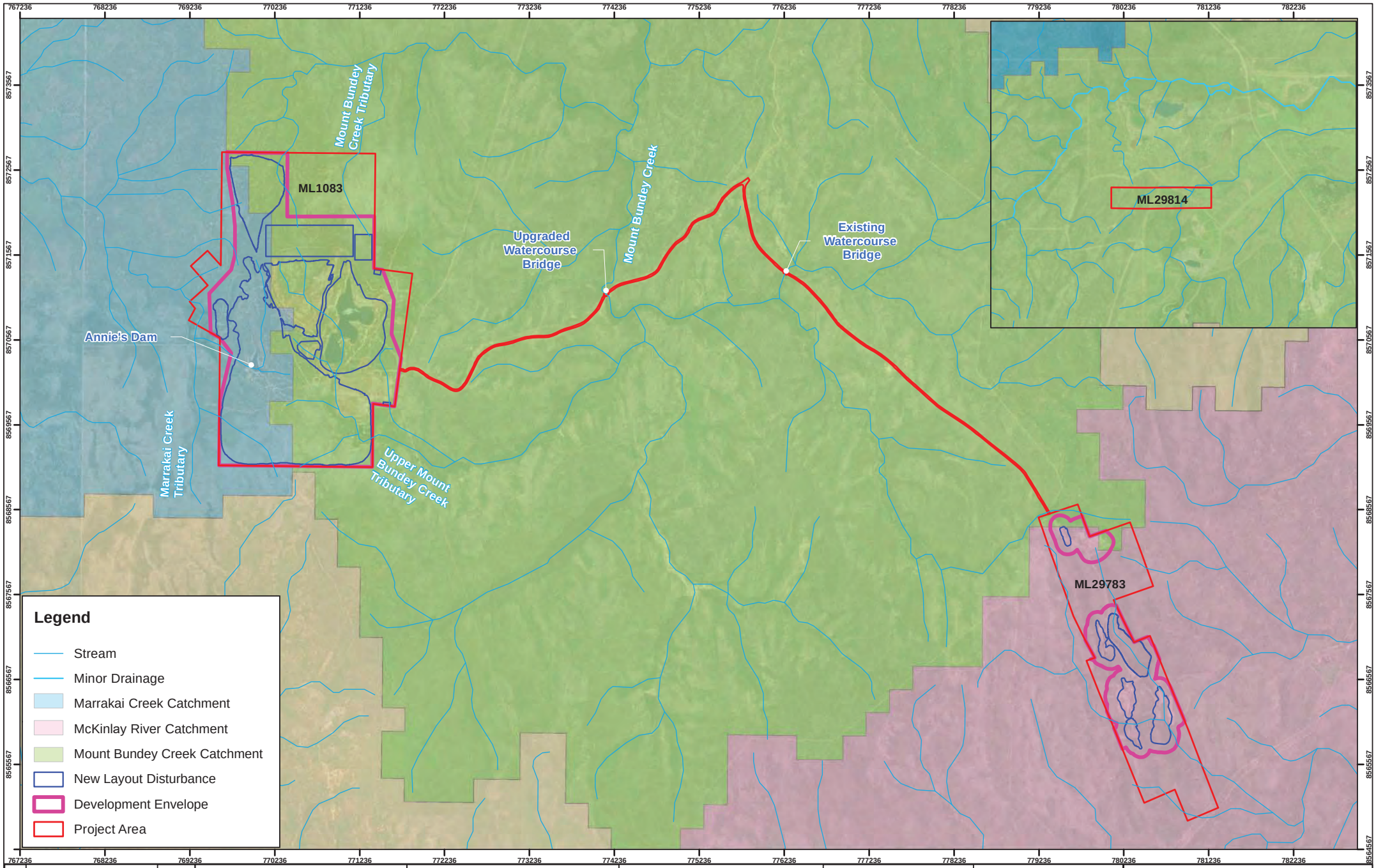

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Notes:

N

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Meters
1 cm = 402 meters
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FIGURE 7-39

Project Area Aquatic Features

DRG Ref: 1001087-EIS-07-7.5

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All tributaries and creeks within the Project area have ephemeral flows only. However, while there are no natural permanent water bodies within the Project area, there is a dam about 2.5 km downstream of the Rustlers Roost Project area in Marrakai Creek (refer to Figure 7-41).

Furthermore, there are permanent water features located in Mount Bundey Creek about 7.5 km from Rustlers Roost, respectively 11 km from Quest 29, as well as about 3 km downstream from Quest 29 in a McKinlay River tributary (Figure 7-42). The environmental quality of these pools is unknown; however, they are in a previously disturbed area with pastoral land use, where livestock accesses these waterbodies regularly.

The Mount Bundey Creek catchment comprises a series of small ridges and dissected hills that are drained by small, steep rivulets, which converge into Mount Bundey Creek, a higher order stream (refer to Figure 7-41). Most of the catchment consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. In general, Mount Bundey Creek flows west to east and is approximately 30 km long, eventually draining north into Hardies Creek, and then the Mary River.

The riparian zone of Mount Bundey Creek is more intact than surrounding tributaries such as Coulter Creek (refer below) and clearing of land beyond the riparian zone is greater in the downstream section than in the upstream area near the Project. Although during sampling events there were observable breaks in surface water, where dry sand was present in the creek bed, surface water flow was recorded at most sites during surveys in 2015, 2017 and 2018 (AES 2019).

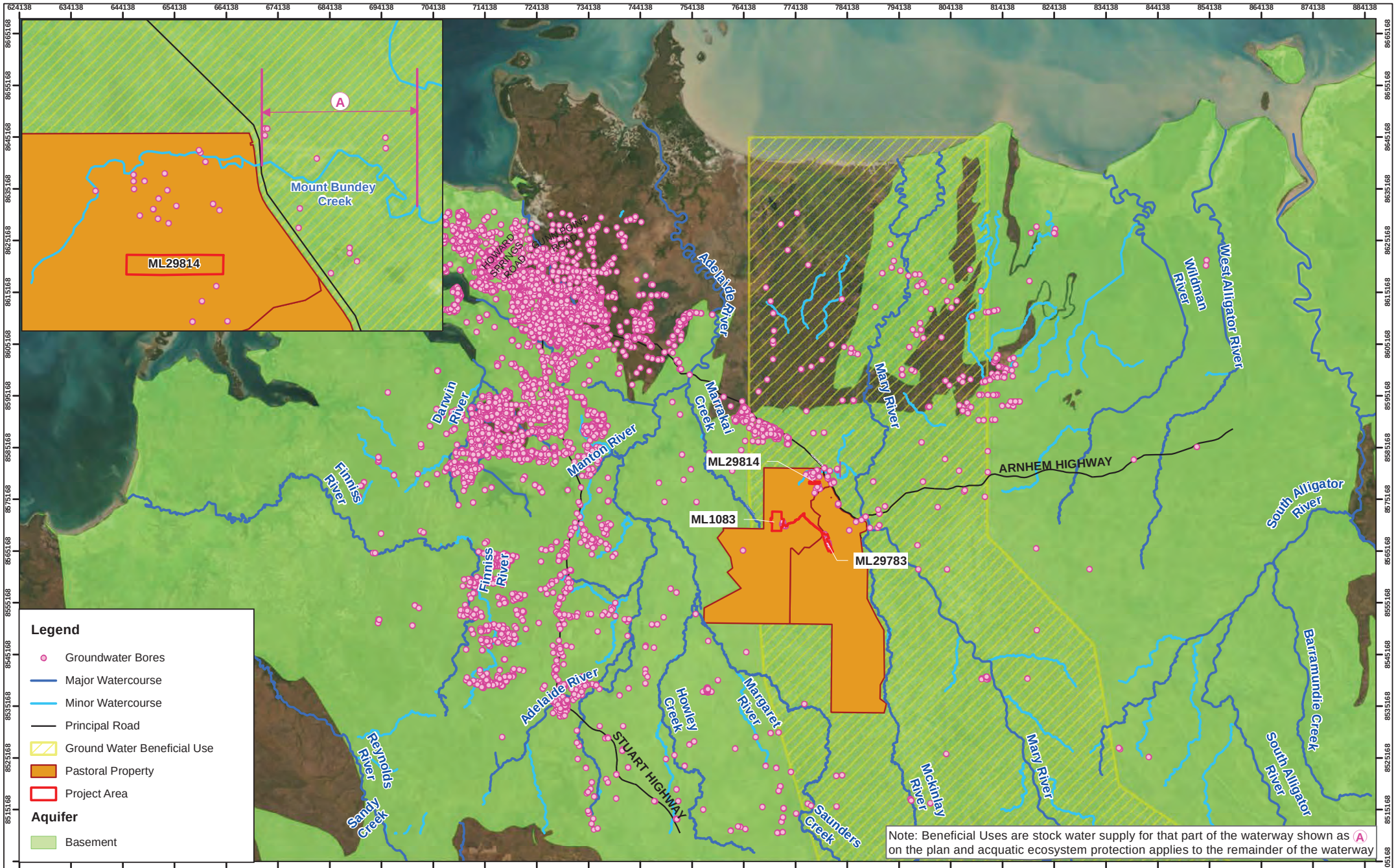
Alluvial groundwater and surface water interact along Mount Bundey Creek, and there is likely an extended period of sub-surface flow in the dry season through the sandy substrates found there. The presence of reptiles such as turtles and monitors in Mount Bundey Creek indicate that refugial pools are likely to occur along the watercourse. Although not observed in camera trapping or during monitoring, large saltwater crocodiles have been observed in Mount Bundey Creek between the Arnhem Highway and Hardies Creek (AES 2019).

The southwestern aspect of the Rustlers Roost Project area with the existing Annie's Dam and the proposed TSF is hydrologically connected to Marrakai Creek. Marrakai Creek, a higher order stream, displays similar landform and surface geology features as the Mount Bundey Creek catchment and terminates into Adelaide River in the west. There has been some disturbance in the catchment from pastoral activities, however most of the riparian vegetation is in relatively good condition. Furthermore, some areas in the upper reaches of Marrakai Creek are also listed in the directory of important wetlands in Australia, which at the closest point is approximately 8 km downstream from the Rustlers Roost Project area.

Coulter Creek, a tributary of Mount Bundey Creek, originates upstream of the accommodation camp on the Old Mount Bundey Station. The confluence of the two creeks is located approximately 4 km downstream of the Arnhem Highway. Previous studies have observed impacts at sites on Coulter Creek as a result of cattle access. The riparian zone along Coulter Creek is not continuous, and the greater catchment area has also been cleared for grazing. Although to date there has not been remote camera monitoring on Coulter Creek, there are anecdotal observations of turtles, freshwater and saltwater crocodiles along the creek (AES 2019).

The Rustlers Roost portion of the Project area contains a number of artificial permanent water bodies related to previous mining activities and to pastoral land use including the pit lake, heap leach and sediment ponds and Annie's dam. Within the Quest 29 Project area there are five pit lakes and three distinct heap leach ponds (refer to Plate 7-18 and Figure 7-42).

Surface and sediment quality surveys and analysis have been conducted on numerous occasions and locations. The results and analysis of the data is discussed more broadly in Section 7.4. In general, the analysis indicates that existing mining activities from Rustlers Roost and Toms Gully Mine may have impacted fish and macroinvertebrate community compositions. For example, elevated dissolved metal and nutrient levels and low pH were recorded at some sampling locations nearby to Toms Gully. However, the relevant reports also highlighted that other factors such as pastoral activities, variations in precipitation and naturally occurring soil and surface geology characteristics also may have contributed to the results. The results of the fauna surveys are outlined in more detail in the following section.



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Notes:

N

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Meters

1 cm = 6,693 meters

GCS GDA 1994 MGA Zone 52

DATA SOURCE
NT Government Open Source Data

DESIGNER CDM Smith

CLIENT PRIMARY GOLD

FIGURE 7-40

Regional Hydrogeological Features

DRG Ref: 1001087-EIS-07-7.35

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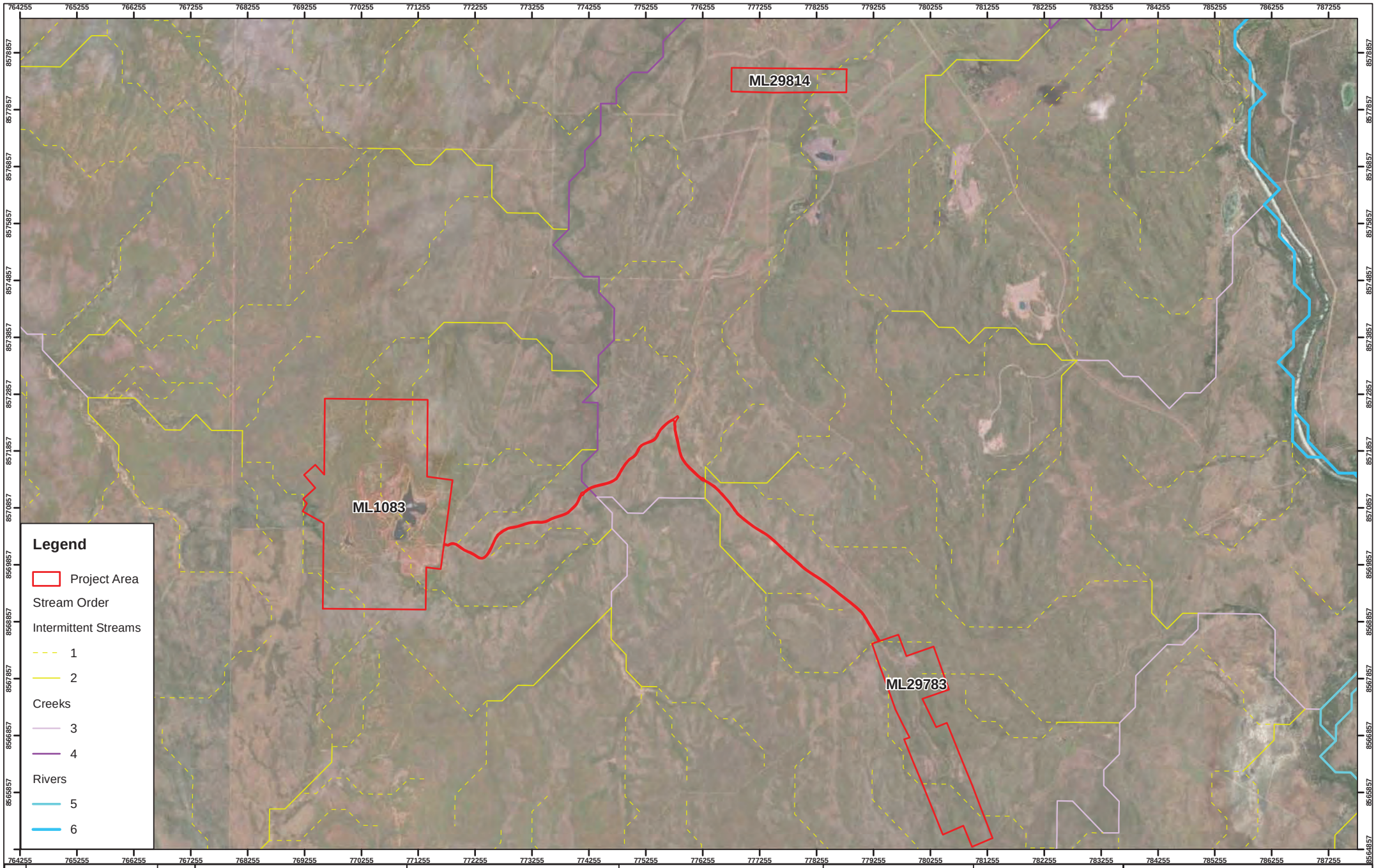

Legend

- Project Area
- Stream Order
- Intermittent Streams
  - 1
  - 2
- Creeks
  - 3
  - 4
- Rivers
  - 5
  - 6

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APPROVED	TK	DATE	04/08/21

Notes:

N

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Meters

1 cm = 600 meters

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DATA SOURCE
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FIGURE 7-41

Stream Orders Relevant to the Project Area

DRG Ref: 1001087-EIS-07-7.7

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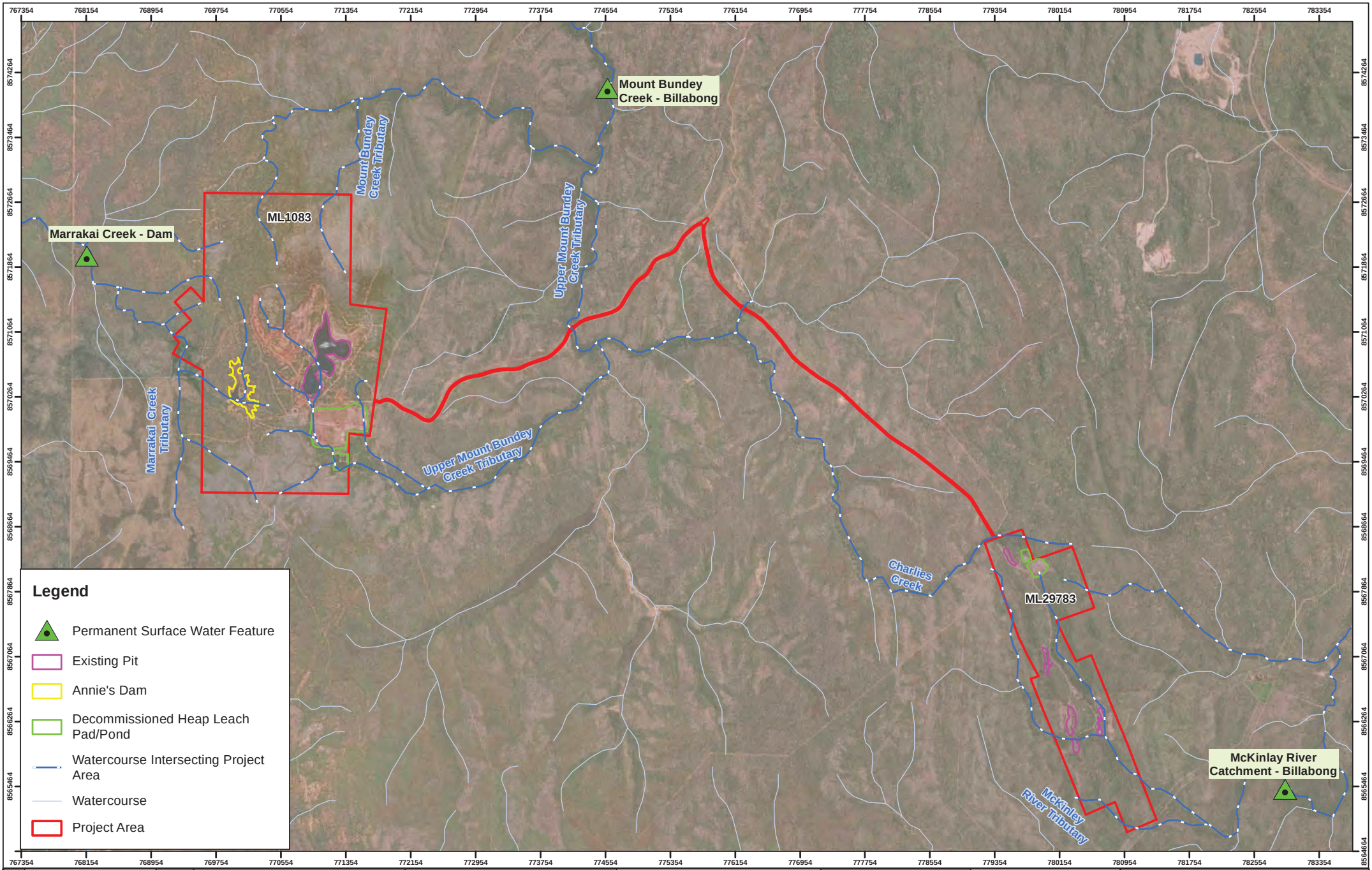
Plate 7-15 Rustlers Roost Annie's dam

Plate 7-16 Rustlers Roost Pit Lake

Plate 7-17 Rustlers Roost Heap Leach Pond

Plate 7-18 Quest 29 Zamu Pit



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Notes:

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Meters

1 cm = 420 meters

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FIGURE 7-42

Permanent Surface Water Features

DRG Ref: 1001087-EIS-07-7.23

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A desktop study and review of available data from previous surveys showed that there are no mapped groundwater dependent ecosystems (GDEs) within the Project area (Rustlers Roost, Quest 29, haul road, and accommodation camp). However, riparian vegetation is present along major drainage lines (EcOz 2020). Broadscale mapping of GDEs downstream of the Project area has identified sections of Mount Bundey and Marrakai Creek and the McKinlay River catchment to have moderate to high potential of GDE occurrence (BoM 2021a). The potential presence of GDEs is further discussed in Section 7.5.1.5.

There are also no wetlands within or intersecting the Project area. The closest significant wetlands are within Marrakai Creek approximately 8 km downstream from the Rustlers Roost Project area and the coastal wetland system of the Mary River and McKinlay River approximately 4 km downstream from the accommodation camp.

The Adelaide River and Mary River wetland systems have been associated with a number of significant and threatened species. A EPBC Act protected matters search relevant to aquatic ecosystems for species or species habitat likely to occur within the Project area and a 25 km buffer zone listed two vulnerable fish species (Freshwater Sawfish – *Pristis pristis*, Northern River Shark (*Glyphis garricki*), nine migratory wetland species with two of them listed as critically endangered (Curlew Sandpiper – *Calidris ferruginuea*, Eastern Curlew – *Numenius madagascarensis*) and two reptile species (Freshwater Crocodile – *Crocodylus johnstoni*, Salt-water Crocodile – *Crocodylus porosus)* (Table 7-55).

In addition, a desktop survey using the NT NR maps system identified three TPWC Act listed reptile species relevant to aquatic ecosystems potentially to occur within the Project area (Table 7-55). However, historical occurrence data only exist for the Yellow-spotted Monitor (*Varanus panoptes*) 600 m to west of the western boundary of the Rustlers Roost portion of the Project area and for Mertens's Water Monitor (*Varanus* mertensi) which was found at the heap leach ponds in the Rustlers Roost portion of the Project area. Targeted aquatic monitoring surveys in 2017 and 2019 at Toms Gully Mine also recorded the occurrence of *V. mertensi* upstream and downstream of the Project area. No information is available on the observed occurrence of Mitchell's Water Monitor (*V. mitchelli*). All of these monitor species are also listed in the International Union for Conservation and Nature red list for threatened species. The species have been further discussed in Section 7.2. No further threatened aquatic species have been identified within the Project area.

Table 7-55 Aquatic Ecosystem Relevant Fauna Identified in EPBC PMST and NT Listed Threatened Species

Listed Species	Status		Project Area Occurrence Likelihood
	EPBC Act	TPWC Act	
Fish Species			
Freshwater Sawfish (*Pristis pristis*)	Vulnerable	Vulnerable	Very unlikely
Northern River Shark *(Glyphis garricki)*	Endangered	Endangered	Very unlikely
Migratory Wetland Birds			
Oriental Reed-Warbler (*Acrocephalus orientalis)*	Migratory	-	Likely
Common Sandpiper (*Actitis hypoleucos)*	Migratory	-	Likely
Sharp-tailed Sandpiper (*Calidris acuminata)*	Migratory	-	Likely
Curlew Sandpiper (*Calidris ferruginuea)*	Migratory - Critically Endangered	Vulnerable	Likely
Pectoral Sandpiper (*Calidris melanotos)*	Migratory	-	Likely

Listed Species	Status		Project Area Occurrence Likelihood
	EPBC Act	TPWC Act	
Oriental Plover (*Charadrius veredus)*	Migratory	-	Likely
Oriental Pratincole (*Glareola maldivarum)*	Migratory	-	Likely
Eastern Curlew (*Numenius madagascarensis)*	Migratory - Critically Endangered	Vulnerable	Likely
Osprey (*Pandion haliaetus)*	Migratory	-	Likely
Reptiles			
Freshwater Crocodile (*Crocodylus johnstoni)*	Marine	-	Certain
Salt-water Crocodile (*Crocodylus porosus)*	Migratory Marine	-	Very Likely
Yellow-spotted Monitor (*Varanus panoptes*)	-	Vulnerable	Certain
Mertens' Water Monitor (*Varanus mertensi*)	-	Vulnerable	Certain
Mitchell's Water Monitor (*Varanus mitchelli*)	-	Vulnerable	Likely

'-' not listed

The 2017 and 2021 PMST search result and a collation of the species search records from both the PMST and NT Fauna Atlas is provided in Appendix R.

7.5.1.1 Desktop and Field Surveys

Aquatic ecology field surveys were conducted at Mount Bundey Creek in 2015, 2017, 2018, 2019 and 2020. In 2017, 2018 and 2019, remote camera trapping was included to understand the spatial distribution of Mitchell's and Mertens Water Monitors along Mount Bundey Creek. While the surveys were commissioned for the neighbouring Toms Gully Mine, the survey area included Mount Bundey Creek which is hydrologically connected to the current Project area. Therefore, the survey results are also relevant to the current Project.

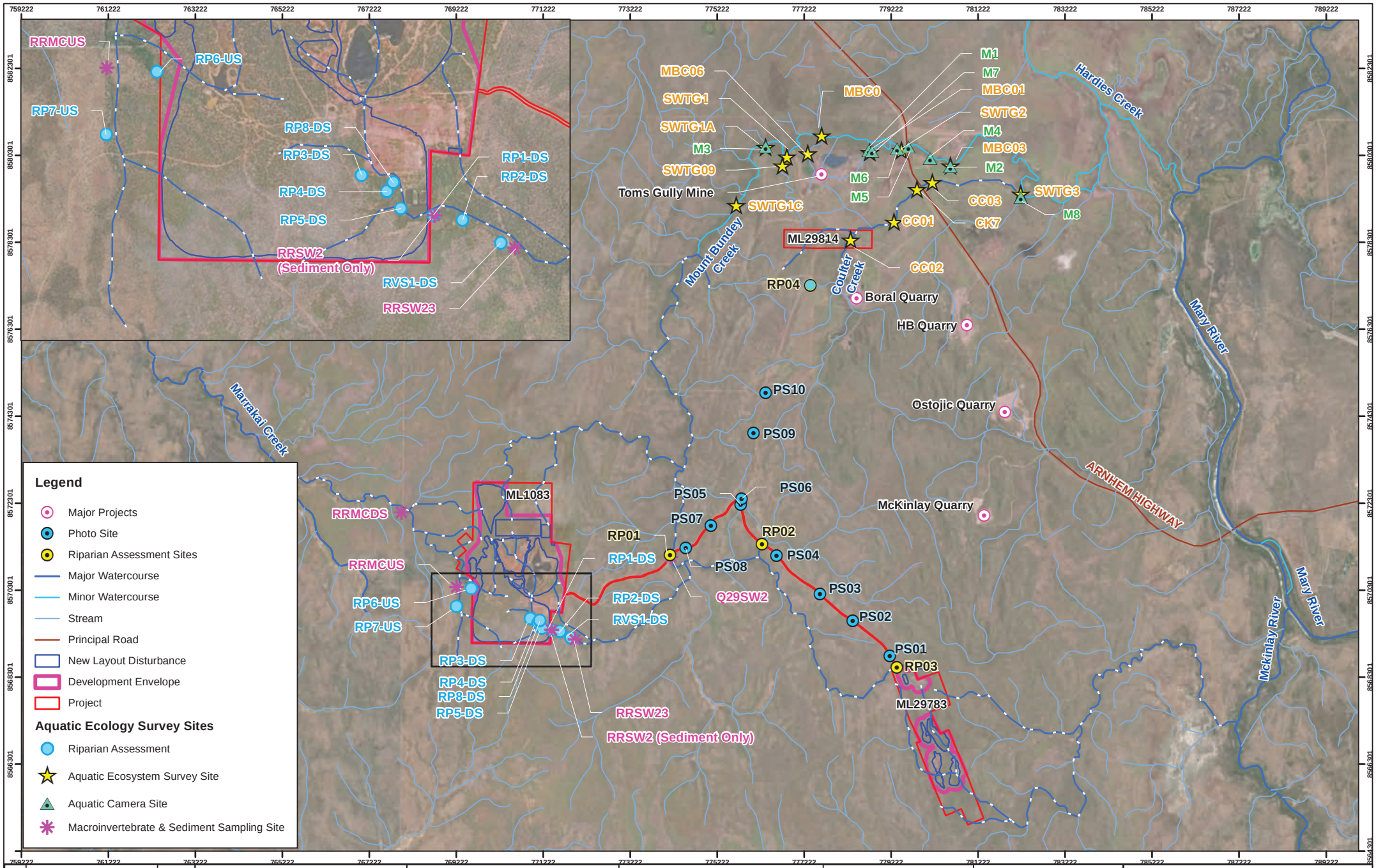
Subsequent riparian habitat and condition surveys were conducted in September and October 2020 to collect baseline information regarding community structure and to assess the riparian habitat value and current condition of riparian areas both upstream and downstream of the Project area. Macroinvertebrate and sediment sampling was completed for upper Mount Bundey Creek and an unnamed tributary to Marrakai Creek to the west in April 2021. This section provides an overview of these surveys.

The 2015 to 2021 field surveys captured a total of 34 sites. Due to site access and weather constraints not all sites were surveyed during each year. All survey sites are listed in Table 7-56 and the location shown on Figure 7-43.

Table 7-56 Aquatic Ecosystem, Riparian, Macroinvertebrate and Sediment Sampling Sites

Site	Latitude	Longitude	Location
Aquatic Ecology (Survey)			
SWTG1A	-12.828164	131.545889	Mount Bundey Creek approximately 11.8 km downstream of the Project area (haul road)
SWTG1C	-12.840763	131.539783	Mount Bundey Creek approximately 2.5 km upstream of SWTG1A.
SWTG1	-12.830004	131.550272	Mount Bundey Creek at confluence of unnamed tributary and approximately 12.3 km downstream of the Project area (haul road)
SWTG2	-12.828563	131.574453	Located at the Arnhem Highway Crossing of Mount Bundey Creek
SWTG3	-12.837900	131.600558	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek
SWTG09	-12.831785	131.549747	Tributary adjacent to Toms Gully Mine site and 1.5 km north of the accommodation camp Project area
MBC0	-12.829152	131.567747	Mount Bundey Creek upstream of tributary draining Toms Gully Mine
MBC01	-12.831928	131.585085	Mount Bundey Creek at confluence of tributary draining new Toms Gully Mine TSF area
MBC03	-12.829462	131.554575	Mount Bundey Creek 500m downstream from Toms Gully Mine site
MBC06	-12.829462	131.554575	Mount Bundey Creek of downstream tributary draining Toms Gully Mine site
CC01	-12.843365	131.563979	Coulter Creek approximately 2 km upstream from CK7
CC02	-12.843275	131.573130	Coulter Creek approximately 1 km upstream from CK7, closest to accommodation camp
CC03	-12.835301	131.581086	Coulter Creek approximately 750 m downstream of CK7
CK7	-12.836571	131.577794	Coulter Creek at highway crossing
Aquatic Ecology (Camera Traps)			
M1	-12.828641	131.567438	MBC01 as associated aquatic ecology site
M2	-12.831928	131.585085	MBC03 as associated aquatic ecology site
M3	-12.828164	131.545889	SWTG1A as associated aquatic ecology site
M4	-12.830514	131.574473	Between M2 and M2
M5	-12.828563	131.574453	SWTG2 as associated aquatic ecology site
M6	-12.828371	131.573752	Mounty Bundey Creek upstream from Arnhem Highway crossing
M7	-12.828542	131.568321	MBC01A as associated aquatic ecology site
M8	-12.837900	131.600558	SWTG3 as associated aquatic ecology site

Site	Latitude	Longitude	Location
Rustlers Roost Macroinvertebrate Survey			
RRMCUS	-12.919623	131.480976	Marrakai creek upstream site
RRMCDS	-12.904950	131.469576	Marrakai creek downstream site
RRSW2	- 12.92867	131.50156	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad
RRSW23	-12.930765	131.50637	Upper Mount Bunt Creek tributary upstream
Q29SW2	-12.914634	131.52644	Upper Mount Bundey Creek tributary down-stream
Riparian Assessment			
RVS1-DS	-12.930660	131.505565	Mount Bundey Creek tributary downstream from Rustlers Roost heap leach pad
RP1-DS	-12.929035	131.501420	Small creek immediate downstream Rustlers Roost heap leach pond
RP2-DS	-12.929315	131.503213	Creek line further downstream from RP1-DS
RP3-DS	-12.926642	131.496960	Creek line adjacent to heap leach pad
RP4-DS	-12.927622	131.498539	Creek line further downstream from RP3-DS
RP5-DS	-12.928647	131.499400	Small creek adjacent to Rustlers Roost heap leach pond
RP6-US	-12.920539	131.484333	Creek downstream of Annie's dam, Marrakai Creek catchment
RP7-US	-12.924354	131.481253	Marrakai Creek tributary upstream of confluence with RP6-US
RP8-DS	-12.927080	131.498932	Creek line adjacent to heap leach pad



Legend

- Major Projects
- Photo Site
- Riparian Assessment Sites
- Major Watercourse
- Minor Watercourse
- Stream
- Principal Road
- New Layout Disturbance
- Development Envelope
- Project

Aquatic Ecology Survey Sites

- Riparian Assessment
- Aquatic Ecosystem Survey Site
- Aquatic Camera Site
- Macroinvertebrate & Sediment Sampling Site

R	Details	Date
1	Final	01/10/21
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-	-	
-	-	
-	-	
-	-	
-	-	

DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	01/10/21

Notes:

N

0 850 1,700 3,400

Meters
1 cm = 785 meters
GCS GDA 1994 MGA Zone 52

DATA SOURCE
NT Government Open Source Data

DESIGNER
CDM Smith

CLIENT
PRIMARY GOLD

FIGURE 7-43

Survey Sites Related to Aquatic Ecology

DRG Ref: 1001087-EIS-07-7.43

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Table 7-57 Representative Sampling Sites for Fish, Macroinvertebrates and Riparian Vegetation

Site	Description
Fish and Invertebrate Sampling Sites	
SWTG1A	SWTG1A is the site closest to the Rustlers Roost Project area and upstream from the Toms Gully Mine. The site is characterised by two large deep pools extending for the whole length of the reach. The pools were divided by a deposit of sand and gravel. Both pools were lined by a thick strip of riparian vegetation shading most of the creek and had steep banks approximately 4 m high (Plate 7-19).
MBC01	MBC01 is located at the confluence of Mount Bundey Creek with a smaller tributary draining a Toms Gully Mine tailings dam (TSF2). The location is representative for an area of high disturbance to aquatic ecosystems. The site was characterised by large deep pool covered the length of reach. The pool contained large woody debris and was lined by riparian vegetation comprising River Pandanus, bamboo and native trees. Banks at the site were vertical and approximately 1.5 m high above the water surface. The creek was heavily shaded from the riparian vegetation, the roots of many of the trees were exposed, and undercut banks were present (Plate 7-20).
SWTG3	SWTG3 is the site furthest downstream in Mount Bundey Creek within the survey area and closest to its confluence to Hardies Creek. The sampling reach was characterised by a long pool and run with large woody debris and undercut bank. Thick riparian vegetation comprising of stands of bamboo and native vegetation provided heavy shading. However, very little understory vegetation was present, with evidence of livestock access to the creek (Plate 7-21).
CC02	This site is furthest upstream in Coulter Creek and closest to the proposed accommodation camp. The site was characterised by a deep pool containing large woody debris and divided by a ford made of large cobbles. Downstream there was a series of connected pools. The creek banks were shaded by a dense, 5 m wide strip of native riparian vegetation. Beyond the riparian zone the land is cleared and used for grazing (Plate 7-22).
Macroinvertebrate Sampling Sites	
RRMCUS	The site is located in a Marrakai Creek tributary and 100 m upstream of the confluence with a creek line connected to Annie's dam. The sampling site was a pool and characterised by grassy vertical banks with few shrubs and trees. The water was flowing with some apparent turbidity the time of the sampling (Plate 7-23).
RRMCDS	The site is further downstream from the Rustlers Roost Project area in a Marrakai Creek tributary. The site is characterised by a narrow, meandering creek line through Paperbark and Pandanus which lined the banks and provided shading. Water was flowing at the time of the sampling and slightly turbid, and shading was high. Leaf packs and branches were common throughout (Plate 7-24).
RRSW23	The site is outside the Rustlers Roost Project area in a tributary of Mount Bundey Creek that receives drainage from the Rustlers Roost heap leach pad and ponds. The site consisted of a large, deep pool between riffles and runs. Substrate in shallow habitats was a mixture of sand and pebbles, and the pool contained sand with bedrock covered by detritus. Riparian vegetation was made up of shrubs, with some trailing into the water, providing shade and ample edge habitat for macroinvertebrates. The water was flowing and relatively turbid at the time of the sampling (Plate 7-25).
Q29SW2	This site was the furthest downstream in Mount Bundey Creek at the proposed haul road crossing. The site was highly shaded by overhanging well-established riparian tree and shrub vegetation along the creek. Water flow was observable, but very slow and turbid (Plate 7-26).
Riparian Vegetation Survey Sites	
RP8 - DS	The site is nearby a Rustlers Roost heap leach pad drainage line connected to a Mount Bundey Creek tributary. There was no water flow observed during the survey, however a few small pools where observed. Much of the vegetation was disturbed due to mining activities (heap leach pad) and land clearing adjacent to the channel. The site was classified as open forest patch only providing limited shading to the drainage line (Plate 7-27).
RP6 - US	The site is within a creek line that connects Annie's dam with a Marrakai Creek tributary. Water was flowing during sampling and was clear. The site was representative of undisturbed riparian vegetation edging a meandering 4 m wide and 1 m deep creek channel and therefore classified as closed forest patch (Plate 7-28).

Plate 7-19 Mount Bundey Creek, Site SWTG1A

Plate 7-20 Mount Bundey Creek, Site MBC01

Plate 7-21 Mount Bundey Creek, Site SWTG3

Plate 7-22 Coulter Creek, Site CC02

Plate 7-23 RRMCUS Marrakai Creek Control Upstream from Site

Plate 7-24 RRMCDS Marrakai Creek Tributary Downstream from Site

Plate 7-25 RRSW23 Mount Bundey Creek Tributary Downstream from the Rustlers Roost Heap Leach Pad

Plate 7-26 Q29SW2 Mount Bundey Creek Downstream

Plate 7-27 **RP8-DS Drainage Line Directly Adjacent to South of Heap Leach Pad**

Plate 7-28 **RP6-US Creek Downstream of Annie's Dam, Marrakai Creek Catchment**

7.5.1.2 Macroinvertebrates

A number of macroinvertebrate indices relevant to aquatic ecosystems have been used to describe the level of anthropogenic disturbance, habitat degradation and water quality in aquatic ecosystems. Responses to contaminants or changes in flow can result in anything from changes in abundance and diversity, changes in community composition and / or the loss or reduction of sensitive taxa.

For example, the PET Richness measure is calculated as the total number of families from three orders of insects (Plecoptera (stoneflies); Ephemeroptera (mayflies); and Trichoptera (caddisflies), as these orders are particularly sensitive to changes in their environment (Karr & Chu 1999). Higher numbers of PET taxa are generally an indication of a lower level of degradation of habitat and better water quality. Furthermore, SIGNAL-2 is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high sensitivity whilst a value of 1 indicates high pollution tolerance (Chessman 1995). The AUSRIVAS model uses site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress, with allocating bands of conditions compared to the reference sites (e.g. Band X = more diverse than the reference site, Band A = reference site, Band B = significantly impaired) (Lamche 2007).

Mount Bundey Creek and Coulters Creek

Macroinvertebrate surveys in Mount Bundey Creek and Coulters Creek were conducted in 2010, 2012, 2015, 2017 and 2019 as part of the Toms Gully Mine aquatic ecology monitoring program. The sampling and processing for the surveys followed procedures outlined in the Northern Territory AUSRIVAS Manual for the Darwin-Daly Region (Lamche 2007) and are discussed in detail in Appendix S.

The relative abundance of macroinvertebrates collected in May 2017 showed that Coulter Creek contained consistently higher numbers of macroinvertebrates across samples, with CC03 recording the highest abundance of any site. Sites SWTG1A and SWTG1 had the highest relative abundances of any sites sampled on Mount Bundey Creek. All other sites were generally similar across both replicates collected, except MBC06, which varied markedly. MBC01 and MBC03 contained the lowest numbers of macroinvertebrates collected in May 2017. Results were compared against those from sites sampled in previous years. Sites located furthest upstream on Mount Bundey Creek recorded much higher relative abundances in 2017 than from any previous sampling event, whereas those towards the downstream end of the study area were relatively similar. Site MBC03 recorded consistently low relative abundances in both sampling events that it was visited. Sites on Coulter Creek recorded far higher relative abundances in 2017 to those in samples collected in 2015.

While abundance was not recorded for the 2019 survey, the invertebrate taxonomic richness was. Taxa richness was lowest at adjacent site MBC06, where a maximum of 15 taxa were collected from the two replicate samples. All other samples collected from potentially impacted sites adjacent to and downstream of Toms Gully Mine contained between 22 and 28 taxa. Taxa richness was also low at the furthest upstream site on Mount Bundey Creek, control site SWTG1C, and the furthest downstream site on Coulter Creek, reference site CC03. Taxa richness was highest at Coulter Creek reference site CC01 and decreased in a downstream direction from this point. At control sites, taxa richness was much higher at SWTG1A than at SWTG1C, with 25 taxa collected in both replicates at SWTG1A, compared with 18 taxa in both replicates at SWTG1C. Statistical analysis identified that there was a significant ($p<5\%$) difference in community composition between site types. Furthermore, pairwise tests for sites showed that there were no significant similarities in the macroinvertebrate community between individual pairs. In addition, pair wise testing between individual sampling years also indicated a significant difference in the macroinvertebrate community composition on Mount Bundey Creek and Coulter Creek. The results underpin the large temporal and spatial variability in the examined macroinvertebrate community.

Site SWTG1A (furthest upstream on Mount Bundey Creek) showed no intra-site variability in PET Richness and were dominated by Ephemeroptera (Mayflies) families. Sites adjacent to and downstream of Toms Gully Mine showed a greater amount of variability in PET richness between samples at a given site. The greatest variability was found at MBC01 and MBC03. Furthermore, there was very little variability in SIGNAL-2 scores between sites with the majority of the sites having a score of 4 or less.

Overall, the macroinvertebrate community of the study area was characterised by low sensitivity taxa, often in high abundances. The majority of macroinvertebrate families collected had low sensitivity grades and had very little preference for habitat. There was no clear pattern in macroinvertebrate metrics on Mount Bundey Creek. The results of the AUSRIVAS model showed that most sites on Mount Bundey Creek returned a Band A rating, which indicate that they were similar to the reference condition, with three sites (SWTG09, MBC01 and MBC03) returning a Band B rating (significantly impaired condition).

In conclusion, the macroinvertebrate community of the study area was characterised by pollution tolerant families that are more likely being influenced by habitat availability at a given site, rather than by water quality in Mount Bundey Creek and Coulter Creek. Sites closest to the TSF at Toms Gully Mine showed more intra-site variability than those upstream of it, the furthest downstream site showed consistent results that indicated recovery from any impairment, should it have been detected downstream of Toms Gully Mine. However, sites adjacent to and directly downstream of Toms Gully Mine showed variation in the community and health metrics between samples at the same site, denoting an uneven distribution of macroinvertebrate families, indicating different pressures on the system.

Mount Bundey Creek and Marrakai Creek survey

A macroinvertebrate survey in Mount Bundey Creek and Marrakai Creek catchment was conducted in 2021 to establish baseline data prior to re-commencement of mining actives and pit dewatering at the Rustlers Roost Project area. The results including the sampling methodology are discussed in detail in Appendix Q.

The macroinvertebrate sampling from the four survey sites has shown that the relative abundance of macroinvertebrates was greatest at RRMCDS and RRSW23 with both sites recording values over 1,400. RRMCUS recorded the next highest value, exceeding 600 individuals, while Q29SW2, with slightly above 400, recorded the lowest value. Overall taxa richness was lowest at RRMCUS, with lower than twenty taxa, and highest at Q29SW2 with thirty taxa identified. Both RRMCDS and RRSW23 recorded over twenty taxa each.

PET richness was very similar at all sites, with RRMCUS recording just one fewer PET taxa (five) than the other three sites (six each). Signal-2 results varied from slightly greater than 3.5 to just over 4, showing minimal variation between sites, with RRMCDS and Q29SW2 recording the lowest and greatest score respectively. There is an observable difference in community composition between the upstream site on Marrakai Creek and all other sites. True flies (Diptera) dominate the community at the upstream site. This is in contrast to the other sites, where mayflies (Ephemeroptera) were the most abundant taxa, indicating greater variability in community composition.

The relative abundance results may be explained by differences in habitat at each sample location. The photos provided for RRMCDS and RRSW23 showed a greater number of trees lining the bank with exposed roots providing more structured habitat for macroinvertebrates. In contrast, RRMCUS had fewer trees and more grasses lining the bank, perhaps providing different habitat which may have contributed to the overall lower abundance.

The high taxa richness at Q29SW2 may be due to its location three km downstream, in a section of the creek where seasonal flows extend over a longer time period then further upstream, hence providing more suitable habitat for macroinvertebrates. This may be relevant given that the two wet seasons immediately preceding the 2020-2021 wet season were some of the poorest on record, potentially reducing the taxa richness through shortened periods of water flow (BoM 2021b, c).

The SIGNAL-2 results demonstrated a high proportion of non-pollution tolerant taxa at all sites. The comparison of data post pit dewatering discharge will assess any potential environmental impacts, as the pollution tolerant taxa may increase proportionally to the non-pollution tolerant taxa.

The results from RRMCUS were substantially different from the three other sites, with a significantly larger proportion of true flies (Diptera) and smaller of mayflies (Ephemeroptera). However, water quality differences did not appear to be driving any differences in community composition, habitat characteristics are likely playing a major role in the presence or absence of macroinvertebrate families in each individual sampling site.

Overall, the differences in the macroinvertebrate community between sites highlights the importance of sampling prior to mining/dewatering activities recommencing within the Project area, as it provides site-level baseline data for future comparison. In summary, ongoing monitoring of the receiving environment will be the most effective tool in adaptive management of the discharge strategy, should negative impacts be observed.

7.5.1.3 Fish

There is limited publicly available data on the freshwater fish community within the catchments of the Rustlers Roost Project area, however data is available for the neighbouring Daly River catchment. A total of 38 fish species belonging to 17 families are known to inhabit the Daly River catchment, giving some indication of the number of species that could potentially inhabit the Adelaide River and Mary River catchments. Information provided by the World Wildlife Fund for the Daly River freshwater fish community shows that none of the recorded species has a 'threatened' conservation status (WWF 2005).

Fish survey methods to assess baseline conditions associated with the Project included electro-fishing, bait trapping, seine and cast netting depending on site characteristics. Further details of methodology are outlined in the aquatic ecology survey reports (Appendix S). The sampling results from the 2017 survey identified 471 individuals belonging to 13 species of fish. Of the thirteen species of fish recorded in May 2017, Eastern Rainbowfish (*Melanotaenia splendida*) comprised the largest number of those collected, followed by Sailfin Glassfish (*Ambassis agrammus).* Spangled Perch (*Leiopotherapon unicolor*) and Eastern Rainbowfish were the most widely distributed fish. Mount Bundey Creek sites recorded a higher diversity of fish species compared with Coulter Creek. With diversity being generally low on Coulter Creek, and sites upstream of the Arnhem Highway recorded the lowest diversity of any sites on that watercourse, with only one species being caught at both sites. Furthermore, there was little difference in diversity between sites on Mount Bundey Creek.

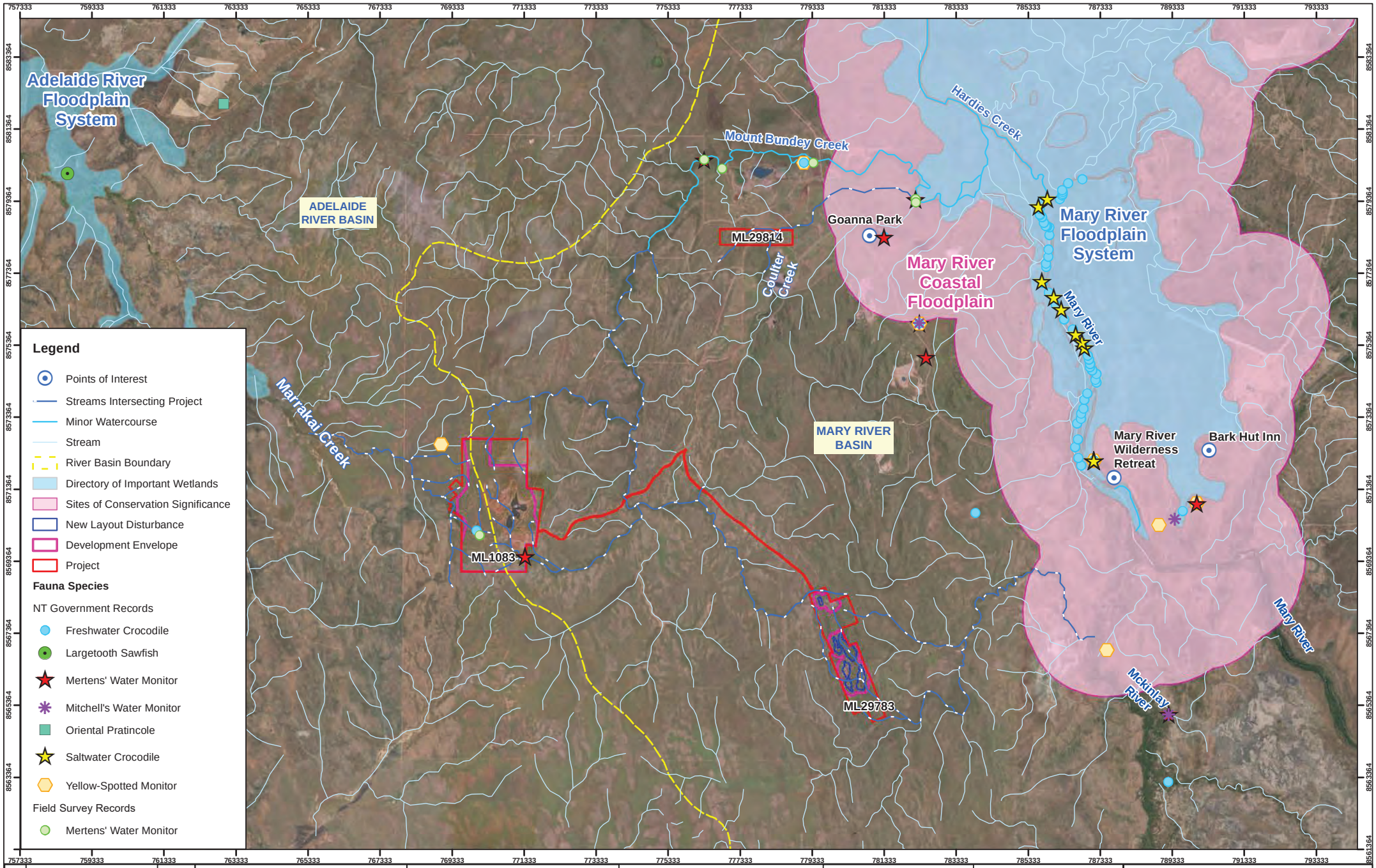
SWTG3 recorded the highest number of fish species, closely followed by the farthest upstream sites on Mount Bundey Creek (SWTG1A and SWTG1). The fish community of Mount Bundey Creek appeared to be less diverse at sites in close proximity to the TSF at Toms Gully Mine in May 2017. In addition, two species caught at the site closest to the TSF (MBC01) were recorded as being in poor condition. *L. unicolor* were found with legions, and Seven-Spotted Archerfish (*Toxotes chatareus*) were observed swimming slowly. This may indicate that those individuals may have been affected in some way by water quality at this location, regardless of their broad tolerance range for pH, EC and dissolved oxygen.

Besides fish condition at MBC01, sites downstream of the Toms Gully Mine recorded a lower diversity and abundance of fish, with the exception of a large number of *M. splendida* being recorded from SWTG2. Availability of woody debris, pool and run sequences and riparian vegetation was present at all sites along Mount Bundey Creek, and surface flow was recorded at almost all sites. As fish habitat was not found to be markedly different at each site and connectivity was not an issue at the time of sample, or presumably before the prior wet season, water quality is a likely contributor to the presence of fish. The connectivity of sites denotes that fish may have been capable of moving upstream or downstream of the waters having higher concentrations of metals, as well as high EC or low pH conditions. The site located furthest downstream (SWTG3) recorded a number of fish, which were also present at sites upstream of the TSF, as well as similar water quality attributes to upstream sites, except EC, which was slightly elevated. This denotes some recovery in water quality and fish communities downstream with distance from the area of poorer water quality.

7.5.1.4 Reptiles

Camera trapping was undertaken in 2017 and 2019 at the survey area to examine the potential occurrence of water monitors (*Varanus mertensi*, *V. mitchelli*) inhabiting the riparian zone of Mount Bundey Creek and Coulter Creek. Water monitors of either species were not recorded at sites downstream of or adjacent to Toms Gully Mine and only a single individual Merten's Water Monitor (*V. mertensi*) was captured on camera unit M3 upstream of Toms Gully Mine on Mount Bundey Creek during the 2017 survey. The 2019 survey resulted in recording of one *V. mertensi* at the M3 location and two recordings of the same species on different dates at the M8 location (refer to Figure 7-16 and Appendix K). No sightings of *V. mertensi* were recorded over the camera deployment period (116-120 days).

In addition, a desktop survey for threatened fauna within the Project area shows an occurrence record for *V. mertensi* in 2015 at the Rustlers Roost heap leach ponds (Figure 7-15). Furthermore, observations made during a May 2017 survey indicate the presence of saltwater and freshwater crocodiles (*Crocodylus porosus*, *C. johnstoni*) in the lower Mount Bundey Creek and Coulter Creek (GHD 2018). Freshwater crocodiles have been observed in Annie's Dam (Appendix K). There is also anecdotal evidence of saltwater crocodiles occurring in Annie's dam. In general, it can be assumed that crocodiles are present in permanent water bodies (mine pits, leach ponds and dams) within the Project areas and outside in permanent pools.



R	Details	Date
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DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	24/08/21

Notes:

N

0 1,000 2,000 4,000

Meters

1 cm = 948 meters

GCS GDA 1994 MGA Zone 52

DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 7-44

Occurrences of Aquatic Related Threatened Fauna

DRG Ref: 1001087-EIS-07-7.25

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7.5.1.5 Riparian Vegetation

Overview

Riparian vegetation is defined as native vegetation surrounding a waterway and plays a critical role in protecting wetland systems, providing structured habitat, shade and food resources for aquatic fauna, maintaining nutrient levels in waterways, and providing bank stabilisation (DENR 2020). The aim of the riparian habitat assessment was to collect baseline information about vegetation community structure and to assess the riparian habitat value and current condition of riparian areas both upstream and downstream of the Project area. Riparian surveys in the Project area were undertaken in October 2020 (EcOz 2020).

At the Rustlers Roost Project area four riparian areas within and adjacent to Rustlers Roost were visited – two to the west of the Rustlers Roost Project area, one to the east, and one within the Project area on the eastern edge (Figure 7-8). As the Rustlers Roost area drains into two principal river systems (Adelaide River and Mary River); the riparian survey sites were located to capture both catchments. All were downstream of the Project area; due to its position in the catchments, there is no upstream riparian habitat at Rustlers Roost. Overall most of the riparian vegetation on the eastern side (Mary River catchment) appeared to be disturbed due to land clearing and mining activities (e.g. site RP8-DS). Furthermore, weeds were common along the banks (*Hyptis suaveolens* and Sida sp.). The riparian vegetation on the western side (Adelaide River catchment) was more intact and the survey sites were free of weeds (e.g. site RP6-US).

At the Quest 29 site the riparian vegetation had been disturbed, with original native vegetation already cleared and large stockpiles of fill material present adjacent to the riparian zones, similar to the Rustlers Roost site RP8-DS.

The accommodation camp site location is connected to the Mary River system via Coulter Creek. Vegetation surveys have shown that while there was a dense narrow riparian vegetation strip along both banks of the creek, much of the land beyond the riparian zone has been cleared and used for grazing (GHD 2018).

Overall, the existing riparian vegetation within the Project area has been affected by previous mining activities and current land use at different levels of disturbance with some sections still providing crucial services to aquatic ecosystems like shading, structured habitat and food source.

Groundwater Dependent Ecosystems

Whilst regional groundwater systems provide water sources for pastoral and other anthropogenic uses, groundwater also supports surface (above ground) and subsurface (below ground) ecosystems that are likely to include habitat for threatened species. The Australian GDE toolbox (Richardson *et al.* 2011) provides a framework to assist with the identification of GDEs and the management of their water requirements. The toolbox adopts the approach of Eamus *et al.* (2006) and classifies GDEs based on the role groundwater plays in maintaining biodiversity and ecological condition.

Three types of GDEs are defined by the GDE toolbox:

- Subterranean ecosystems dependent on water held in aquifers (e.g., stygofauna) or inundated caves (Type 1 GDEs). These ecosystems typically include karst aquifer systems and fractured rock groundwater environments;

- Ecosystems dependent on the surface expression of groundwater (Type 2 GDEs), including wetlands, lakes, seeps, springs, and river baseflow systems. In these cases, surface expression of groundwater exists, providing water that can support aquatic biodiversity through access to habitat (especially when surface run-off is low or non-existent) and regulation of water chemistry and temperature; and

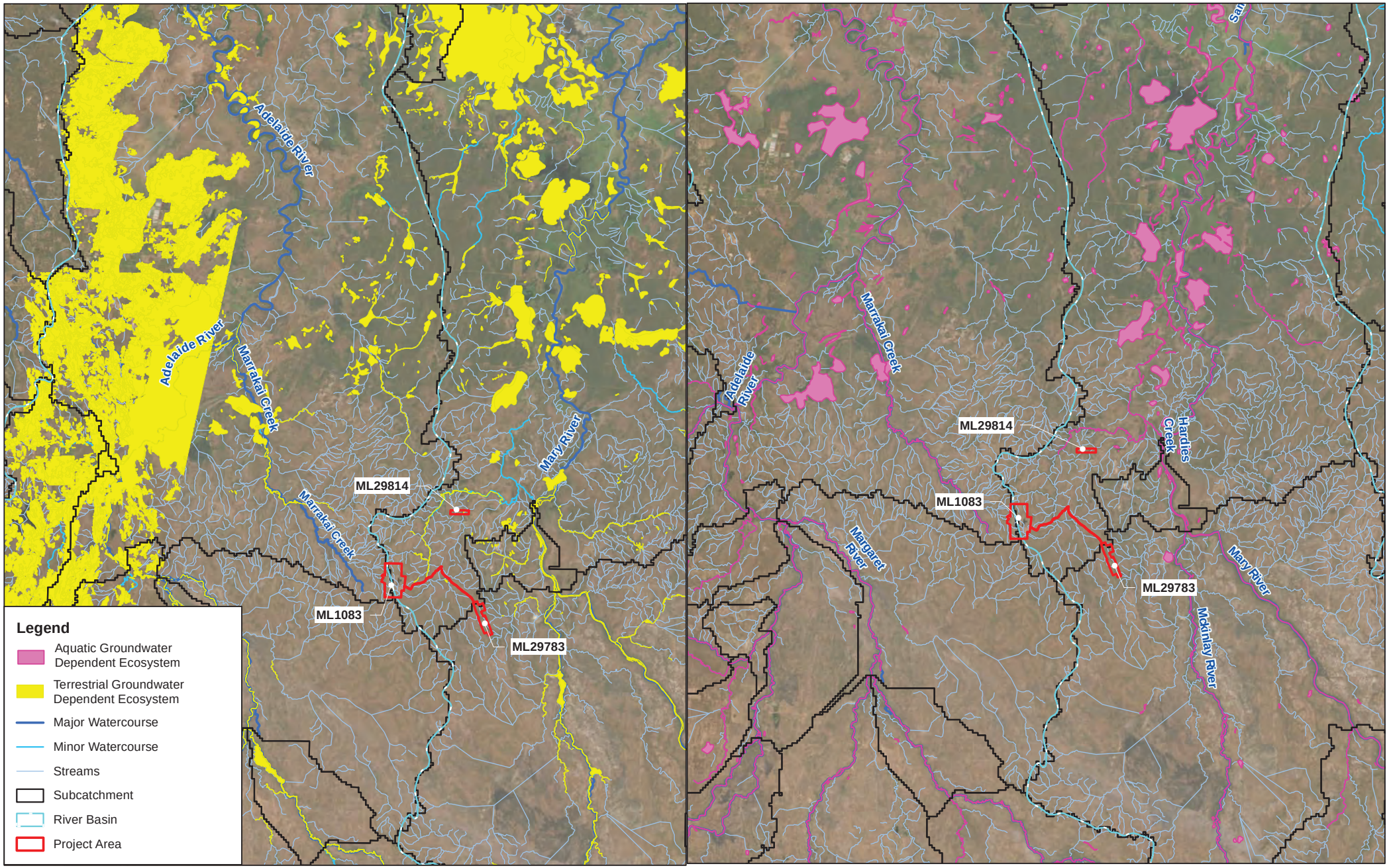
- Ecosystems dependent on subsurface presence of groundwater (Type 3 GDEs), including terrestrial and riparian vegetation that depends on groundwater either seasonally, episodically or permanently to prevent water stress and avoid adverse impacts to their condition. Groundwater that Type 3 GDEs depend on is not visible from the surface. Type 3 GDEs can exist wherever the water table and capillary fringe is within the root zone of the plants, either permanently or episodically. The capillary fringe is the semi-saturated zone of soil above the water table.

For the Northern Territory, the National Atlas of GDEs (GDE Atlas) presents the best current knowledge of ecosystems that may depend on groundwater at a broadscale level. At the beginning of 2017, the GDE Atlas was updated with the latest information pertaining to GDEs and therefore the GDE Atlas can be considered as the primary data source.

There are no mapped Type 1 GDEs within either the Project area (including the general region) or downstream (the Northern Territory has not been mapped for type 1). In addition, there are no type 2 GDEs mapped within the Project area; however, the lower reaches of Mount Bundey Creek, the McKinlay River and lower reaches of Marrakai Creek are mapped as having a high potential for aquatic GDEs. The GDE Atlas maps Type 2 GDEs (i.e. surface expressions) as potentially occurring consistently along the entire length of the downstream receiving watercourses including the Adelaide River and Mary River (Figure 7-45). Similarly, Type 3 terrestrial GDEs are mapped as potentially occurring along large portions of the downstream area, but at a much broader scale (i.e. greater width along the riparian corridor) (Figure 7-45). However, type 3 GDE mapping extends further upstream in both Marrakai Creek and Mount Bundey Creek, in proximity to the haul road. Potential GDE mapping covers areas mapped as potential habitat for threatened species. It is likely that swathes of the mapped downstream habitat access water through either surface expression of groundwater (Type 2) or subsurface groundwater (Type 3).

Aquatic Vegetation

Aquatic habitat values that provide for aquatic plants in the Project area are limited by the ephemeral nature of flows in the higher order watercourses that drain the sites and the lack of natural permanent water bodies (refer to Figure 7-41). No submerged aquatic plants were identified during the surveys. This underpins the highly ephemeral nature of the creeks and drainage lines (AES 2019). However, images from site inspections indicate the presence of aquatic vegetation at numerous locations related with previous mining and pastoral activities within the Project area (Annie's Dam, Rustlers Roost and Quest 29 pit lakes and leach ponds) (refer to Plate 7-15 to Plate 7-18). These waterbodies, however, will be consumed by new and extended mining infrastructure.



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APPROVED	TK	DATE	20/08/21
Notes:			

N

0 4,125 8,250 16,500

Meters

1 cm = 3,872 meters

GCS GDA 1994 MGA Zone 52

DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 7-45

Groundwater Dependent Ecosystem Mapping

DRG Ref: 1001087-EIS-07-7.26

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Chapter 7\Figure 7-26.mxd

7.5.2 Potential Impacts and Risk

This section identifies, describes and assesses the potential impacts and risks to aquatic ecosystems, including loss of habitat and species as a result of alteration of off-site surface water and groundwater quality from erosion and AMD, discharge of poor-quality water, and alteration of flows from mining activities.

While this section discusses potential impacts to aquatic ecosystems, it does not consider potential impacts to aquatic habitats to man-made water bodies within the Project area associated with mining activities (i.e., the pit lakes and the leach ponds). It is possible that these legacy man-made waterbodies support aquatic biodiversity, but they are not assigned a specific value for protection for the purpose of this section. It is noted however, that PGO will endeavour to take potential aquatic ecosystem values associated with the mine pit dewatering and TSF expansion into consideration and to reflect this in the relevant management and construction plans (e.g. relocation of significant fauna).

Furthermore, it needs to be noted that the key environmental factor 'aquatic ecosystems' is inherently tied to other important factors such as hydrological processes and inland water environmental quality. Therefore, any potential risks to ground and surface water quality will be discussed in these relevant sections of the report. The environmental risk assessment discussed in Section 6 and presented in Appendix B identified and considered 20 potential sources of impact to existing aquatic ecosystems. These were considered with regard to the potential to cause significant impacts and residual consequences.

Table 7-58 Potential Sources of Impact to Aquatic Ecosystems

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
AE-1	Vegetation clearing for the Project	Construction and Operation	**Direct** - Disturbing an additional 333.4 ha of land for the Rustlers Roost, 26.16 ha for Quest 29, 7.3 ha for the accommodation camp and 2 ha for the haul road. Loss of 368.86 ha of habitat. Resulting in destabilised soils, potential erosion, loss of topsoil and sedimentation of Marrakai Creek and Mount Bundey Creek and their tributaries. Alteration of characteristics of water, including chemical, physical, biological and aesthetic qualities are degraded in the vegetation clearing area. Resulting in less productive aquatic ecosystems and potential impacts (through the abovementioned erosion). **Indirect or Cumulative** - Elevated sediments in waterways from the Project, nearby major operations (e.g. Toms Gully Mine, quarry operations and Mount Bundey Training Area) and general anthropogenic activities (e.g. runoff from unsealed roads) may result in reduced biodiversity in affected areas. Sediment runoff into aquatic habitats can cause increased turbidity, decreased oxygen levels, reduced light penetration, changes in channel morphology and altered sediment composition in substrates. In addition, interference with flows may alter the local wetting and drying regime, including water heights, flow paths, retention times and ponding. Such changes can have flow-on effects on aquatic habitats, resulting in their loss or alteration and a reduction in the quality and/or quantity of important food sources. Cumulative or indirectly sediments that runoff due to vegetation clearing could adversely impact downstream aquatic habitats that support fish populations important to recreational fishing and traditional activities (reduced fish abundance).
AE-2	Overtopping, embankment failure	Construction, Operation,	**Direct** - Contamination of surrounding water features. Alteration of water characteristics, including chemical, physical,

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	or seepage from the new TSF at Rustlers Roost leading to uncontrolled release of tailings material to surrounding environment.	Decommissioning, or Closure	biological and aesthetic qualities. Adversely affecting the biological processes that depend on water quality (surface and groundwater). Direct result in the loss of ecological integrity and suitable aquatic fauna habitat in the impacted areas. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminants of concern being cyanide and metals). Groundwater pathways contributing to environmental contaminants mobilised in the surrounding environment through historic mining and quarrying activities. Potential for bioaccumulation of excessive contaminants within aquatic fauna (heavy metals) and risks of consumption of fish.
AE-3	Overtopping, embankment failure or seepage from the process water storage at Rustlers Roost leading to uncontrolled release of process water to surrounding environment.	Operation, Decommissioning and Closure	**Direct** - Contamination of surrounding water features. Alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the biological processes that depend on water quality (surface and groundwater). Direct result in the loss of ecological integrity and suitable aquatic fauna habitat in the impacted areas. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminants of concern being cyanide and metals). Groundwater pathways contributing to environmental contaminants mobilised in the surrounding environment through historic mining and quarrying activities. Potential for bioaccumulation of excessive contaminants within aquatic fauna (heavy metals) and risks of consumption of fish.
AE-4	Embankment failure or seepages from the new WRDs at Rustlers Roost and Quest 29 to surrounding environment.	Operation, Decommissioning and Closure	**Direct** - Contamination of surrounding water features. Alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the biological processes that depend on water quality (surface and groundwater). Direct result in the loss of ecological integrity and suitable aquatic fauna habitat in the impacted areas. **Indirect or Cumulative** - Potential transportation of contaminants throughout the Project area and external (AMD, heavy metals, and NORMS). Aquatic ecosystems and human health implications. Contamination of downstream aquatic environments resulting disturbance of ecological integrity and functioning of aquatic ecosystems. Human health risks that would necessitate the closure of watercourse to extraction of drinking water, stock watering, recreation, and fishing. Groundwater pathways contributing to environmental contaminants mobilised in the surrounding environment through historic mining and quarrying activities. Potential for bioaccumulation of excessive contaminants in environmental pathways should the same contaminants be released from the nearby Toms Gully Mine or already be present in the environment due to historic activities.
AE-5	Embankment failure of Annie's Dam water storage or process water ponds and uncontrolled water and sediment release (temporary risk noting closure of dam	Construction and Operation	**Direct** - Early closure resulting in long term loss of job opportunities and increased unemployment. No funding to undertake rehabilitation to required standards and potentially affecting downstream receptors. Visual amenity of the area not meeting desired completion criteria. **Indirect or Cumulative** - Impact on local services and employment.

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	for Rustlers Roost TSF).		
AE-6	Poor quality runoff or seepage from the historic WRDs and heap leaches.	Construction, Operation, Decommissioning and Closure	**Direct** - Contamination of surrounding water features and alteration of water characteristics, including chemical, physical, biological, and aesthetic qualities. Potential direct aquatic species health implication (reduced physical health or mortality) depending on contaminant in seepage material. Inability of impacted water features to maintain biological qualities to support standard aquatic flora and fauna. **Indirect or Cumulative** - Potential transportation of contaminants throughout the Project area and external (AMD, heavy metals, and NORMS). Aquatic ecosystems and human health implications. Contamination of downstream aquatic environments resulting disturbance of ecological integrity and functioning of aquatic ecosystems. Human health risks that would necessitate the closure of watercourse to extraction of drinking water, stock watering, recreation, and fishing. Groundwater pathways contributing to environmental contaminants mobilised in the surrounding environment through historic mining and quarrying activities. Potential for bioaccumulation of excessive contaminants in environmental pathways should the same contaminants be released from the nearby Toms Gully Mine or already be present in the environment due to historic activities.
AE-7	Poor water quality released from site during wet season (stormwater).	Construction, Operation, Decommissioning and Closure	**Direct** - Primary contaminants of concern in wet season stormwater release is acidity and sediment, thus resulting in increased turbidity of waterways. This could result in poor quality drinking water for terrestrial fauna, reduced quality of habitat for aquatic fauna and sedimentation of riparian environments which intrinsically support the health of the inland aquatic ecosystems. Habitat modification and/or lifecycle disruption and/or impact on the size of a population (aquatic flora and fauna). Decrease in fish abundance and species richness from ecotoxicity. Depending on geochemistry of the waste rock material to be exposed in the new pits and the placement on site, runoff may also contain heavy metals and NORMS. These would have direct aquatic fauna health implications should this water be released. **Indirect or Cumulative** - Decrease in fish populations and species richness resulting in decreased suitability of the environment for aquatic species. Potential for bioaccumulation of excessive contaminants within native fauna (heavy metals) and risks of consumption of fish. Potential contamination of downstream environments resulting in human health risks that would necessitate the closure of watercourse to extraction of drinking water, stock water, recreation, and fishing.
AE-8	Planned pit over topping or release to surface water features during extreme rainfall and flooding events.	Construction, Operation	**Direct** - Contamination of surrounding water features and alteration of water characteristics, including chemical, physical, biological, and aesthetic qualities. Potential direct aquatic species health implication (reduced physical health or mortality) depending on contaminant in seepage material. Inability of impacted water features to maintain biological qualities to support standard aquatic flora and fauna.

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
			Indirect and Cumulative - Potential transportation of contaminants throughout the Project area and external (AMD, heavy metals, and NORMS). Aquatic ecosystems and human health implications. Contamination of downstream aquatic environments resulting disturbance of ecological integrity and functioning of aquatic ecosystems. Human health risks that would necessitate the closure of watercourse to extraction of drinking water, stock watering, recreation, and fishing.
AE-9	Unplanned pit overtopping or release to surface water features during extreme rainfall and flooding events.	Construction, Operation, Decommissioning and Closure	**Direct** - Contamination of surrounding water features and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Potential direct aquatic species health implication (reduced physical health or mortality) depending on contaminant in seepage material. Inability of impacted water features to maintain biological qualities to support standard aquatic flora and fauna. **Indirect and Cumulative** - Potential transportation of contaminants throughout the Project area and external (AMD, heavy metals, and NORMS). Aquatic ecosystems and human health implications. Contamination of downstream aquatic environments resulting disturbance of ecological integrity and functioning of aquatic ecosystems. Human health risks that would necessitate the closure of watercourse to extraction of drinking water, stock watering, recreation, and fishing. Contribution of overtopping flows or embankment failures to discharges from Toms Gully Mine into the Mount Bundey catchment resulting in decreased water quality in the catchment. Negative implications on the aquatic ecosystem and functionality and capacity to naturally accommodate wet season events.
AE-10	Release of hazardous chemicals or materials during storage, handling, or transport	Construction, Operation, Decommissioning	**Direct** - Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the aquatic ecosystem if the contaminants reach water features and leading to decrease of aquatic ecological functioning. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external, resulting in reduced local capacity of surface water features to perform ecological functions. Human health implications (primary contaminant of concern being cyanide). Contamination of downstream aquatic environments resulting in human health risks that would necessitate the closure of watercourse to extraction of drinking water, recreation and fishing.
AE-11	Poor handling and management of tailings and waste rock	Construction, Operation, Decommissioning	**Direct** - Release of AMD leading to contamination of surface water and groundwater quality and ecosystems. Alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Diversion of existing runoff pathways, whether this be overland flow within drainage lines. This would likely result in scouring and incision causing altered flow paths leading sedimentation of waterways and altered aquatic ecosystem and functionality. This would adversely affect the biological processes that depend on water quality. **Indirect or Cumulative** - Increased disturbance and lost productivity of surface water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine, nearby quarries, and Mount Bundey Training Area, resulting in

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
			reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation. Indirect biological and human health implications in the immediate location of the placement and areas subject to seepage or runoff.
AE-12	Unfinished/unsuccessful rehabilitation of Project due to inadequate funds or natural disaster (e.g. cyclone).	Construction, Operation, Decommissioning and Closure	**Direct** - Site not rehabilitated to required standards. Increased potential for offsite impacts from AMD, erosion, and sedimentation. Degradation of water quality onsite and various forms of erosion (sheet, rill, wind etc.) transporting soils into water features, potentially resulting in sedimentation and decrease in the aquatic ecosystem functioning. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminants of concern being cyanide and metals). Contamination of downstream environments resulting in aquatic ecosystem and human health risks that would necessitate the closure of watercourse to extraction of drinking water, recreation and fishing. Given PGO is the same proponent for the nearby Toms Gully Mine project it would likely result in unfinished or unsuccessful rehabilitation at both sites. This would result in a large area of disturbed and unrehabilitated land in the catchment cumulatively resulting in increased sediment loads to Mount Bundey Creek and Marrakai Creek and the downstream Mary River and Adelaide River.
AE-13	Long term positive water balance	Construction, Operation, Decommissioning and Closure	**Direct** - Potential build-up of water onsite and the need for long term treatment and constant discharges of water. Positive water balance could potentially mean surrounding areas (groundwater and surface water) are not receiving typical supply. Thus, imbalance of the local hydrological regime which could adversely impact ecological features such as GDEs. **Indirect and Cumulative** - Likely result in a constant requirement for ongoing discharges and a regular pulses of site water into the environment rather than a seasonal flow that would occur in a natural system. This could result in scouring and degradation of water features and its functionality. Furthermore, impacts from change in flow patterns on fauna migration.
AE-14	Pit lake becomes a groundwater source	Construction, Operation, Decommissioning and Closure	**Direct** - Gradual development of plume of contaminated groundwater. Pit lake water quality may become more acidic and with higher concentration of contaminants which may impact fauna species and the quality of groundwater in the area through seepage. **Indirect and Cumulative** - Groundwater pathways contributing to environmental contaminants mobilised in the surrounding environment through historic mining and quarrying activities. Potential for bioaccumulation of excessive contaminants in environmental pathways should the same contaminants be released from the nearby Toms Gully Mine or already be present in the environment due to historic activities. Potential for bioaccumulation of excessive contaminants within native fauna (heavy metals) and risks of consumption of fish.
AE-15	Lack of rehabilitation materials leads to inadequate tailings closure and poor	Decommissioning and Closure	**Direct** - Completion criteria and environmental outcomes unable to be met. Potential soil erosion, loss of topsoil and sedimentation (through both water and wind erosive forces)

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	quality site rehabilitation.		affecting water quality and aquatic ecosystems in the surrounding water features. Characteristics of water, including chemical, physical, biological and aesthetic qualities are degraded in the vegetation clearing area, resulting in less productive aquatic ecosystems and potential impacts (through the abovementioned erosion) on adjacent catchment. **Indirect or Cumulative** - Increased disturbance and lost productivity of water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine, nearby quarries, and Mount Bundey Training Area, resulting in reduced local capacity of water to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation and loss of aquatic ecosystem functioning.
AE-16	Inappropriate management of the decommissioned site, post closure landform.	Closure	**Direct** - Unauthorised access to the site by externals (including public, leaseholders, and livestock) negatively affecting rehabilitation potential and contributing to rehabilitation failure. Potential scouring, soil erosion and sedimentation resulting in the alteration of water quality on and off-site drainage features. Site not rehabilitated to required standards. Increased potential for offsite impacts from AMD, erosion, and sedimentation. Degradation of water quality onsite and various forms of erosion (sheet, rill, wind etc.) transporting soils into water features, potentially resulting in sedimentation and decrease in the aquatic ecosystem functionality. **Indirect or Cumulative** - Increased disturbance of water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and nearby quarries and the Mount Bundey Training Area, resulting in reduced local capacity of water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation and decreased aquatic ecological functionality.
AE-17	Ineffective operational implementation of site environmental management system, plans and procedures.	Construction, Operation, Decommissioning Closure	**Direct -** Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological, and aesthetic qualities. Adversely affecting the aquatic biodiversity if the contaminants reach drainage lines and leading to decreased aquatic ecological functioning of the surrounding water features. **Indirect or Cumulative** - Rehabilitation success is affected by inappropriate operational procedures which results in decreased likelihood of achieving rehabilitation goals and closure requirements following decommissioning. Potential increase in cumulative concentration of contaminated sediments within the downstream watercourse because of any sediment discharged. Increased downstream depositions and siltation impacts leading to decreased aquatic ecological functionality.
AE-18	Construction and operational activities (incl. vegetation clearing) result in introduction of new weeds and spread of existing weeds into new areas.	Construction, Operation, Decommissioning or Closure	**Direct** - Impact of reduced ability for successful revegetation due to weed spread which could lead to increased erosion and sediment runoff into the surrounding water features. Increased fire risk. **Indirect or Cumulative** - Increased weed species in the area negatively affecting rehabilitation potential and contributing to rehabilitation failure. Failure to establish appropriate capping and native vegetation leading to increased erosion and sediment runoff from rehabilitated areas which has the

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
			potential to adversely impact the water quality of surrounding water features and its biological functionality. Agreed PMLU cannot be achieved due to significant environmental incidents resulting in widespread ongoing contamination of water features. Cumulative impact as a result of reduced area of natural vegetation in the general Mount Bundey locality resulting in a general low aquatic fauna species abundance and lack of biodiversity.
AE-19	Inappropriate liquid and solid waste disposal.	Construction, Operation, Decommissioning Closure	**Direct -** Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological, and aesthetic qualities. Adversely affecting the aquatic biodiversity if the contaminants reach drainage lines and leading to decreased aquatic ecological functioning of the surrounding water features. **Indirect or Cumulative** - Rehabilitation success is affected by inappropriate operational procedures which results in decreased likelihood of achieving rehabilitation goals and closure requirements following decommissioning. Agreed PMLU cannot be achieved due to significant environmental incidents resulting in widespread ongoing contamination of water features. Potential increase in cumulative concentration of contaminated sediments within the downstream watercourse as a result of any sediment discharged. Increased downstream depositions and siltation impacts leading to decreased aquatic ecological functioning.
AE-20	Major mechanical failure of processing plant	Operation	**Direct -** Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological, and aesthetic qualities. Adversely affecting the aquatic biodiversity if the contaminants reach drainage lines and leading to decreased aquatic ecological functioning of the surrounding water features. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminants of concern being cyanide, hydrocarbons, and metals). Contamination of downstream environments resulting in aquatic ecosystem and human health risks that would necessitate the closure of watercourse to extraction of drinking water, recreation, and fishing. Agreed PMLU cannot be achieved due to significant environmental incidents resulting in widespread ongoing contamination of water features.

7.5.2.1 Drainage Line Alterations

The Project will result in the removal and/or intersection of approximately 2,500 m of natural drainage and creek lines due to the construction of the TSF, pit expansion, and haul road. However, it will be highly unlikely that any significant aquatic fauna will be affected due to the highly ephemeral characteristics of these drainage lines. To minimise impacts on aquatic fauna any works that interfere with drainage and creek lines will be prioritised for completion during the dry season.

Three crossings (one bridge and two culverts) over Mount Bundey Creek and tributaries have been proposed for the extension of the haul road between Quest 29 and the processing facility at Rustlers Roost. Only the bridge crossing of Mount Bundey Creek is proposed to be upgraded. Poorly designed crossings have the potential to alter the hydraulic

characteristic like change in flow speed and volume resulting in increased erosion and sedimentation. The potential narrowing of the channel may also result in increased flow velocities impairing the ability of the fish fauna to move upstream. Furthermore, culvert crossings may also create unfavourable habitats for aquatic fauna due to high velocity flows and the absence of natural light. In addition, many culverts have a drop at the downstream end which can be a barrier to fish passage.

7.5.2.2 Alterations in Flow Characteristics

Pit lake dewatering is required to commence mining at Rustlers Roost and Quest 29. It is proposed to dewater into the upper Mount Bundey Creek and the Marrakai Creek Catchment. No other sensitive aquatic receptors have been identified in the vicinity of the Project. However, several conservation areas are located in the downstream receiving environment:

- Mary River Coastal Floodplain around 10 km north-east (SoCS 13);
- Mary River National Park around 11 km to the east;
- Adelaide River Foreshore Conservation Area around 24 km to the west; and
- Adelaide River Coastal Floodplain around 28 km to the west (SoCS 12).

There are also semi-permanent pools approximately 5.5 km downstream of Rustlers Roost in an unnamed tributary to Marrakai Creek.

Flood events are part of the natural hydrological regime and an important feature of the ephemeral characteristics of the creeks in the area. The onset of stream flow at the beginning of the wet season and changes in water levels deliver breeding cues for fish, which have adapted to utilise upstream areas for these and other life cycle processes. In addition, fish use off-channel habitats during flooding for a variety of reasons, such as shelter, feeding, spawning and recruitment. Dewatering activities from pit lake dewatering and the resulting discharge of water into creek lines during dry season may result in the delivery of ecological cues that triggers upstream migration and spawning, resulting in negative impacts on species assemblages when higher flows are not continued.

7.5.2.3 Introduction of Weeds into Aquatic Environment

Weeds are broadly defined to be a plant that requires some form of action to reduce its negative effect on the economy, the environment and human health or amenity (DAWR 2017). Some weeds are declared and have legislative controls in place to assist with reducing their impacts. In the Northern Territory, a declared weed is a species of plant identified for eradication, control, or prevention of entry in all or part of the Territory under section 7 of the *Northern Territory Weeds Management Act 2001*.

The spread of weed species into the aquatic environment has been associated with mining activities and pastoral land use. A flora and fauna survey at Rustlers Roost, Quest 29 and Toms Gully conducted in 2016 identified eight introduced weed species recorded throughout the survey, including three declared Weeds of National Significance (WoNS) (LES 2017). Three of these have been associated with aquatic and riparian ecosystems: Olive hymenache (*Hymenachne amplexicaulis*), Giant sensitive plant (*Mimosa pigra*), and Gamba grass (*Andropogon gayanus*).

Any existing occurrence or introduction of additional aquatic weeds to the Project area could result in high likelihood of downstream transportation into more sensitive environments (Adelaide River and Mary River floodplains) during flow events. However, it is highly unlikely that the proposed activities will result in the spread of aquatic weeds due to the ephemeral characteristics of the drainage and creek lines on site.

7.5.2.4 Erosion and Sedimentation

Additional clearing of approximately 368.86 ha of native vegetation, the construction of a new haul road and the expansion of the WRD and TSF will result in soil disturbance with increased risk of erosion and sedimentation. Mobilised sediments can increase suspended sediments in surface water and turbidity, directly impacting on aquatic biota. The most significant impacts from sedimentation are the direct alteration of the aquatic habitat where coarse features like rocks and pebbles are smothered as well as benthic organisms. Furthermore, suspended sediments increase fish morbidity and mortality directly from gill trauma and indirectly by exposure to contaminants at excessive levels contained in the sediments (Birtwell 1999). Feeding structures of benthic filter feeders may also be affected. Cumulative effects of sedimentation may be increased by high water temperatures from increased absorption of sunlight leading to decreased dissolved oxygen in the water column, mainly in stagnant water bodies. Overall, increased suspended solids can lead to decline of diversity and abundance of aquatic biotic components.

Regular inspections have shown relatively small impacts from suspended solids from existing infrastructure erosion on drainage lines. Only the existing heap leach pile at the Rustlers Roost shows signs of gully erosion with limited impacts on surrounding areas and drainage lines. Impacts from erosion and sedimentation on landforms and soils have been discussed in Section 7.1 – Terrestrial Environmental Quality.

7.5.2.5 Contamination of Surface Water

Details of the geochemical properties of waste rock and tailings are provided in Section 4.7 and Section 7.1. In summary, the survey results have shown that the waste rock at existing WRD at Rustlers Roost has been classified as NAF and poses minimal risk to surface water quality regarding AMD. Therefore, impacts on aquatic fauna from existing waste rock stockpile runoff during the wet season are not expected.

However, with the proposed commencement of mining at Rustlers Roost and Quest 29 new materials from deeper sections of the geological profile may be raised and deposited on the surface, potentially affecting surface water quality. A preliminary geochemical assessment indicated that the decrease in water quality may be related to increased salinity and increased concentrations of Al, As, Fe, Mn, Sn and Zn are possible. This may result in toxicity effects to aquatic fauna when mobilised in runoff during the wet season. For example, bioaccumulation and magnification of metals via food chain across tropic levels can lead to adverse effects and death of fish in affected systems (Baby *et al*. 2011).

Surface water systems can often exhibit naturally high heavy metal concentrations due to local geology and soil composition; however, concentration levels can often be increased through environmental disturbance (for example soil erosion) and other anthropogenic activities (for example mining and agriculture). Heavy metals present in a system due to soil erosion are typically associated with sediment particulates and the undissolved fractions are typically not bioavailable. As such, dissolved metals provide a more accurate concentration of bioavailable metals that can cause toxicity to aquatic fauna and accumulate in the food chain through direct ingestion or passive diffusion (for example direct contact) with organisms (ANZG 2018).

Cyanide-leached ore in tailings material may produce leachates containing elevated levels of arsenic and metals which may affect surface water quality and aquatic fauna when mobilised into the environment.

A TSF dam break and consequences assessment has been conducted for a potential dam break scenario resulting in the release of tailings/and/or water (Knight Piesold Consulting 2021). Due to the location in the Adelaide River and Mary River catchment the high expected runout distance can be anticipated to have relevance to both river systems. The desktop assessment identified the following areas of conservation significance in the Adelaide River further downstream.

- Djukbinj National Park;
- Harrison Dam Conversation Area;

- Melacca Swamp Conservation Area; and
- Floodplains of the Adelaide River and Mary River.

Hydrocarbon and other chemicals spills and leaks from storage and transport may also have a significant impact on aquatic ecosystems during an uncontrolled release into the environment.

7.5.2.6 Cumulative Impacts

The construction and operation of the Project has the potential to incrementally contribute to declining aquatic habitat quality from clearing activities and water pollution in a cumulative context.

To address the ToR requirement for this Draft EIS, an assessment of the cumulative impacts of the Project across four spatial scales has been conducted. The spatial scales of consideration are:

- Property – defined as Mount Bundey Station and McKinlay River Station;
- Catchment – defined as the Mount Bundey Creek catchment, Marrakai Creek catchment and McKinlay River catchment;
- Region – defined as the Marrakai-Douglas Daly unincorporated area; and
- Bioregion – defined as the Pine Creek bioregion.

The cumulative impact assessment has considered the effects of multiple actions or impacts on the aquatic ecosystem (refer Table 7-59).

Table 7-59 Assessment of Cumulative Impacts to Aquatic Ecosystems

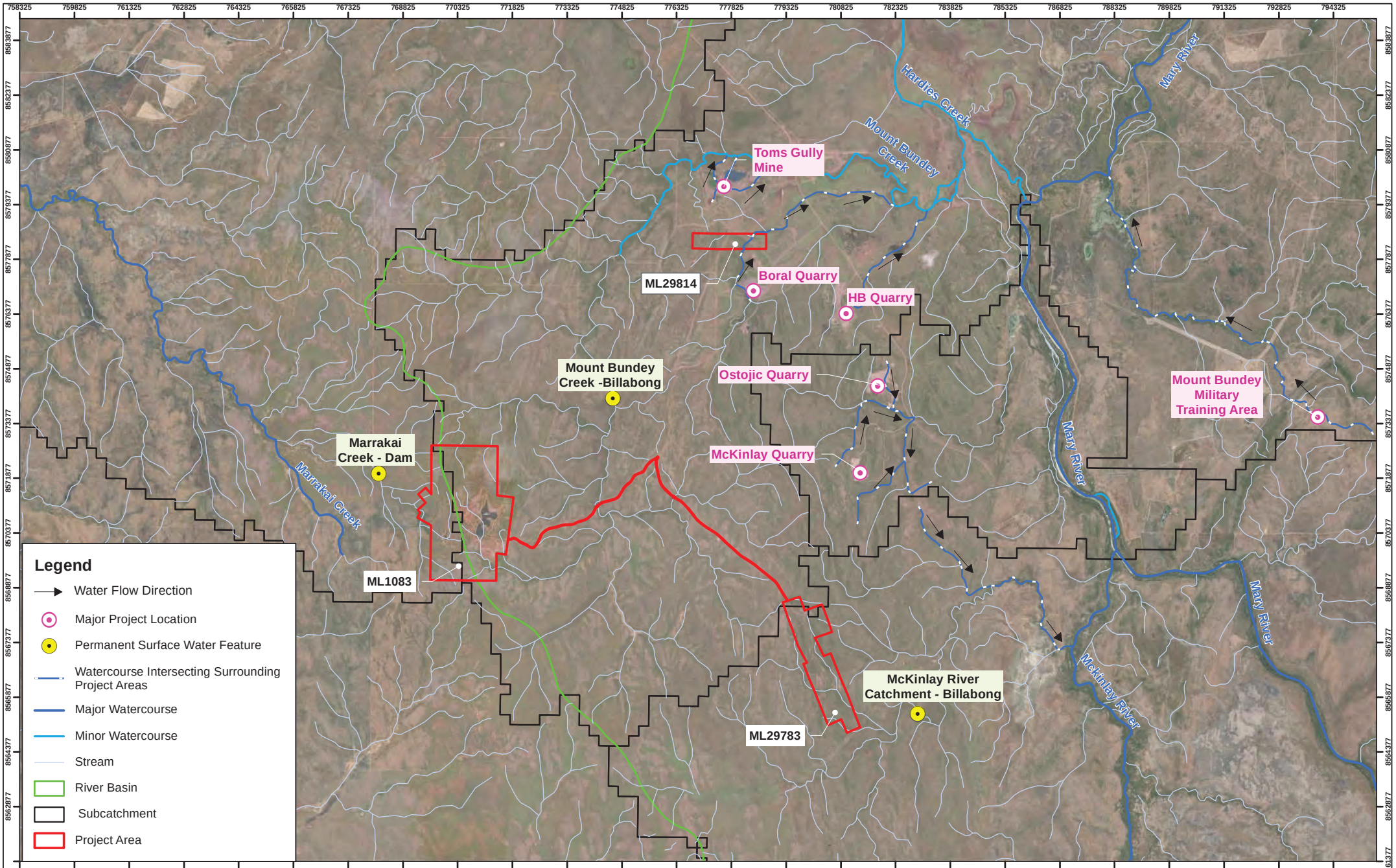
Project	Spatial Extent				Approx. Distance from Project	Impact Details	Reference
	Property	Catchment	Region	Bioregion			
Toms Gully Mine	✓	✓	✓	✓	0 m	Downstream of Rustlers Roost and Quest 29 sites. Aquatic surveys in Mount Bundey Creek indicated potential cumulative impacts from mining activities on aquatic biota.	NT EPA 2020a GHD 2018
Boral Quarry	✓	✓	✓	✓	700 m	Upstream from accommodation camp on Coulter Creek. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping (DEPWS 2021)
HB Quarry	✓	✓	✓	✓	2 km	Connected to Mary River catchment via smaller tributary between McKinlay River and Mount Bundey Creek confluence. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021)
McKinlay Quarry	✓	✓	✓	✓	3.5 km	Connected to Mary River catchment via smaller tributary between McKinlay River and Mount Bundey Creek confluence. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021)
Ostojic Quarry	✓	✓	✓	✓	4.4 km	Connected to Mary River catchment via smaller tributary between McKinlay River and Mount Bundey Creek confluence. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021)
Mount Bundey Military Training Area			✓	✓	9 km	Connected to Mary River catchment upstream from McKinlay River. Unknown environmental impacts from site, no publicly available data.	NR Maps spatial mapping tool (DEPWS 2021)
Woolwonga Mine				✓	47 km	Connected to Adelaide River via Margaret River catchment. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021)
Hayes Creek Mine				✓	58 km	Connected to Adelaide River via Margaret River catchment. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021) LES 2017
Union Reefs Gold Mine				✓	60 km	Connected to Mary River via McKinlay River catchment. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021) NT EPA 2020b

Project	Spatial Extent				Approx. Distance from Project	Impact Details	Reference
	Property	Catchment	Region	Bioregion			
Frances Creek Iron Ore Mine				✓	75 km	Connected to Mary River via McKinlay River catchment. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021) MBS Environmental 2006
Finnis Lithium Mine					80 km	Not hydrologically connected. Located in a separate river basin and cumulative impacts to aquatic ecosystems unlikely. Potential contribution to spread of aquatic weeds in the wider region is a likely potential cumulative impact.	NR Maps spatial mapping tool (DEPWS 2021) EcOz 2020
Fountain Head Gold Mine				✓	90 km	Connected to Adelaide River via Margaret River catchment. Potential sedimentation and release of pollutants resulting in declining water quality impacting on aquatic biota.	NR Maps spatial mapping tool (DEPWS 2021) ERIAS 2021
Jabiru Hybrid Power Station				✓	140 km	Not hydrologically connected. Located in a separate river basin and cumulative impacts to aquatic ecosystems unlikely. Potential contribution to spread of aquatic weeds in the wider region is a likely potential cumulative impact.	NR Maps spatial mapping tool (DEPWS 2021) CDM Smith 2021

While there are no sensitive aquatic receptors located within the Project area, there are mining and extractive activities connected to the Rustlers Roost and Quest 29 drainage system that have the potential of cumulative impacts to Mount Bundey Creek and the Mary River (Figure 7-46).

Toms Gully Mine is located further downstream on Mount Bundey Creek (Figure 7-46). As previously discussed, recent surface water quality monitoring and aquatic ecosystem surveys indicate that water quality is impacted from mining runoff at Toms Gully Mine with low pH and increased salinity (GHD 2018). Elevated levels of metals have also been associated with the mining operation, with high concentrations of dissolved aluminium, cadmium, cobalt, copper, iron, nickel and zinc exceeding site-specific trigger values. Furthermore, the report found pollution tolerant invertebrate assemblage and the fish community to be of low diversity and abundance. In addition, poor condition of individual fish sampled to a site nearby the TSF at Toms Gully Mine site appeared to be related to potentially ecotoxic water quality parameters.

There are four quarries located within 10 km of the Project area (Figure 7-46). The Boral quarry is upstream of Coulter Creek from the proposed accommodation camp. Due to the activities at the campsite cumulative impacts on aquatic ecosystems from decreased water quality are unlikely. Furthermore, HB Quarries is connected to the lower reaches of Mount Bundey creek, therefor run-off from the Project area, Toms Gully Mine and HB quarry may result in cumulative impacts on aquatic ecosystems for this area. Ostojic and McKinlay Quarry drain directly into Mary River. Significant impacts are not expected due to the hydrological connection between the Project area and associated activities.



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1	Final	25/08/21
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DESIGNED	SS	CHECKED	TK
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APPROVED	TK	DATE	25/08/21

Notes:

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0 1,000 2,000 4,000

Meters

1 cm = 950 meters

GCS GDA 1994 MGA Zone 52

DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 7-46

Surrounding Projects with Potential Cumulative Aquatic Ecology Impacts

DRG Ref: 1001087-EIS-07-7.28

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7.5.3 Avoidance, Mitigation and Management

This section presents the strategy of a hierarchical approach of avoidance, mitigation, and management to minimise potential impacts to aquatic ecosystems based on the relevant risk assessment (Table 7-60).

Table 7-60 Potential impacts to Aquatic Ecosystems and avoidance, mitigation, and management measures

Potential Consequences	Measures / Commitments
Sedimentation and erosion altering water quality impacting on aquatic fauna and flora	**Avoid** ▪ Only clearing the practical minimum footprint necessary for the portion of the Project to be implemented ▪ Clearly mark limits of clearing ▪ Make use of already disturbed areas where possible ▪ Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines ▪ Avoid land clearing during the December to March portion of the wet season. ▪ TSF to be planned, designed, constructed and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016c) ▪ Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams ▪ Continued use of drainage controls and bunds ▪ Implementation of fencing and access restriction to prevent vehicle and livestock accessing significant creek lines ▪ Construction of abandonment bunds around the processing plant **Mitigation and Management** ▪ Adherence to Ground Disturbance Procedures ▪ Implement erosion and sediment controls in accordance with an ESCP ▪ Implementation of Biodiversity Management Plan ▪ Implementation of AMDMP and WMP ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams ▪ Daily monitoring of waste rock handling and tailings disposal ▪ Tailings and Waste Rock will be managed in accordance with the Tailings Management Plan and Operational Manual (including inspections) ▪ Infrastructure design to withstand extreme events ▪ Improve site drainage controls ▪ Clearing and Topsoil Procedures Implementation of Mine Closure ▪ Corporate commitment to EMS implementation via policy ▪ Environmental Management System and various management plans (EMP, WMP, MMP etc.) ▪ All personnel will be trained in the appropriate relevant management practices and protocols as is applicable to their position ▪ Regular maintenance and inspections of plant

Potential Consequences	Measures / Commitments
	Rehabilitation ▪ Progressive clearing and rehabilitation of disused areas ▪ Implementation of detailed mine closure plan ▪ Review options for WRD Rehabilitation ▪ Financial provisioning for closure implementation ▪ Recover topsoil from TSF, WRD and processing plant footprints
Run-off, discharge of contaminants (AMD, metals, NORMS, and hydrocarbons) altering water quality impacting on aquatic fauna and flora	**Avoid** ▪ Make use of already disturbed areas where possible ▪ Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines ▪ TSF to be planned, designed, constructed and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016c) ▪ Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure ▪ Install seepage control and underground drainage including a cut-off trench, compact soil liner, basin underdrainage collection system, underdrain collection sump and embankment tow drain ▪ Capping of the WRDs to reduce ongoing water infiltration and seepage ▪ Continued use of drainage controls and bunds ▪ Implementation of fencing and access restriction to prevent vehicle and livestock accessing significant creek lines ▪ Construction of abandonment bund around the processing plant ▪ Maximise runoff pond capacity prior to wet season ▪ Cap WRD with suitable waste rock ▪ Design, storage and handling of hazardous materials to Australian Standards and regulations ▪ Specific adherence of the ANFO storage to *Dangerous Goods Act 1998* and the NT *Work Health and Safety (National Uniform Legislation) Act 2011* ▪ Regular maintenance of storage facilities ▪ Bunding of the process plant ▪ Diesel in bunded storage tanks, waste oil in stored bunded tanks ▪ Chemical storage will be located a minimum 30m from any drainage line or watercourse ▪ Limit pit catchment post closure to reduce inflow ▪ Design and construct landfill in accordance with relevant standard ▪ Implement leachate prevention and capture into landfill design **Mitigation and Management** ▪ Implement erosion and sediment controls in accordance with an ESCP ▪ Implementation of Biodiversity Management Plan ▪ Groundwater monitoring to check quality and any seepage ▪ Tailings performance monitoring (e.g. TSF water volume, collection efficiency of underground system) ▪ Implementation of AMDMP and WMP ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF and process water dam, survey pins to monitor the embankment and piezometers to measure pore water pressure

Potential Consequences	Measures / Commitments
	▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams ▪ Manage the site water balance to reduce any build-up of water ▪ Daily monitoring of waste rock handling and tailings disposal ▪ Tailings and Waste Rock will be managed in accordance with the Tailings Management Plan and Operational Manual (including inspections) ▪ Infrastructure design to withstand extreme events ▪ Improve site drainage controls ▪ Clearing and Topsoil Procedures ▪ Implementation of Mine Closure Plan ▪ Corporate commitment to EMS implementation via policy ▪ Environmental Management System and various management plans (EMP, WMP, MMP etc.) ▪ All personnel will be trained in the appropriate relevant management practices and protocols as is applicable to their position ▪ Regular maintenance and inspections of plant Weekly inspections of storage areas, tanks, containers ▪ Develop Emergency Response Plan and include in induction ▪ Spill kits available around the site and procedures and training for the cleaning up of hazardous spills ▪ Implementation of hazardous materials management plan training for emergency response ▪ Cyanide management and storage will be aligned to the Commonwealth of Australia Leading Practice Handbook for Sustainable Mining - Cyanide Management (Australian Government 2008). ▪ Compliance with the WDL ▪ All water storage facilities geotechnically stable and engineered ANCOLD guidelines ▪ Regular surveys to measure the tailings and waste rock deposition and water depths ▪ Improve and maintain site drainage infrastructure ▪ Geochemical assessment and modelling of pit water ▪ Contingency to manage water chemistry changes ▪ Contaminant transport modelling further refined ▪ Manage disposal of wastes in accordance with the Project EMP (including bunded waste oil bins) **Rehabilitation** ▪ Progressive clearing and rehabilitation of disused areas ▪ Implementation of detailed mine closure plan ▪ Review options for WRD Rehabilitation ▪ Financial provisioning for closure implementation ▪ Recover topsoil from TSF, WRD and processing plant footprints
Discharge of pit dewatering effluent altering seasonal flow regimes impacting on fish migratory patterns	**Avoid** ▪ Pit-dewatering in drainage lines only during wet season **Mitigation and Management** ▪ Implementation of Biodiversity Management Plan ▪ Manage the site water balance to reduce any build-up of water ▪ Ongoing surface water monitoring program **Rehabilitation** ▪ Implement drainage diversions as per the ESCP

Potential Consequences	Measures / Commitments
Construction of water way crossing altering flow regimes with increased risk of erosion and sedimentation	**Avoid** ▪ Pit-dewatering in drainage lines only during wet season **Mitigation and Management** ▪ Implementation of Biodiversity Management Plan ▪ Manage the site water balance to reduce any build-up of water ▪ Ongoing surface water monitoring program **Rehabilitation** ▪ Reconstruction of original channel landform
Construction of water way crossing posing barrier for fish movements	**Avoid** ▪ Construction of creek crossings with culverts and bridge during dry season **Mitigation and Management** ▪ Construction of fish-friendly water way crossings ▪ Culverts and bridge to maintain the cross-sectional area of channels to retain the hydraulic characteristics of the area ▪ Implementation of Biodiversity Management Plan ▪ Manage the site water balance to reduce any build-up of water ▪ Ongoing surface water monitoring program **Rehabilitation** ▪ Reconstruction of original channel landform

7.5.3.1 Sedimentation and Erosion Management and Mitigation

The disturbance of an additional 368.86 ha of vegetation increases the risk of destabilising soils with potential erosion, loss of topsoil and sedimentation of Marrakai Creek and Mount Bundey Creek. To limit potential erosion, only absolutely necessary areas will be cleared for the portion required to continue with the Project. Furthermore, buffer zones for riparian vegetation in drainage lines will be implemented in accordance with Northern Territory Land Clearing Guidelines were possible and clearing will be avoided during wet season. In addition, a sediment and erosion control and management plan will be implemented.

The TSF and WRD will be designed appropriately to minimise the risk of sedimentation from erosion. For, example the proposed slope of the dam wall is 1:3 to reduce the erosion risk, in addition sediment traps will be placed at relevant sections to intersect sediments. In general, construction activities for processing facilities and infrastructure increases the risk of erosion and sedimentation into watercourses. The haul road crossings will be constructed to minimise the risk of erosion by maintaining the cross-sectional areas of the channels to retain the hydraulic characteristic of the area. This will also minimise impacts on fauna utilisation (e.g. fish movement upstream for spawning) of the creeks during times of flow and include the construction of fish friendly culverts as outlined by King and Torre (2007). Further details will be outlined in the relevant construction management plan for the crossings.

Risks are posed by overtopping, embankment failure or seepage from the new TSF at Rustlers Roost leading to uncontrolled release of tailings material to surrounding environment resulting in sedimentation and the subsequent loss of ecological integrity of the affected areas. To avoid any potential impacts from TSF embankment failure or over topping considerations in the design of the TSF will be given to extreme weather events. Furthermore, the TSF will be designed, constructed, and operated in accordance with leading practice and industry standards.

7.5.3.2 Contamination Management and Mitigation

To avoid adverse impacts to aquatic ecosystems from contamination with AMD, heavy metals and chemical compounds uncontrolled water release into the environment will be avoided.

For example, the TSF will be constructed with low permeable fill material to reduce seepage flow beneath the embankment. In addition, the upstream slope will be HDPE lined to reduce seepage through the embankments further. A toe drain will be located along the upstream toe of the embankment to reduce the phreatic surface in the tailings as low as practicable. A compacted soil liner (CSL) as well as an HDPE liner will be installed over the whole basin. An underdrainage system consisting of collector and finger drains to reduce seepage losses and maximise recovery of underdrainage from the tailings will be installed on top of the lining system.

Furthermore, to prevent contamination from WRD runoff material classified as Non-acid forming (NAF) will be placed at the outer annulus of the WRD. NAF material with sufficient ANC will be placed on the natural surface, lining the drainage lines. PAF material will be encapsulated with the central areas of the dump, not near the outer slopes or toe areas and covered with NAF waste material from the outer perimeter of the existing WRD in accordance with the AMD Management Plan (Appendix T).

To prevent the release of contaminated water from TSF, WRD and the process water dam during the wet season, all storage facilities will be geotechnically stable engineered in accordance with ANCOLD guidelines and managed in accordance with the WMP (Appendix I).

Furthermore, to minimise the impacts from potentially contaminated pit lake dewatering prior to mining operations, it is proposed to limit maximum discharge rate at 330 L/s during the wet season, which is negligible in comparison to peak flow rates calculated for Marrakai Creek and Mount Bundey Creek (CDM Smith 2019).

In general, measures proposed to avoid impacts to aquatic ecosystems will be implemented to ensure that contaminant levels in water released from the mine site are sufficiently low that there is no measurable impact to water quality outside of the Project area boundaries. Measures are detailed in Section 6 and will include the use of sediment basins and flocculants to remove sediments from water prior to discharge and only discharging when baseline creek flows will provide for mixing and dilution of mine-affected waters. Further groundwater and surface water studies have informed the establishment of SSTVs for discharges that will protect the downstream receiving environment. SSTVs have been established at Toms Gully Mine based on water quality upstream in Mount Bundey Creek and have been designed to protect the receiving environment from changes to water quality associated with minewater discharge. Discharges will be authorised through an approved operational WDL and will be subject to monitoring and reporting in accordance with the licence conditions.

7.5.3.3 Further Management and Mitigation Measures

The risk assessment has determined that pit dewatering may alter seasonal flow regimes impacting on fish migratory patterns. Dewatering into creek lines during dry season will be avoided to prevent environmental cues to potentially migratory fish species at the wrong time. Future aquatic fauna surveys will inform the subsequent management of pit water discharge into drainage and creek lines.

7.5.4 Monitoring and Reporting

Surface and groundwater monitoring at Toms Gully Mine has been undertaken since 2012 when PGO took ownership of the site and prior to 2012 by previous owners. This has been completed as a part of their environmental compliance check monitoring program. The monitoring program has been conducted in accordance with the approved Toms Gully Water Management Plan and includes the fortnightly/ monthly sampling of surface and mine affected water. Furthermore, surface water assessment guideline values have been derived from ANZG 2018 trigger values for 90%

aquatic ecosystem protection and local background condition (Primary Gold 2018). The sampling program for the Project has been developed based on those parameters identified historically as being of concern in the area, as well as through discussions with DME and EPA.

Proposed water quality monitoring sites are outlined in the Section 7.4.4 and the WMP, and the water quality will be reported in accordance with relevant legislative requirements.

The WMP includes annual biological monitoring of macroinvertebrates and fish coupled with habitat assessments and in-situ water quality testing. Biological monitoring is proposed to be completed at nine sites as per Table 7-61. The locations of the proposed ongoing monitoring locations are presented in Figure 7-36 and Figure 7-37.

Table 7-61 Proposed Biological Monitoring Locations

Site Code	Sampling location / Description	Position		Frequency	Biota
		Latitude	Longitude		Category*
Rustlers Roost					
RRMCUS	Marrakai creek upstream site – control site	- 12.919623	131.480976	Annual	M, H
RRMCDS	Marrakai creek downstream Site	- 12.904950	131.469576	Annual	M, H
RRSW2	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad	- 12.928670	131.501560	Annual	M, H
RRSW23	Upper Mount Bunt Creek tributary downstream from RRSW2	- 12.930765	131.50637	Annual	M, H
Accommodation Camp					
CC02	Coulter Creek approximately 500 m downstream from accommodation camp boundary	-12.847370	131.563955	Annual	M, F, H
CC01	Coulter Creek approximately 1.5 km downstream form CC02 outside of mining lease	-12.843499	131.573087	Annual	M, F, H
Toms Gully					
SWTG1A	Mount Bundey Creek upstream of mine at lease boundary- control site	-12.828336	131.545764	Annual	M, F, H
SWTG2	Mount Bundey Creek at Arnhem Highway Crossing	-12.828622	131.574529	Annual	M, F, H
SWTG3	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	-12.837374	131.599889	Annual	M, F, H

**Biota Sampling Categories*
M – Macroinvertebrates
F – Fish
H – Habitat Assessment

Site specific trigger values for physico-chemical stressors, nutrients, and toxicants will be set in accordance with the site-specific recommendations provided by CSIRO (Stauber and Batley 2018). The WMP provides further details on the monitoring and reporting commitments (Appendix I).

7.5.5 Residual Impact

All potential residual impacts to aquatic ecology were assessed as either moderate (11) or lower (9), following application of controls.

While the risk for aspects such as overtopping and embankment failure or seepage from the new TSF remains moderate, there is a high degree of certainty that the new tailings embankment will remain stable, based on the historical use of the TSF at the nearby Toms Gully Mine in the same geology, geotechnical studies, engineering design and modelling (e.g. dam break and consequence assessment for TSF (Knight Piesold 2021). In particular, the TSF will be planned, designed, constructed, and operated in accordance with approaches detailed in the "Leading Practice Sustainable Development Program for the Mining Industry" (Australian Government 2016a) and the relevant ANCOLD (2012) guidelines in conjunction with the development of a monitoring plan/ operational manual which includes weekly inspections of the site storage infrastructure, there is high certainty that the infrastructure embankments will remain stable.

Furthermore, no previous instability issues with either the existing WRDs or leach pads at the Rustlers Roost or Quest 29 sites have been reported from historical mining operations. The justification is also based on the new TSF being designed, constructed and operated in accordance with leading practice.

Poor water quality during the wet season and seepage from the pit lake has also been identified as major driver for potentially declining aquatic ecosystem quality. While the initial assessment identified an extreme risk to aquatic fauna due to likely significant contaminants associated with runoff from mining activities (AMD, metals, and hydrocarbons), the residual risk has been classified as moderate; however, it is highly unlikely the detrimental impacts will occur as mitigation and management measures include monitoring of water quality and discharge volumes. Furthermore, sampling of the waste materials and water has indicated that there is a low risk of contamination from the historical mining activities (Appendix D) and the pit water (Appendix P).

In general, aquatic ecosystems in the ephemeral streams downstream of Rustlers Roost and Quest 29 could be indirectly impacted by poor water quality resulting from mine site discharges. It is expected that these ephemeral streams in the immediate Project areas do not have enough consistent water flows to support aquatic ecosystems until much further downstream in more well-defined receiving waterways. This results in some uncertainty surrounding all of these potential impacts. PGO will develop detailed management plans (MMP, WMP) in consultation with the regulator to ensure the protection of the relevant environmental values for the Project area and surroundings are maintained.

Overall, with the discussed measures and relevant mitigation systems and management plans to minimise impacts on aquatic ecosystems the residual impacts are expected to be minimal, largely limited to direct disturbance footprint of the watercourses intersected by infrastructure and within acceptable limits.

The significance of the residual risk for aquatic ecosystems from the Project have been assessed assuming the successful implementation of avoidance, mitigation and management measures as outlined in Section 7.5.3. The residual risk for each source of impact is shown in Table 7-62.

Table 7-62 Aquatic Ecosystem Residual Impact Assessment Summary

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
AE-1	Vegetation clearing for the Project	Construction and Operation	Extreme	> Adherence to Ground Disturbance Procedures > Progressive clearing and rehabilitation > Implement erosion and sediment controls in accordance with an ESCP >Only clearing what is absolutely necessary for the portion of the project to be implemented > Implementation of Biodiversity Management Plan > Clearly mark limits of clearing > Make use of already disturbed areas where possible. > Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines > Avoid land clearing during the December to March portion of the wet season.	Moderate
AE-2	Overtopping, embankment failure or seepage from the new TSF at Rustlers Roost leading to uncontrolled release of tailings material to surrounding environment.	Construction, Operation, Decommissioning or Closure	High	> TSF to be planned, designed, constructed, and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry. (Australian Government 2016c). > Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria. > An operational emergency spillway to be constructed as part of each embankment raise. > Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure. > Tailings performance monitoring (e.g. TSF water volume, collection efficiency of underground system). > Install seepage control and underground drainage including a cut-off trench, compact soil liner, basin underdrainage collection system, underdrain collection sump and embankment tow drain. > Groundwater monitoring to check quality and any seepage. > Implementation of AMDMP and WMP. > Manage the site water balance to reduce any build-up of water.	Moderate
AE-3	Overtopping, embankment failure or seepage from the process water storage at Rustlers Roost leading to	Operation, Decommissioning and Closure	High	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams.	Moderate

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
	uncontrolled release of process water to surrounding environment.			> Groundwater monitoring > Manage the site water balance to reduce any build-up of water.	
AE-4	Embankment failure or seepages from the new WRDs at Rustlers Roost and Quest 29 to surrounding environment.	Operation, Decommissioning and Closure	Extreme	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams. > Groundwater monitoring > Manage the site water balance to reduce any build-up of water. > Capping of the WRDs to reduce ongoing water infiltration and seepage	Moderate
AE-5	Embankment failure of Annie's Dam water storage or process water ponds and uncontrolled water and sediment release (temporary risk noting closure of dam for Rustlers Roost TSF).	Construction and Operation	Moderate	> Geotechnical studies and assessment to ensure structural stability Engineering design to ANCOLD standard. > WMP. > Weekly inspections to check sufficient freeboard and structural integrity.	Low
AE-6	Poor quality runoff or seepage from the historic WRDs and heap leaches.	Construction Operation Decommissioning Closure	Moderate	> Continued use of drainage controls and bunds > Maximise runoff pond capacity prior to wet season >Ongoing monitoring of existing groundwater bores > Investigation and consideration of long-term closure options > Cap with suitable waste rock > Calculations, identification and provisioning of suitable cap material > Implementation of AMDMP > Daily inspections for runoff and drainage problem areas	Low
AE-7	Poor water quality released from site during wet season (stormwater).	Construction, Operation, Decommissioning or Closure	Extreme	> Compliance with the WDL > Implementation of AMDMP and WMP >All water storage facilities geotechnically stable and engineered ANCOLD guidelines > Groundwater / surface water quality monitoring > Weekly inspections of freeboard, structural integrity and pipelines. > Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines to reduce sedimentation risk	Moderate
AE-8	Planned pit over topping or release to surface water features during extreme rainfall and flooding events.	Construction Operation	Low	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the pits. > Implementation of AMDMP and WMP > Manage the site water balance to reduce any build-up of water. > Adhere to buffer widths recommended by the Northern Territory Land	Low

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
				Clearing Guidelines with regard to riparian vegetation in drainage lines to reduce sedimentation risk	
AE-9	Unplanned pit overtopping or release to surface water features during extreme rainfall and flooding events.	Construction Operation Decommissioning Closure	Extreme	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the pits > Implementation of AMDMP and WMP > Manage the site water balance to reduce any build-up of water. > Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines to reduce sedimentation risk > Implement drainage diversions as per the ESCP	Low
AE-10	Release of hazardous chemicals or materials during storage, handling or transport.	Construction, Operation, Decommissioning	Moderate	> Design, storage, and handling of hazardous materials to Australian Standards and regulations. > Specific adherence of the ANFO storage to *Dangerous Goods Act 1998* and the NT *Work Health and Safety (National Uniform Legislation) Act 2011* > Regular maintenance of storage facilities. > Bunding of the process plant > Ensure containment bunding is adequate and SDS available > Diesel in bunded storage tanks, waste oil in stored bunded tanks > Weekly inspections of storage areas, tanks, containers > Develop Emergency Response Plan and include in inductions > Weekly inspections of storage areas for leaks or damages > Spill kits available around the site and procedures and training for the cleaning up of hazardous spills > Implementation of hazardous materials management plan training for emergency response > Cyanide management and storage will be aligned to the Commonwealth of Australia Leading Practice Handbook for Sustainable Mining - Cyanide Management (Australian Government 2008). > Chemical storage will be located a minimum 30m from any drainage line or watercourse.	Low
AE-11	Poor handling and management of tailings and waste rock		Moderate	> Daily monitoring of waste rock handling and tailings disposal. > Tailings and Waste Rock will be managed in accordance with the Tailings Management Plan and Operational Manual (including inspections). >Use of a perimeter spigot with regular movement to evenly distribute tailings. > Regular surveys to measure the tailings and waste rock deposition and	Low

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
				water depths. > Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines to reduce sedimentation risk	
AE-12	Unfinished/unsuccessful rehabilitation of Project due to inadequate funds or natural disaster (e.g. cyclone)	Construction, Operation, Decommissioning and Closure	Extreme	> Progressive rehabilitation of disused areas > Implementation of detailed mine closure plan > Early planning and financial provision for closure works > Infrastructure design to withstand extreme events > Ongoing management of levels in water infrastructure > Improve site drainage controls	Moderate
AE-13	Long term positive water balance	Construction, Operation, Decommissioning and Closure	High	> Improve and maintain site drainage infrastructure > Review options for WRD Rehabilitation > Implementation of Mine Closure Plan and adherence to commitments > Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning > Financial provisioning for closure implementation	Moderate
AE-14	Pit lake becomes a groundwater source.	Construction, Operation, Decommissioning and Closure	Moderate	> Geochemical assessment and modelling of pit water. > Contingency to manage water chemistry changes. > Investigate in pit water treatment options (i.e. use of lime or caustic). > Contaminant transport modelling further refined. > Limit pit catchment post closure to reduce inflow. > Ongoing groundwater monitoring program.	Moderate
AE-15	Lack of rehabilitation materials leads to inadequate tailings closure and poor quality site rehabilitation.	Decommissioning and Closure	High	> Financial provisioning for closure implementation. > Calculation of material requirements and identification of extraction areas > Recover topsoil from TSF, WRD and processing plant footprints. > Progressively rehabilitating the mine. > Clearing and Topsoil Procedures Implementation of Mine Closure	Moderate
AE-16	Inappropriate management of the decommissioned site, post closure landform.	Closure	Moderate	> Implement fencing and access restriction to prevent vehicle and livestock accessing rehabilitation areas. > Ongoing monitoring of rehabilitation. > Progressive rehabilitation during mining to enable more established areas upon closure	Low
AE-17	Ineffective operational implementation of site	Construction, Operation,	High	> Corporate commitment to EMS implementation via policy > Environmental Management System and various management plans (EMP,	Moderate

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
	environmental management system, plans and procedures.	Decommissioning Closure		WMP, MMP etc.). > All events/incidents to be reported and managed through to resolution via event/incident reporting procedures. > All personnel will be inducted into the area and informed of the hazards and relevant management protocols of the areas. > All personnel will be trained in the appropriate management practices as is relevant to their position.	
AE-18	Construction and operational activities (incl. vegetation clearing) result in introduction of new weeds and spread of existing weeds into new areas.	Construction, Operation, Decommissioning or Closure	High	> Annual weed mapping (by June each year) to understand nature of the spread of weeds and plan weed control activities accordingly. > Conduct seasonal weed control activities in consultation with local landholder as necessary and in accordance with the Project Weed and Pest Management (grazing control as option). > Implementation of the Biodiversity MP Project EMP. > Weed hygiene procedures - including inspection and wash down of all vehicles and machinery entering site. > Establish and implement appropriate control fire regime for area in the MLs.	Moderate
AE-19	Inappropriate liquid and solid waste disposal.	Construction, Operation, Decommissioning Closure	High	> Manage disposal of wastes in accordance with the Project EMP (including bunded waste oil bins). > Hazardous materials stored in accordance with Australian standards. > Spill kits available around site and spill clean-up procedures implemented. > Employees and contractors trained in clean up procedures. > Weekly inspections of, waste area, landfill, and general tidiness of site. > Burial of waste in dedicated landfill. > Design and construct landfill in accordance with relevant standards > Implement leachate prevention and capture into landfill design > Groundwater monitoring	Low
AE-20	Major mechanical failure of processing plant	Operation	High	> Ensure appropriate warranties in place and maintain appropriate critical mechanical spares inventory. > Regular maintenance and inspections of plant. > Engineer sign off before recommencement of plant. > Construction of abandonment bund around the processing plant.	Low

7.5.6 Predicted Outcome and Conclusions

This section has outlined the risks associated with mining activities, the potential discharge of contaminated surface water and alterations to creek lines to environmental vales defined for Aquatic Ecosystems. While mining can pose to aquatic ecosystems, the risk assessment process has demonstrated that the risks can be managed in accordance with legislative requirements by relevant management plans and licences. Furthermore, data analysis from similar mining activities within Mount Bundey Catchment (Toms Gully Mine) has shown that potential impacts on aquatic ecosystems are mostly localised and are not likely to impact on the Mary River system. This indicates relatively small cumulative impacts risks outside of the Project area.

The Project will result in the removal and/or intersection of approximately 2,500 m of natural drainage and creek lines due to the construction of the TSF, pit expansion, and haul road. A total of 4.85 ha of this area has been mapped as riparian vegetation through field surveys. However, it will be highly unlikely that any significant aquatic fauna will be affected due to the highly ephemeral characteristics of these drainage lines.

The water quality and aquatic fauna monitoring program as outlined in the WMP presents an opportunity to create valuable information to better understand the environmental values of aquatic ecosystems in the associated Adelaide River and Mary River catchments.

The potential risks from uncontrolled discharge, spills and poor closure will remain throughout the Project. However, with the application of effective controls in accordance with the environmental decision framework, management and mitigation measures the risks will remain sufficiently low.

The environmental objective identified in the ToR (NT EPA 2021) is to protect aquatic ecosystems, to support and maintain environmental values like aquatic flora and fauna and riparian vegetation. As such the Project is not determined to cause significant decline to relevant environmental, social, cultural, and economic values at the local scale.

Considering the assessment of residual impacts, and the application of mitigation and monitoring committed by PGO, it is concluded that impacts on aquatic ecosystems are manageable, such that the ToR objective for this factor is able to be met.

7.5.7 Assumptions

The key assumptions made in assessing potential impacts on aquatic ecosystems are:

- There are no natural permanent aquatic water bodies within the Project area, all drainage and creek lines are of ephemeral nature providing only spatial and temporal limited habitat to aquatic fauna and flora;
- Aquatic surveys in Mount Bundey Creek did not identify protected or threatened fish species, however protected reptile fauna associated with waterways were identified. The Project will not affect range and available habitat for these species;
- Potential impacts to aquatic ecosystems are inherently linked to hydrological processes (flows) and water quality. The potential impacts to these factors are assessed in Sections 7.3 and 7.4;
- Section 7.3 states that the Project is unlikely to significantly affect surface water flows and therefore the aquatic ecosystem assessment has assumed that there is unlikely to be any significant impact to aquatic ecosystems from runoff quantity/flow changes; and
- Section 7.4 identifies potential for the Project to impact downstream water quality. It has been assumed there will be localised increases in turbidity downstream during mining. It is also assumed that measures to avoid generation and/or release of AMD and processing chemicals will be developed and implemented, and these will be effective in protecting downstream water quality from mine related impacts.