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Tropicana Joint Venture

AngloGold Ashanti Australia

Independence Group NL

Tropicana Gold Project

Surface Water Evaluation of the Infrastructure Corridor Options

Report

June 2009

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Background

The Tropicana Joint Venture (TJV) is planning to establish the Tropicana Gold Project (TGP), which is centred on the Tropicana and Havana gold prospects. The proposed TGP is located approximately 330 km east north-east of Kalgoorlie, and 15 km west of the Plumridge Lakes Nature Reserve, on the western edge of the Great Victoria Desert biogeographic region of Western Australia. The project is a joint venture between AngloGold Ashanti Australia Limited (70% and Manager) and the Independence Group NL.

As part of the proposed TGP the TJV intends to construct an infrastructure corridor between Kalgoorlie and the project area. The infrastructure corridor will house an access road and / or fibre optical cable for the site communication. The TJV is currently evaluating two different routes; one via the Pinjin Station, and one via the existing Trans Australian Railway Access Road.

The objective of this investigation is to review the impact of the proposed infrastructure corridors on existing hydrology.

Existing environment

The majority of the drainage catchments upstream of the infrastructure corridors are characterised by low relief, poorly defined drainage lines and areas with strong linear sand dunes and internal drainage. The regional geology is predominantly aeolian sands, with high infiltration capacity, interspersed with areas of colluvial soils with lower infiltration capacity.

The region's climate is hot and dry, with potential evaporation greatly exceeding rainfall. Rainfall and flood events are highly variable in size and timing, and are often influenced by tropical cyclones.

Accordingly, stormwater flows are usually infrequent and of short duration, resulting from periods of intense rainfall. Runoff rates and volumes along the proposed corridors are generally low. However, local drainage from less permeable soils has the potential to produce runoff that could impact on the infrastructure and surrounding environment, including areas that contain Declared Rare Flora and Priority Flora.

Potential impacts

The main potential impacts of the infrastructure corridor relate to:

- Constriction of flows at cross-drainage structures causing downstream erosion and shadowing (i.e. reduced surface water flows due to upslope modification of flow paths);
- Ponding upstream of the corridor, as a result of interruption to runoff flow paths, causing increased waterlogging or flooding;
- Clearing and disturbance increasing erosion risk; and
- Increased salinity and sediment concentration of stormwater sourced from the infrastructure corridor surface.

Management recommendations

To minimise impacts of the infrastructure corridor on the existing surface water hydrology of the area, it is recommended that the following principals are adopted during the design and construction process:

- Survey the selected route to confirm topography and identify any low-lying and sheet-flow areas requiring drainage;
- Minimise the footprint of the corridor and construction facilities to minimise disturbance of the vegetation, soil and hydrologic characteristics;
- Employ soil conservation techniques to prevent erosion, scour and increase in surface water turbidity, including design of drainage structures to detain water and reduce flow velocity before discharge, armouring of susceptible points and stabilisation of disturbed slopes during construction;
- Use appropriately located and designed culverts and/or floodways to minimise disruption to natural flow paths, downstream runoff shadowing and upstream ponding;
- Use existing vegetation survey and further site observation to identify the location of Declared Rare Flora and Priority Flora within buffer distance adjacent to selected route;
- For vulnerable vegetation, ensure that any runoff shadowing downstream of the corridor does not reach or impact on the vegetation by either increasing the frequency of culverts and/or floodways or respreading concentrated flows downstream of the drainage structures; and
- Minimise salt contamination of downstream surface water by containing and infiltrating dust suppression material in table drains, and rehabilitate on closure.

1. Introduction

1.1 Background

The Tropicana Joint Venture (TJV) is currently progressing through the Western Australian Environmental Impact Assessment process for the establishing the Tropicana Gold Project (TGP), which is centred on the Tropicana and Havana gold prospects. The proposed TGP is located approximately 330 km east north-east of Kalgoorlie, and 15 km west of the Plumridge Lakes Nature Reserve, on the western edge of the Great Victoria Desert biogeographic region of Western Australia (Figure 1). The project is a joint venture between AngloGold Ashanti Australia Limited (70% and Manager) and the Independence Group NL (30%). The TGP consists of three main components (Figure 1):

- Operational Area - This area contains the mine, processing plant, aerodrome, village and other associated infrastructure;
- Water Supply Area - Two basins have been investigated, the Minigwal Trough and Officer Basin; and
- Infrastructure Corridor - Two options are under consideration (Pinjin and Tropicana Transline options).

As part of the proposed TGP the TJV intends to construct an infrastructure corridor between Kalgoorlie and the project area. The infrastructure corridor will house an access road and / or fibre optical cable for the site communication. The TJV is current evaluating two different routes one via the Pinjin Station and one via the existing Trans Australian Railway Access Road.

Surface water management issues need to be considered as part of the pre-feasibility, approvals and design process. The main surface water issues relate to impacts of the infrastructure corridor on the existing hydrology, which may have structural and environmental consequences.

1.2 Scope of work

The general objective of this investigation is to review the impact of the infrastructure corridor on existing hydrology. Specific areas covered include:

- Review of background material and desktop characterisation of hydrology;
- Assessment of impacts of the proposed infrastructure corridor on hydrology, flow patterns and shadowing of downstream areas;
- Development of a concept stormwater management plan for the corridor to manage potential impacts on local hydrology; and
- Summary of findings and recommendations, and comment on further work if required.

The deliverable is this report, outlining the results of this investigation and presenting recommendations.

1.3 Summary of methods

1.3.1 Impact review

The work was undertaken as a desktop review. The analysis was primarily based on information provided by AngloGold Ashanti, and on readily available topographic information.

Two proposed infrastructure corridors were reviewed; the Pinjin Infrastructure Corridor and the Tropicana Transline Infrastructure Corridor. The evaluation looked at the potential hydrologic impacts of construction of the new sections of corridor, and at the impacts of upgrading existing tracks and roads along these routes. The existing Kurnalpi Road and Trans Access Road, which connect the Pinjin and Tropicana Transline Corridors respectively to Kalgoorlie, were not assessed as these roads are already in place, and proposed changes and their potential impact on hydrology are minor.

Locations of potential cross-drainage structures on the new and upgraded sections of the corridor were identified based on the available data, which is minimal (mainly aerial imagery) and as such are indicative.

1.3.2 Available data

The following data and information were utilised:

- 2 m and 4 m contour data, supplied by AngloGold Ashanti, for 9,000 km^2 of the catchment area surrounding the mine site, covering approximately 25% of the proposed Pinjin Infrastructure Corridor, and approximately 40% of the Tropicana Transline Infrastructure Corridor;
- Aerial imagery, covering the area of the mine site and proposed infrastructure corridor, supplied by AngloGold Ashanti;
- 1:250,000 scale regional topographic and geological mapping;
- Results of infiltration measurements undertaken by AngloGold Ashanti;
- Engineering report on the proposed Tropicana Gold Project Access Road (Shawmac 2008);
- Hydrologic assessment of Tropicana Gold Project (URS 2007);
- Vegetation survey reports of the Tropicana Transline Corridor (ecologia Environmental 2008) and Pinjin Corridor (Mattiske 2008);
- Surface water assessment for Tropicana by GHD (2008); and
- Other reports and information as referenced.

Accuracy was limited by existing data. In particular, site survey and hydrologic information were not available for the entire alignment. Confirmation will be required as design progresses to more detailed stage.

2. Existing environment

2.1 Climate

The climate of the area is classified as hot, persistently dry desert, according to a modified Koëppen climate classification system (BoM 2008). Average annual rainfall for the area is 173 mm, and is greatly exceeded by estimated average evaporation of 3,473 mm/year (URS 2007). Rainfall is highly variable, and can occur all year round, though average monthly rainfall tends to be slightly higher from December to June.

The Tropicana Gold Project site is subject to the influence of tropical cyclones (URS 2007). Heavy rainfall can be received during summer as a result of dissipating cyclones, which occasionally trend toward the mine site from the northwest. Considerable year-to-year variation in cyclone occurrence, intensity and track occurs in the area (BoM 2008), meaning that rainfall and flood events are intermittent and variable in size and nature. Cyclones are most likely to track across the mine site over the period from December to May.

Rainfall amounts for events of various durations and recurrence intervals are given in GHD (2008). Rainfall events tend to occur either in durations of up to one or two days or in wet periods of up to three months. Rainfall intensity in events with durations of one hour or less can exceed 100 mm/h, which is likely to produce runoff even on very sandy soils. Climate change could possibly lead to smaller low-ARI rainfall and runoff events while larger events could increase by as much as 30% (GHD 2008).

2.2 Geology and soils

Regional geology is shown in Figure 2. The infrastructure corridors are predominantly over aeolian sands with areas of colluvium. Within these corridors Shawmac Pty Ltd (2008) identified six broad soil types:

- Dunal sands,
- Pindan sands,
- Clayey sands,
- Gravel,
- Calcareous material, and
- Clay soils.

These soils each have distinguishing physical characteristics. Dunal sands consist of very well draining coarse sand with low cohesive material content. Pindan sands have low to medium cohesive material content, and high strength. In contrast, clayey sands have high content of fine cohesive material, which leads to low strength when the soil is saturated.

Gravelly soils have particles greater than 2 mm in diameter, and are strong unless they contain more than 15% of cohesive materials. Calcareous material is strong unless disturbed. Clay soils are found in flat lake bases and on creek flood plains, and consist of fine particles with very low strength (Shawmac 2008).

These physical qualities affect the use of the soil as a road base, and potentially impact on local hydrology.

2.3 Regional hydrology

Catchments near the Tropicana Gold Project are characterised by low relief, poorly defined drainage lines and areas with strong linear sand dunes. These catchments tend to be internally draining, that is, they do not discharge to the coast (DoE 2005). Regional drainage is shown in Figure 1.

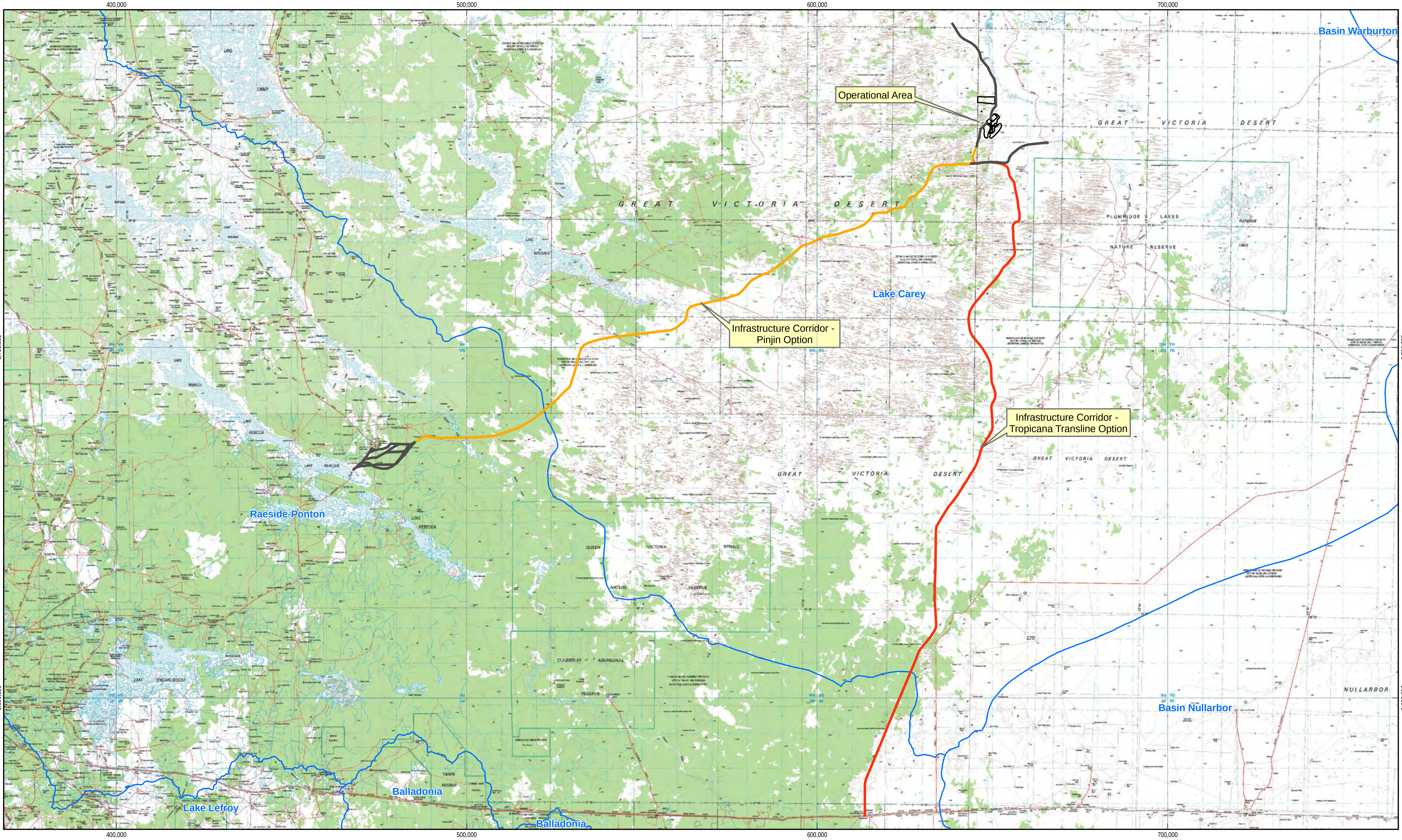
The mine site and most of the length of the proposed infrastructure corridors fall within the broader Lake Carey catchment, as defined by DoW (2008). The southern ends of both corridors lie in the Raeside-Ponton catchment. The main large drainage features near the proposed corridors are Lake Minigwal, Ponton Creek and Lake Rebecca.

Two wetlands of regional significance in the Great Victoria Desert, Lake Minigwal and Lake Rason, are located to the north and northwest of the proposed corridors. Lake Minigwal and Lake Rason are both seasonal intermittent saline lakes, important to maintenance of ecological processes (Australian Government 2008). Ponding in Lake Rason's drainage system does not extend as far south as the mine site and does not appear to affect drainage or flooding near the proposed infrastructure corridor locations.

The Pinjin Corridor alignment lies near the southern end of Lake Minigwal. The lake is good condition, with static trend, but its hydrology is threatened by dewatering of mine sites and discharge of hyper saline water into lake beds (Australian Government 2008).

Ponton Creek, one of the few watercourses in the Western Plateau region (DoE 2005) and a tributary of Lake Raeside, crosses the proposed Pinjin Corridor alignment approximately 200 km west of the Tropicana Gold Project. Ponton Creek is ephemeral in nature, without groundwater base flow, instead flowing towards Lake Raeside only after heavy rainfall events. It is considered to be generally in near-pristine condition (DoE 2005).

The western end of the proposed Pinjin Corridor alignment also crosses a section of Lake Rebecca. Lake Rebecca is an elongated chain of salt lakes, running southeast to northwest. This lake is crossed by the existing Kurnalpi Pinjin Road, south of Pinjin.



1:1,000,000 at A3

0 5 10 20 30 40

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 51

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LEGEND

Conceptual Site Layout
AngloGold Ashanti Australasia - 200808

- Proposed Mine Infrastructure
- Infrastructure Corridor - Pinjin Option
- Infrastructure Corridor - Tropicana Transline Option
- Other Roads
- Catchments - DoW - 20080923

Locality Map

NECKERSGAT RANGE, MALCOLM, MOUNT MARGARET, CUNDEELEE, HAIG, KALGOORLIE-BOULDER, NORSEMAN, SOUTHERN OCEAN

GHD

INDEPENDENCE GROUP NL

ANGLOGOLD ASHANTI AUSTRALIA

Tropicana Gold Project, Surface Water Evaluation of the Infrustructure Corridor Options

Job Number	6121984
Revision	2
Date	June 2009

Regional Drainage

Figure 1

G:\61\21984\GIS\MXDS\6121984-G7_Rev1.MXD

Note that positional errors can be > 5m in some areas. Dataset names include published date where available. Background taken from 1:250,000 Topographic Mosaic, Geoscience Australia, May 2004. Created by: K Iralu/ W Davis

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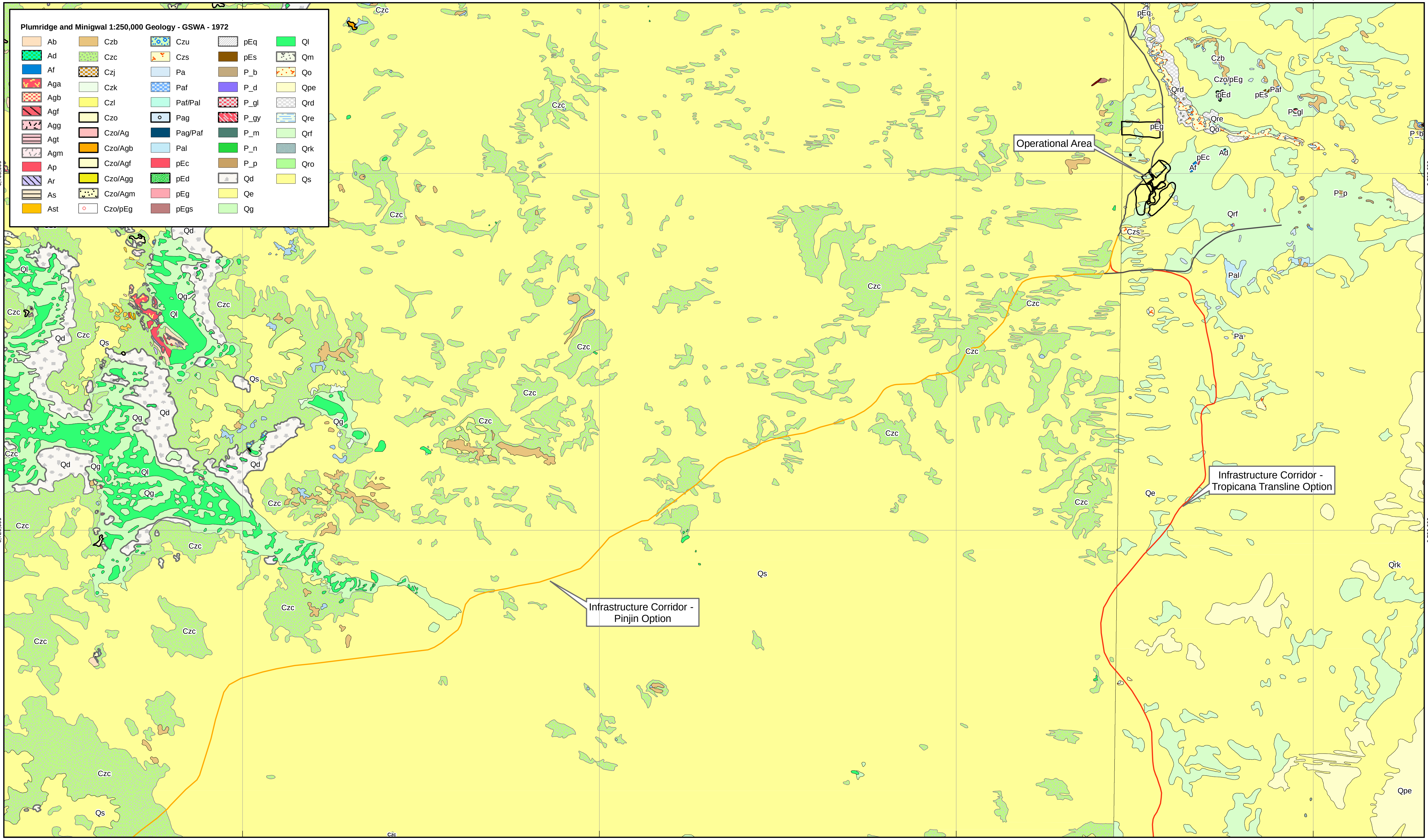

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0 2.25 4.5 9 13.5 18

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 51

N

LEGEND

Conceptual Site Layout - AngloGold Ashanti Australasia - 200808

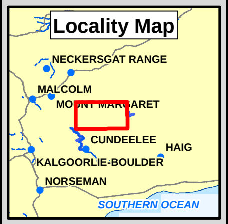
Proposed Mine Infrastructure

Infrastructure Corridor - Pinjin Option

Infrastructure Corridor - Tropicana Transline Option

Other Roads

Refer to figure 2a for geology descriptions



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ANGLOGOLD ASHANTI AUSTRALIA

Tropicana Gold Project, Surface Water Evaluation of the Infrustructure Corridor Options

Job Number	6121984
Revision	2
Date	June 2009

Regional Geology

Figure 2

G:\61\21984\GIS\MXDS\6121984-G8_Rev1.MXD

Dataset names include published date where available. Minigwal 250k Geology Sheet SH 51-7 (1972) and Plumridge 250k Geology Sheet SH 51-8 (1972) sourced from DOIR. Created by: K Iralu/W Davis

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LEGEND

Plumridge and Minigwal 1:250,000 Geology - GSWA - 1972

Ad - Fine to coarse-grained mafic rocks: metamorphosed dolerite and gabbro

Af - Banded quartz-magnetite rock: banded iron-formation

Ar - Chlorite-actinolite rock: ultramafic

As - Clastic rocks; phyllitic schist, siltstone; includes minor tuffaceous and felsic rocks

Ast - Fine-grained felsic volcanoclastic rocks

Czb - Silcrete: sub-vitreous siliceous rock with angular quartz grains, commonly ferruginized

Czc - Clay, silt, sand and rock fragments; poorly sorted colluvium and minor alluvium

Czj - Deep-weathering products over ultramafic rocks: chalcedonic and opaline silica

Czk - Kankar, massive, nodular and sheet-like soil carbonate, minor chalcedony

CZL - Laterite; massive, cavernous and pisolitic

Czo - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified

Czo/Ag - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified; on Ag

Czo/Agb - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified; on Agb

Czo/Agf - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified; on Agf

Czo/Agg - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified; on Agg

Czo/Agm - Deeply weathered Archaean rocks; kaolinized, in part ferruginized and silicified; on Agm

Czo/pEg - Overprint, indicating deeply weathered Precambrian rocks: kaolinized, in part ferruginized and silicified on pEg

Czs - Residual sand and laterite: red quartz sand with ironstone pisoliths, commonly overlying ironstone crust

P_b - Quartzo-feldspathic gneiss and granofels, augen gneiss

P_gl - Granite-adamellite with potash feldspar megacrysts

P_gy - Leucocratic granite

P_m - Migmatite, banded gneiss, mafic gneiss; garnetiferous

P_n - Metamorphosed noritic dolerite and gabbro, minor hybrid rock with rapakivi texture

P_p - Felsic porphyry: cataclastically deformed

P_u - Ultramafic intrusive rocks serpentinite, tremolite rock, pyroxenite

Paf/Pag - Coarse grained, poorly sorted sandstone, conglomerate, minor siltstone, fluviatile

Pa - Paterson Formation

Pag - Diamictite (probably tillite), minor sandstone, siltstone, conglomerate; glacial

Pal - Claystone, siltstone, fine-grained sandstone, some erratics, rare varves; lacustrine and glacio-lacustrine

Qe - Eolian sand: red quartz sand; forming seif dunes and sand plains

Qo - Eolian sand: gypsum and quartz sand; derived from salt lakes; commonly forming lunette dunes

Qpe - Residual sand and kankar: sand containing sheet and nodular kankar; overlies Precambrian rocks, Paterson Formation and Colville Sandstone

Qrd - Colluvium: clay, silt and sand; in saline drainages and marginal to salt lakes

Qre - Lake deposits: gypsum, halite, clay and sand

Qrf - Colluvium: silty sand, containing detrital ferruginous laterite

Qrk - Lake deposits: clay

Qro - Colluvium: calcareous clay, in places containing sand

pEc - Hybrid rocks: adamellite to gabbro

pEd - Layered mafic intrusions; metamorphosed garnetiferous gabbro, hornblendite

pEg - Granitic rocks of uncertain age

pEgs - Strongly sheared felsic rock

pEq - Quartzite, pure, cross-bedded

pEs - Metasedimentary rocks: impure tourmaline quartzite, quartz-mica schist, minor quartz conglomerate

Ab - Mafic extrusive rocks; basalt; fine to medium-grained; minor mafic intrusive rocks

Aga - Muscovite-biotite granite to adamellite; medium-grained

Agb - Biotite granite to adamellite; medium to coarse-grained

Agf - Leucocratic granite in small intrusions

Agg - Strongly foliated granitic rock

Agm - Migmatite and mixed granitic rocks

Agt - Granodiorite

Ap - Felsic intrusive rocks; quartz-feldspar porphyry, porphyritic micrograntite

Czu - Poorly sorted sandstone, conglomerate, minor siltstone; contains silcrete pebbles

P_d - Mafic dykes, quartz dolerite, gabbro, pyroxentite

Paf/Pal - Coarse-grained, poorly sorted sandstone, conglomerate, minor siltstone; dominantly fluviatile; on Pal

Pag/Paf - Tillite; minor sandstone, siltstone, conglomerate; glacial; on Paf

Qd - Clay, silt and sand; in saline drainages and marginal to salt lakes

Qg - Eolian deposits; lake derived sand and gypsum in dunes and sheets

Ql - Lake deposits; clay, silt and sand; saline and gypsiferous

Silt and sand composed of quartz and feldspar grains; marginal to granite outcrops

Qs - Red and yellow quartz sand, eolian

GHD

INDEPENDENCE GROUP NL

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Figure 2a

2.4 Runoff characteristics

URS (2007) indicated that surface runoff is only generated from periods of intense rainfall; typically rainfall events of greater that 20 mm in summer, and 10 mm in winter. Rainfall from smaller events is rapidly lost to evapotranspiration or infiltration into the ground. Surface water flows are likely to be infrequent and of short duration, during periods of extreme rainfall (URS 2007).

Work conducted by Landloch (2008) found no evidence of runoff occurring from the loosely packed sand dunes which are stabilised by vegetation. The steady infiltration rates of dune and swale soils from the Tropicana site were measured under simulated rainfall and found to be from 44 - 140 mm/h, with dunes having higher infiltration than their associated swale. Simulation of 100-year rainfall on 40 m high slope with 14 degree gradient showed that runoff was negligible or zero if the soil's steady infiltration rate was greater than 30 mm/h. While this study focussed on the impact of runoff and consequent water erosion on mine waste dump slopes, the results are relevant to soil types found along the proposed alignments.

It was indicated, however, that the operational area as a whole does occasionally generate runoff (Landloch 2008). URS (2007) estimated that only about 26% of the mine's catchment area consists of colluvium soils likely to contribute to surface runoff, with the remainder being sandy dunal material with very low runoff coefficient. While these estimates were made for the Operation Area, they also provide an indication of the conditions along the proposed infrastructure corridors. As the upper soil profile is typically dry preceding rainfall, runoff is generated when the rainfall rate exceeds the soil's infiltration rate. As infiltration rates in the upper catchments are high, so runoff is low.

Surface water runoff which is generated is impeded in areas where dunal systems cross the topographic drainage lines, and by natural depressions which absorb runoff from their upstream catchment area (URS 2007). The lower parts of catchment appear to drain, however there are no well defined watercourses, and much of the stormwater is likely to become trapped in local depressions.

While much of the area upstream of the infrastructure corridor is not likely to produce runoff, local drainage has the potential to produce stormwater that could impact on the construction and operation of the corridor and on its surrounding environment.

Potential drainage lines crossing the proposed Pinjin and Tropicana Transline Corridors have been identified from topographic contours and imagery as available. These collect water from catchments of various sizes. Cross drainage locations should be confirmed with further survey, or with on ground observation as the corridor is constructed.

2.5 Vegetation

2.5.1 Pinjin Infrastructure Corridor

Mattiske Consulting Pty Ltd undertook a vegetation survey in August 2008 of the proposed Pinjin Corridor. A total of 37 plant communities were recorded within the survey area, composed of 44 families, 123 genera, 260 species, and 267 taxa.

The Pinjin Corridor passes through the Helms and Austin Botanical Districts. The Helms Botanical District consists of "undulating topography with longitudinal dunes", with consistent vegetation dominated by tree steppe of *Eucalyptus gongylocarpa* and *Triodia basedowii* (Mattiske 2008). The Austin Botanical District is "gently undulating topography with occasional ranges of low hills, with extensive sandplains in the east" (Mattiske 2008). This district has Mulga woodlands on the plains, decreasing to scrub vegetation on the hills and rises (Mattiske 2008).

One Declared Rare Flora species, *Conospermum toddii* Proteaceae, was located at five sites within the survey corridor. Despite an intensive search undertaken for Declared Rare Flora species *Eucalyptus articulate* Myrtaceae (the Ponton Creek Mallee), which is known to occur from the Mulga Rocks area, this mallee species was not observed (Mattiske 2008). Thirteen other Priority Flora species were recorded (Table 2). Of the total 37 plant communities, six were identified that impact should be avoided or minimised either due to a prevalence of Declared Rare Flora or Priority Flora, or due to a lack of significant replication within the infrastructure corridor (Mattiske 2008).

Table 1 Declared Rare Flora and Priority Flora surveyed along the Pinjin Infrastructure Corridor

Species	Family	Rank	Typical Habitat
Conospemum toddii	Proteaceae	R	Yellow sand dunes
Baeckea sp. Gt Victoria Desert	Myrtaceae	P2	Red sand or yellow sandy loam on undulating plains
Dicrastylis nicholasii	Lamiaceae	P2	Red sandy loam
Grevillea secunda	Proteaceae	P2	Yellow or red sand dunes and sandplains
Olearia arida	Asteracea	P2	Red or yellow undulating low rises
Thryptomene eremaea	Myrtaceae	P2	Red or yellow sandplains
Dicrastylis cundeeleensis	Lamiaceae	P3	Red, yellow, or reddish yellow sandplains
Eucalyptus pimpiniana	Myrtaceae	P3	Red sand dunes and plains
Microcorys macredieana	Lamiaceae	P3	Yellow sand on dunes and sandplains
Micromyrtus serrulata	Lamiaceae	P3	Brownish sandy and clayey soils over granite
Micromyrtus stenocalyx	Myrtaceae	P3	Yellow or rarely red sand dunes and undulating sandplains
Comesperma viscidulum	Polygalaceae	P4	Yellow or red sand dunes and undulating sandplains
Daviesia purpurascens	Papilionaceae	P4	Sandy or loamy soils over laterite on flats and ridges
Lepidobolus deserti	Restionacear	P4	Yellow or orange sand dunes

Source: Mattiske (2008).

2.5.2 Tropicana Transline Infrastructure Corridor

Ecologia Environment undertook a vegetation survey of the proposed Tropicana Transline Infrastructure Corridor in June 2008. They identified 52 families, 142 genera, 372 confirmed species, and 417 flora taxa, which were divided into 9 main vegetation units and 21 vegetation sub-units (ecologia Environmental 2008).

The middle and northern sections of the corridor are situated within the Helms Botanical District, with sand dunes and undulating topography, as above. The southern section of corridor is to be situated on the boundary of the Eucla Botanical District and the Coolgardie Botanical District. This region consists of thickly wooded succulent steppe, and a mosaic of *Eucalyptus oleosa* with patches of *Eucalyptus salmonophloia* and *Eucalyptus salubris* woodland (ecologia Environmental 2008).

No threatened ecological communities or Declared Rare Flora were identified. However, fourteen Priority Flora taxa of regional significant to the Great Victoria Desert and Nullarbor bioregion or endemic to the project area, and one of conservation significance, were recorded as listed in Table 3. No species of national, state or local significance were identified. The Priority Flora species were recorded on dunes and sand plains and not restricted to a particular habitat type (ecologia Environmental 2008).

The most restricted vegetation community identified was at the southern end of the Corridor, consisting of mallee and spinifex units with patches of salmon gum and gimlet. This occurred in an area where the road will only need to be widened, so clearing will be minimal (ecologica 2008).

Table 2 Priority Flora surveyed on the Tropicana Transline Infrastructure Corridor

Species	Family	Rank	Typical Habitat
Dampiera eiantha	Goodeniaceae	P1	Dunes
Olearia arida	Asteracea	P2	On deeper sands, often with *Eucalyptus gongylocarpa*
Dicrastylis nicholasii	Lamiaceae	P2	On deeper sands, especially in areas that had been burnt
Physopsis chrysotricha	Lamiaceae	P2	Undulating sandplains
Baeckea sp. Gt Victoria Desert	Myrtaceae	P2	Flat red loamy sandplains
Malleostemon sp. Officer Basin	Myrtaceae	P2	Dunes
Isotropis canescens	Papilionaceae	P2	Undulating sandplains
Grevillea secunda	Proteaceae	P2	Generally on or close to dunes
Dicrastylis cundeeleensis	Lamiaceae	P3	Flat / undulating sandplains, undulating dunes, dune crests
Microcorys macredieana	Lamiaceae	P3	Dunes
Micromyrtus stenocalyx	Myrtaceae	P3	Dunes
Comesperma viscidulum	Polygalaceae	P4	Dunes
Daviesia purpurascens	Papilionaceae	P4	On deeper sands close to dunes
Lepidobolus deserti	Restionaceae	P4	Dunes

Source: ecologia Environmental (2008).

2.6 Conclusions

The majority of the drainage catchments upstream of the Tropicana Gold Project and proposed infrastructure corridors are characterised by low relief, poorly defined drainage lines and areas with strong linear sand dunes and internal drainage. The regional geology is predominantly aeolian sands, with high infiltration capacity, interspersed with areas of colluvial soils with lower infiltration capacity.

The region's climate is hot and dry, with potential evaporation greatly exceeding rainfall. Rainfall and flood events are highly variable in size and timing, often influenced by tropical cyclones. Accordingly, stormwater flows are likely to be infrequent and of short duration, resulting from periods of intense rainfall. Runoff rates and volumes along the proposed corridors are generally low. However, local drainage from less permeable soils has the potential to produce runoff that could impact on the infrastructure corridor and surrounding environment, including areas that contain Declared Rare Flora and Priority Flora.

3. Infrastructure corridor impact assessment

3.1 Description of proposed infrastructure corridor

The proposed infrastructure corridor will connect the Tropicana Gold Project site with existing public roads to Kalgoorlie. A new corridor will be constructed from the operational area to the existing roads. The corridors are expected to service five haulage truck trailers per day.

Two alternate routes from Kalgoorlie to the TGP operational area have been identified:

» Pinjin Infrastructure Corridor. This route includes 200 km of infrastructure corridor, referred to as the Pinjin Access Road, and connects to the Kurnalpi-Pinjin Road just south of Pinjin.

» Tropicana Transline Infrastructure Corridor. This corridor is comprised of 100 km of track upgrade and 120 km of new corridor, and connects to the infrastructure corridor of the Trans Australian Railway.

Shawmac Pty Ltd has prepared a concept of the new road sections, with typical cross-sections, drainage drawings and commentary on design criteria (Shawmac 2008).

The potential routes are shown on Figure 1, with details on Figure 3 and Figure 4. General design features are summarised below.

3.1.1 Corridor design

Both potential corridor routes would require approximately 200 km of road construction in addition to utilisation of existing tracks and roads. The road will be unsealed and designed for the vehicle laden weight of public-road-suitable transport vehicles. The road will have a minimum pavement width of 8 m plus two 1 m wide shoulders (Shawmac 2008).

The following pavement design has been recommended:

» Base-course of compacted gravel 250 mm, 300 mm, or 350 mm (dependant on soil type);

» Sub-base of compacted natural material;

» Cross fall of 5% from the road centreline;

» Longitudinal drain batters and road side batters of 1:4 slope;

» Where road cut into existing ground level, batters of 1:2 slope; and

» Levees of 1:3 side slopes.

3.1.2 Corridor selection

The following factors were considered when selecting the possible corridor alignments:

» Minimising the environmental impact on sensitive dunal areas;

» Minimising the length of alignment, which reduces the total clearing area and material demand;

» Minimising the depth of cut or height of fill, which reduces the clearing widths;

» Minimising drainage crossings of major water features;

» Providing a safe geometry for heavy haulage vehicles at 100 km/h desirable speed;

- Providing a geometry that will minimise transport operating costs including fuel usage and exhaust emissions;
- Utilising existing roads and tracks when appropriate with the above listed criteria; and
- Maintenance practices requiring specific design features – for example drainage catch drains for collection of dust suppressant material runoff.

With these factors in mind, two potential routes were selected – the Pinjin Infrastructure Corridor and the Tropicana Transline Infrastructure Corridor.

3.1.3 Pinjin Infrastructure Corridor

From the TGP operational area, the first section of the proposed Pinjin Infrastructure Corridor consists of 200 km of new road that connects to an existing track east of the Pinjin Station. The corridor has a generally northeast to southwest orientation (Figure 3). The corridor then extends southwest of the Pinjin Station 40 km before the intersection with Kurnalpi Road.

The route then follows Kurnalpi Road to the south, which is an unsealed road, the northern section of which is controlled by Shire of Menzies, and the southern section of which is controlled by City of Kalgoorlie-Boulder. This is before joining Yarri Road, which is unsealed for 7 km, then sealed to Kalgoorlie. The total estimated Pinjin Infrastructure Corridor length is 380 km (Shawmac 2008).

Road upgrade and new corridor construction will occur from the mine to the Kurnalpi Road. This will include upgrade of a section of the existing Pinjin Access Road.

The Pinjin Access Road predominantly crosses soils with nil or low cohesive content, thus relatively few drainage structures are required, and these are of small size. Close to the mine site, soils are gravelly, while Pindan sands and Dunal sands are predominant along rest of route. The high porosity of these soil types mean little or no longitudinal drainage has been required for existing unsealed roads in the area (Shawmac 2008).

In addition to the general hydrologic impacts of road construction, the Pinjin Access Road crosses two ephemeral waterways between Tropicana and the Kurnalpi Pinjin Road; Ponton Creek, and Lake Minigwal. Near small lakes and Ponton Creek are clays and clayey sands. The preferred design option is to realign the road away from naturally flat elevation areas (rather than significantly elevate the corridor, forming long embankments).

The Pinjin Station bypass overlies clays and clayey sands. To achieve adequate drainage, this corridor section is to be aligned on higher areas of land, or the road elevated. The Pinjin Infrastructure Corridor will join the existing Kurnalpi Road, prior to a section crossing Lake Rebecca south of Pinjin. The remainder of the route, following Kurnalpi Road and Yarri Road, is controlled by local government authorities, and as such drainage will not be modified by this project.

3.1.4 Tropicana Transline Infrastructure Corridor

The proposed Tropicana Transline Infrastructure Corridor is to travel south from the operational area for 100 km, until the alignment meets the existing Cable Haul Road (Figure 4). The route will then following the existing Cable Haul Road route for 120 km south to Kitchner, the northern 52 km of which is along an infrequently used older road, and the southern 58 km along a relatively newer alignment.

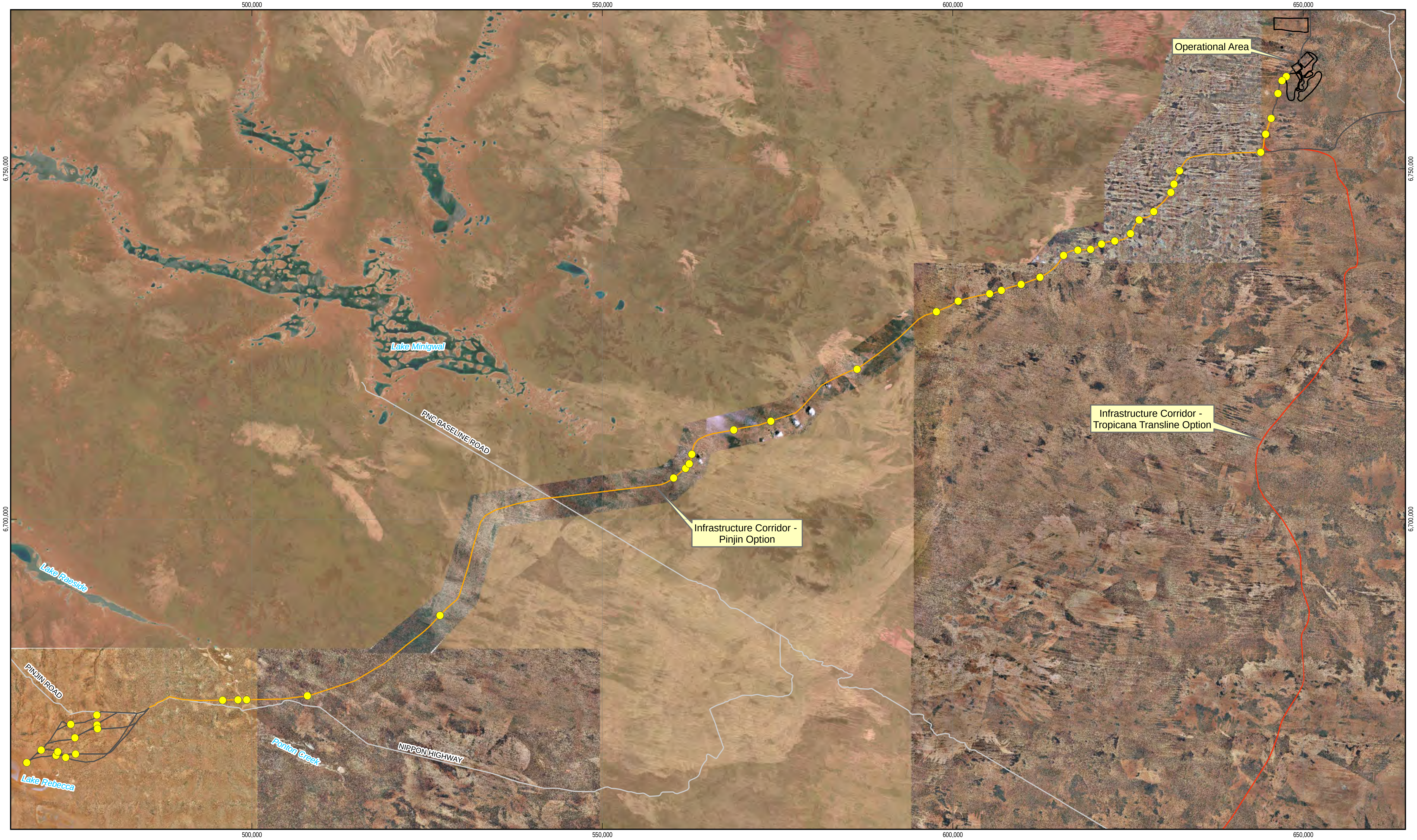
From Kitchner, the route will use the access road of the Trans Australian Railway for 242 km heading west towards Kalgoorlie. The last 29 km will follow the Mount Monger Road, sealed for the last 25 km to Kalgoorlie, with no upgrade necessary. The entire Tropicana Transline Infrastructure Corridor is estimated to be 490 km long (Shawmac 2008).

The new section of the Tropicana Transline Corridor does not cross any defined waterways along the proposed new alignment. Several low lying sections have been identified which may required cross drainage.

In order to drain water from the corridor surface, but not retard high flows from the surrounding land, the first 100 km from the operational area must be designed to be 350 mm higher than surrounding existing ground level. In gravels and clayey sands, drainage channels will be provided along the sides of the corridor. This alignment passes through dunal areas. Longitudinal drainage will be unnecessary for dunal sands and Pindan sands as stormwater direct infiltration along side of corridor.

The next 52 km of corridor along old Cable Haul Road crosses sections of clayey sand and dunal sands. In dunal sands longitudinal drainage is unnecessary; however the road centreline must be above surrounding existing ground level. Following this, the Tropicana Transline Infrastructure Corridor takes a new route, with 18 km on Pindan sands, then next 40 km on clayey sands with calcrete outcrops. Drainage is required along the entire 58 km of new alignment. The eastern 145 km of the Trans Australia Railway Access Road has very poor geometric shape. The western 97 km to Mount Monger Road has better construction. Drainage to Mount Monger Road will not require any upgrade.

Surface water impact assessment in this study is focussed on the new corridors, rather than on the upgrade of existing roads.



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LEGEND

Conceptual Site Layout
AngloGold Ashanti Australasia - 200808

- Proposed Mine Infrastructure
- Infrastructure Corridor - Pinjin Option
- Infrastructure Corridor - Tropicana Transline Option
- Other Roads
- Road Drainage - GHD - 20080916
- Roads - GA - 2006

Locality Map

NECKERSGAT RANGE
MALCOLM
MOUNT MARGARET
CUNDEELEE
HAIG
KALGOORLIE-BOULDER
NORSEMAN
SOUTHERN OCEAN

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AUSTRALIA

Tropicana Gold Project, Surface Water Evaluation of the Infrustructure Corridor Options

Job Number	6121984
Revision	2
Date	June 2009

Infrastructure Corridor - Pinjin Option Conceptual Drainage Points

Figure 3

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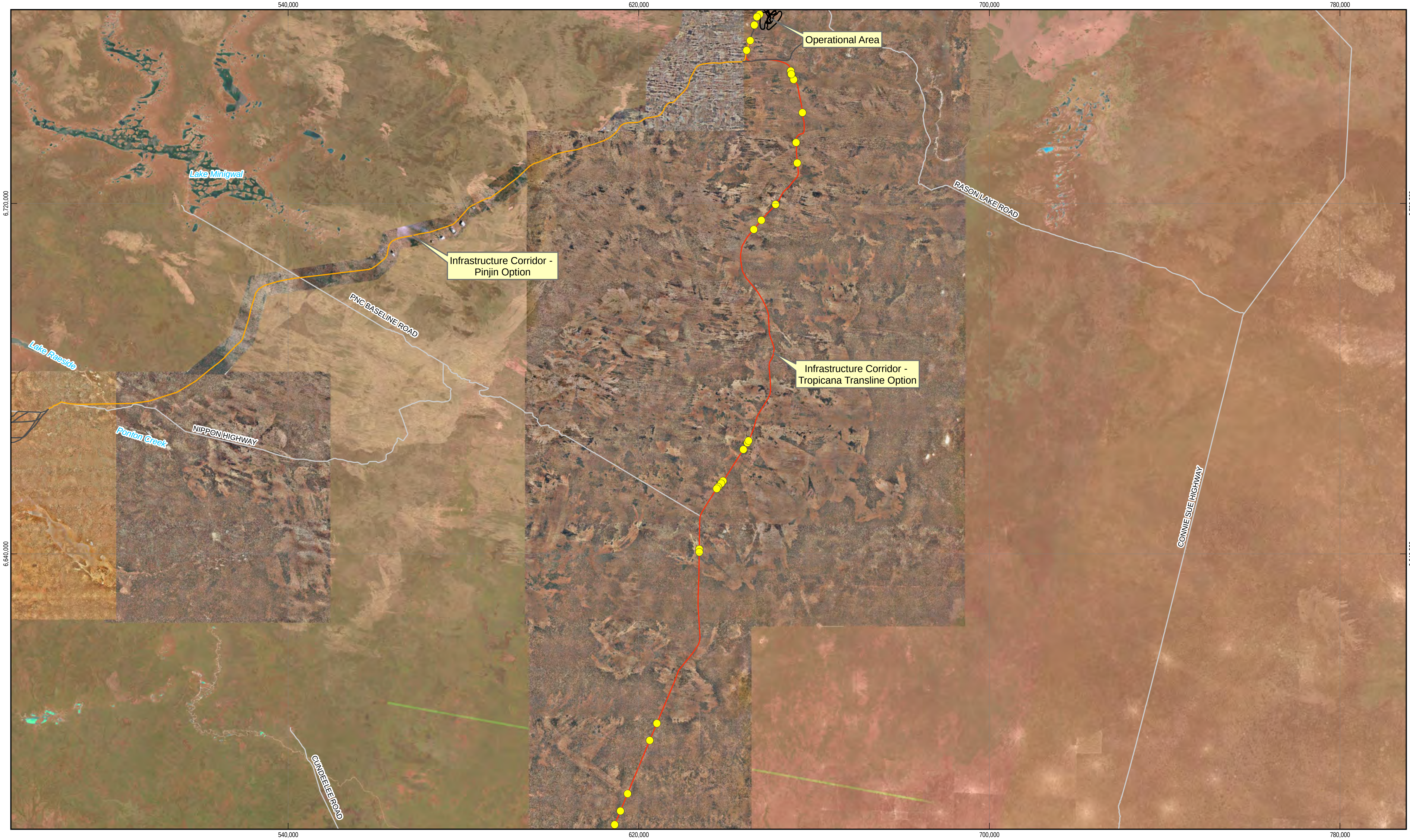
Note that positional errors can be > 5m in some areas. Dataset names include published date where available. Pinjin 2003, Ponton 2005, Pinjin Access Rd, Meinya, Tropicana, Kakarook 2005 and Barlett 2005 mosaics sourced from Anglo Gold 2008. Landsat 2002 Satellite imagery sourced from GA. Created by: W Davis



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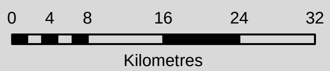

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 51

LEGEND

Conceptual Site Layout
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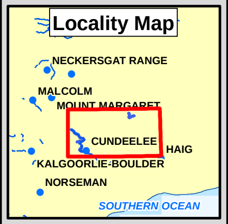

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Tropicana Gold Project, Surface Water
Evaluation of the Infrustructure
Corridor Options

Infrastructure Corridor - Tropicana Transline Option Conceptual Drainage Points

Job Number	6121984
Revision	2
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Figure 4

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Note that positional errors can be > 5m in some areas. Dataset names include published date where available. Pinjin 2003, Ponton 2005, Pinjin Access Rd, Meinya, Tropicana, Kakarook 2005 and Barlett 2005 mosaics sourced from Anglo Gold 2008. Landsat 2002 Satellite imagery sourced from GA. Created by: W Davis

3.2 Surface water impacts

Potential construction and operational impacts of the proposed new infrastructure corridors on surface water hydrology of the surrounding environment can be grouped into three categories:

- Cross drainage impacts,
- Clearing and disturbance, and
- Water quality effects.

3.2.1 Cross drainage impacts

Construction of the infrastructure corridor above the surface level of the surrounding landscape will result in modification of the existing stormwater flow paths. Stormwater collection, detention and conveyance along and across the corridor may lead to flow concentration and scour, reduction of stormwater flows downstream of the corridor, increased or prolonged flooding, as well as related impacts on adjacent vegetation communities.

Where longitudinal side drains are required, stormwater sheet-flow will typically be collected in table-drains and passed across the corridor using culverts and floodways. This stormwater could then be discharged as a concentrated flow from the downstream end of the crossing, depending on the length of floodway. If not appropriately designed, any flow concentration and resulting increase in water velocity may cause downstream erosion, scour and geomorphologic impacts downstream of cross drainage during and post construction.

Capture/redirection of stormwater generated upstream of the proposed infrastructure corridor and concentration at drainage crossings may also result in a reduction in flows in an area downstream of the corridor; this is termed “shadowing”. This means that an area which would traditionally receive sheet-flow from its upstream catchment area no longer receives this runoff, due to upstream infiltration and evaporation or due to redirection through cross drainage. As stormwater does not appear to flow any distance, instead reinfiltrating close to source, this reduction in catchment area will generally not adversely impact the environment downstream. The exception is where vulnerable flora species are situated downstream of the proposed corridor, particularly on runoff-generating soil types. Where this is the case, reduced surface water supply caused by runoff shadowing may adversely affect the health of vegetation.

While corridor construction may reduce runoff to some areas, surface water flow modifications also have the potential to cause flooding or waterlogging upstream of the corridor. Increased or prolonged flooding may disrupt traffic and cause structural damage to the corridor. Native vegetation unused to inundation may also be affected.

3.2.2 Clearing and disturbance

Clearing of vegetation during construction affects not only the corridor width itself, but also the adjacent drainage structures, and within supporting areas such as borrow pits and construction access tracks. Within the corridor design specifications, if the corridor is to be constructed near existing ground level, a clearing width of 16 m will be required. If for topographic, environmental, or safety reasons the corridor level differs significantly from existing ground level, then a clearing width of up to 30 m will be required (Shawmac 2008). As few flora taxa within the corridors are restricted in their range, loss or modification of habitat is unlikely to greatly reduce regional biodiversity (ecologica 2008). However, the impact of clearing and disturbing these areas may include reduction in soil stability and change in hydrologic characteristics.

It is expected that during construction, vehicle movement and earthworks will disturb the soil surface, increasing the soil's vulnerability to erosion by subsequent rainfall events. Erosion risk is greater where soil is of a type with high erodibility, or where soil degradation has previously occurred. While dunal sands are prone to wind erosion, the high infiltration rate of most soils in the area mean that the potential for runoff, and thus runoff induced erosion, is very small in this environment (Landloch 2008).

There may be some increased runoff associated with surfaces and disturbed areas. However, as the area of these surfaces is small compared with the wider catchment, this will have negligible impact.

3.2.3 Water quality effects

Water quality could be impacted by increased salinity and turbidity of stormwater downstream of the infrastructure corridor associated with salt wash-off and erosion.

During construction, water will be applied for the purpose of dust suppression. It is assumed that this water will be sourced from groundwater, and thus will be saline. Over time, the corridor may accumulate salt. Subsequent rainfall events may generate elevated salinity levels in stormwater from the watered surface as the salt is dissolved and mobilised. Whilst regional groundwater generally has high salinity due to accumulation of salts over time, it is assumed that surface water (away from salt lakes) is generally fresh. Accordingly, vegetation is likely to be adversely affected by any substantial increase in the salinity of surface water received.

Erosion not only affects the site where it occurs by stripping the topsoil layer but also the downstream water quality. As sediments are mobilised by runoff, they increase the particulate load, and hence turbidity, of the downstream waterway. This may be important where there is a sensitive downstream environment particularly where soils have high fine particle content, such as clays.

Gross scour can also lead to silt deposition, normally a short distance downstream form the source. Scour and deposition has potential to impact downstream vegetation and flow paths and possibly also the corridor itself.

3.3 Conclusions

The main potential impacts of the proposed infrastructure corridor relate to:

- Constriction of flows at cross-drainage structures causing downstream erosion and shadowing;
- Ponding upstream of the corridor, as a result of interruption to runoff flow paths, causing increased waterlogging or flooding;
- Clearing and disturbance increasing erosion risk; and
- Increased salinity and sediment concentration of stormwater sourced from the corridor surface.

4. Surface water management

4.1 Drainage design

The corridor design includes typical drainage treatments that may be required along the corridor, with applicable design criteria. Drainage structures will be required in some locations to reduce the frequency of corridor closure following rainfall. Floodways will generally be used to convey high stormwater flows across the road, with associated culverts to convey low flows, and levees or diversion drains. The floodways will be constructed with stabilisation and scour protection. The placement of these structures will be dependant on topography and soil physical properties.

Due to high infiltration rate, Dunal sands require no formal drainage (Shawmac 2008). This includes locations where the corridor will be at or near existing ground level. Stormwater management structures are also considered unnecessary in locations where the corridor is significantly elevated above the existing ground level, irrespective of soil type, due to the infrequent nature of runoff events. A small channel at the embankment toe has been recommended for collection of dust suppression material runoff.

Gravelly soils, clayey sands, Pindan sands, and other areas where soils are less permeable, require stormwater to be held away from the pavement to prevent lowering of pavement strength. A side drain, with base a minimum of 600 mm below the base of pavement, will be used to transport water along the corridor to a culvert which will allow water to pass under the corridor. Where side drains are required, cleared width will be approximately 6 m greater than without a drain.

While the existing design has considered minimising environmental impacts, the following sections aim to enhance this by specifically considering management of identified surface water impacts of the proposed corridor, during both construction and operation phases.

4.2 Management concepts

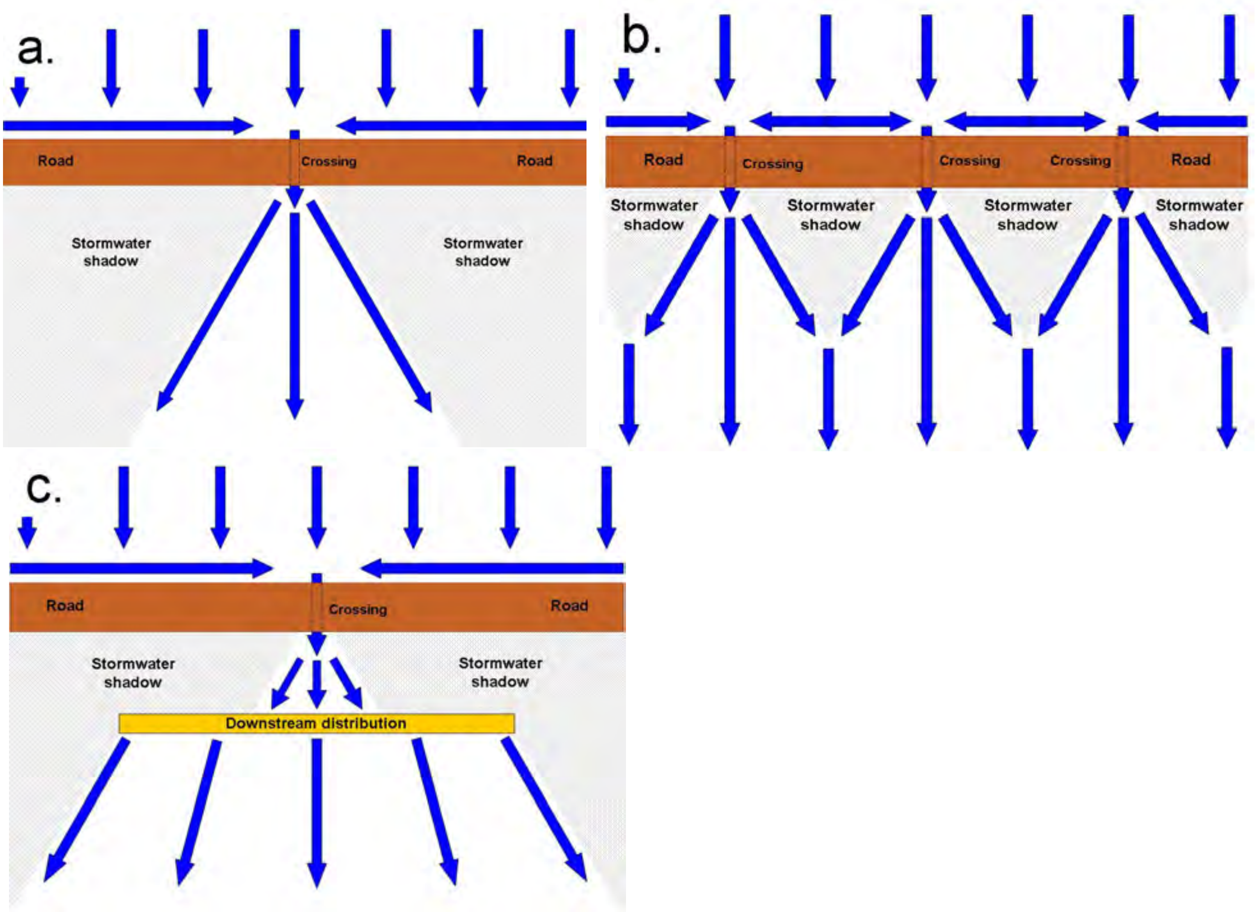
4.2.1 Stormwater flow path

To protect the flora surrounding the infrastructure corridor, Mattiske (2008) recommended that the existing drainage system be maintained, and that tracks and other infrastructure areas should avoid disruption or diversion of historic water flow patterns. Due to the uncoordinated internal regional drainage characteristics, to achieve this it would be necessary to construct the corridor at the existing ground level. This is not practical, as the corridor needs to be raised to maintain an appropriate vertical alignment, to drain both rainwater and dust suppression material from its surface, and to protect structural integrity during storms. Instead, to lessen the modification of minor flow paths and the reduction of downstream flow, it is recommended that frequent small culverts or floodways should be used. The spacing of these drainage crossings can be optimised to minimise downstream shadowing area (Figure 5 a and b).

The potential impact of downstream runoff shadowing is greatest where vulnerable vegetation species or communities are located downstream of the corridor alignment. Of particular significance will be areas with large numbers or diversity of Priority Flora, and all sightings of the Declared Rare Flora species, *Conospermum toddii*. A buffer distance from the corridor alignment should be determined in which shadowing impacts are likely. Priority Flora within the buffer should be identified either through the existing vegetation surveys, or through site observation prior to construction. In these locations, stormwater crossings should be located at an appropriate spacing to minimise downstream shadowing (as shown in Figure 5 b). Alternatively, it may be possible to respread stormwater flows downstream of the crossing (Figure 5 c).

Figure 5 Flow path concentration and minimisation of downstream runoff shadowing

a) single central culvert b) multiple culverts c) downstream flow redistribution



The route has been selected to minimise the drainage crossings of major water features. No significant waterways are crossed on the Tropicana Transline Option. The Pinjin Option, however, does cross Ponton Creek, Lake Minigwal and Lake Rebecca.

There are some 20-30 locations on each route which the available data indicate are low spots, and these may require some form of minor cross-drainage structure.

At both major and minor crossings, normal engineering design principles can be used to minimise ponding against embankments, and stabilise outfalls against erosion. Existing stormwater flow paths will be maintained, so accordingly impacts on the environment are expected to be minimal. Flow concentration is not expected to be a significant issue at major drainage crossings, as runoff is naturally concentrated into the channel at these locations.

4.2.2 Soil and vegetation conservation

The possible alignments have been selected to minimise the environmental impact on the sensitive dune areas, and also to minimise the necessary clearing widths. In addition to this, the environmental footprint of the corridor should be minimised during construction by using existing access tracks in preference to new tracks, to reduce the level of land disturbance and preserve existing vegetation wherever possible. Construction facilities and borrow pits should be rehabilitated as soon as they are no longer required.

To minimise erosion during the construction, soil conservation techniques should be employed. Use of planned tracks for vehicle movement will help to minimise the area of soil disturbance. Where slopes are created or modified, these should be graded and stabilised, for example using mulching. Rehabilitation using native vegetation following construction will also help protect soil from erosion.

To protect against scour, runoff velocity can be decreased, such as by using barriers to attenuate flows. Additionally, the vulnerable points of cross drainage where water velocity is at a maximum should be armoured. This is likely to include areas upstream and downstream of the major creek and lake crossings, where water may collect and damage the infrastructure corridor or modify waterway shape.

As rainfall events are infrequent in this region, construction should be able to avoid wet periods, even if this means stopping work if heavy rainfall is received during construction. December to March is the most likely time for cyclonic activity to be received. Any runoff that does occur during construction should be controlled through temporary/permanent drainage structures as appropriate.

4.2.3 Water quality protection

Use of the soil conservation practices mentioned above will help minimise stormwater sediment load and turbidity. Stormwater turbidity can be managed with appropriate design of flow concentration structures and using normal engineering design to trap any sediment, for example, in table drains.

To manage the saline runoff from dust suppressant material, longitudinal catch drains can be used to contain the saline water. The design of having pavement above surrounding natural surface level to allow collection of this dust suppression material (Shawmac 2008) is supported. This stormwater would normally infiltrate in table drains close to the watered area, and can be rehabilitated if the road is later closed. Should impacts from salt wash-off become noticeable in some areas, runoff in these areas can be managed with containment in sumps, to be rehabilitation on closure.

4.3 Recommendations

To minimise impacts of the infrastructure corridor on surface water, it is recommended that the following principals are adopted during the design and construction process:

- Survey the selected route to confirm topography and identify any low-lying and sheet-flow areas requiring drainage;
- Minimise the footprint of the corridor and construction facilities to minimise disturbance of the vegetation, soil and hydrologic characteristics;
- Employ soil conservation techniques to prevent erosion, scour and increase in surface water turbidity, including design of drainage structures to detain water and reduce flow velocity before discharge, armouring of susceptible points and stabilisation of disturbed slopes during construction;
- Use appropriately located and designed culverts and/or floodways to minimise disruption to natural flow paths, downstream runoff shadowing and upstream ponding;

- Use existing vegetation survey and further site observation to identify the location of Declared Rare Flora and Priority Flora within buffer distance adjacent to selected route;
- For identified key vulnerable vegetation sites ensure that any runoff shadowing downstream of the corridor does not reach or impact on the vegetation by either increasing the frequency of culverts and/or floodways or respreading concentrated flows downstream of the drainage structures; and
- Minimise salt contamination of downstream surface water by containing and infiltrating dust suppression material in table drains, and rehabilitate on closure.

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