# SARAJI EAST MINING LEASE PROJECT

Environmental Impact Statement

## Appendix K-2

Subsidence Management Plan

BHP Mitsubishi Alliance

Prepared for
BM Alliance Coal Operations Pty Ltd
ABN: 67096412752

# Environmental Impact Statement

## Appendix K-2 Subsidence Management Plan

01-Jul-2024
Saraji East Mining Lease Project

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# Abbreviations

| | |
|---|---|
| BMA | BM Alliance Coal Operations Pty Ltd |
| cm | centimetre |
| DES | Department of Environment and Science |
| EA | Environmental Authority |
| EC | Electrical conductivity |
| EIS | Environmental Impact Statement |
| ERA | Environmentally Relevant Activity |
| FPC | Foliage Projective Cover |
| FY | Financial Year |
| ha | hectares |
| IDC | Index of Diversion Condition |
| IRC | Isaac Regional Council |
| kg | kilograms |
| km | Kilometres |
| LGA | Local Government Area |
| LTCC | Longwall top coal caving |
| m | metres |
| ML | Mining Lease |
| MLA | Mining Lease Application |
| Mt | million tonnes |
| NATA | National Association of Testing Authorities |
| NGO | Non-government organisation |
| PMLU | Post-mining land use |
| PRCP | Progressive Rehabilitation and Closure Plan |
| RE | Regional Ecosystem |
| REMP | receiving environment monitoring program |
| RMP | Rehabilitation Management Plan |
| RPEQ | Registered Professional Engineer of Queensland |
| SMP | Subsidence Management Plan |
| TARP | Trigger Action Response Plan |
| µS | microsiemens |

# 1.0 Introduction

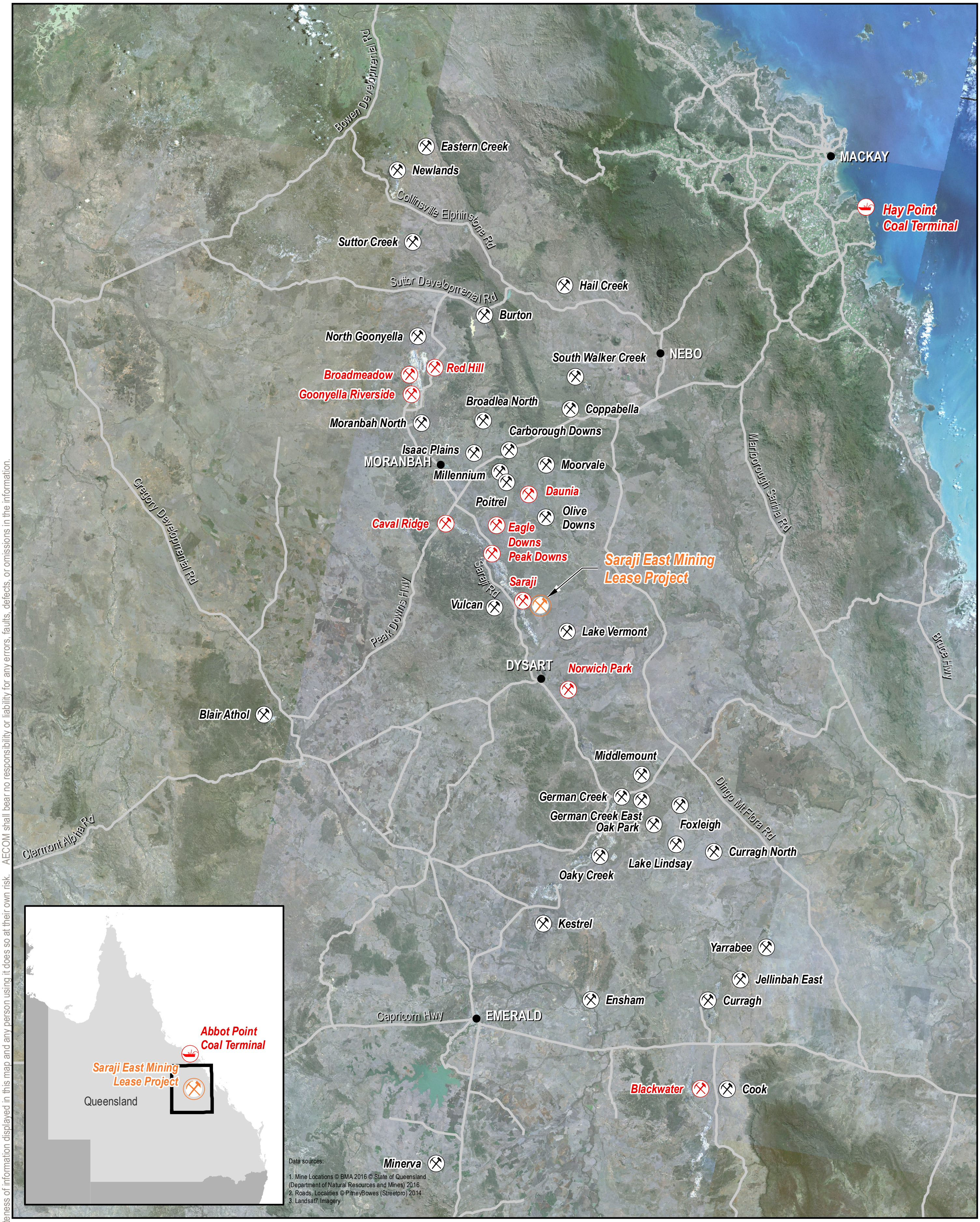
## 1.1 Project overview

BM Alliance Coal Operations Pty Ltd (BMA) is seeking approval to develop the Saraji East Mining Lease Project (the Project) involving a single-seam underground mine and supporting infrastructure on Mining Lease Application (MLA) 70383 and MLA 70459 adjacent to, and accessed through, the existing open cut mine void within Mining Lease (ML) 1775.

Located approximately 30 kilometres (km) north of Dysart in Queensland (Figure 1) the Project (Figure 2) will progressively mine the coal within each longwall panel (approximately 5-11 km in length, up to 320 metres (m) wide and up to 3.6 metre cut height) to produce an estimated 110 million tonnes (Mt) of high-quality metallurgical product coal over a 20-year life of mine.

This draft Subsidence Management Plan (SMP) presents the preliminary mitigation, adaptive management and monitoring approach to be implemented following subsidence of each panel to ensure the surface landform is stable, non-polluting and free draining.

***NOTE: This plan has been drafted in support of the Project Environmental Impact Statement (EIS) and will be finalised prior to commencement of mining activities. The finalised plan will be assessed and certified by suitably qualified and experienced person and provided to the administering authority for comment.***




**LEGEND**

- Saraji East Mining Lease Project
- BMA Coal Terminal
- BMA Mine
- Other Mine
- Locality
- Major Road

N

**Figure 1**
**Regional Context**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 5 10 20
Kilometres

Scale: 1:1,500,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

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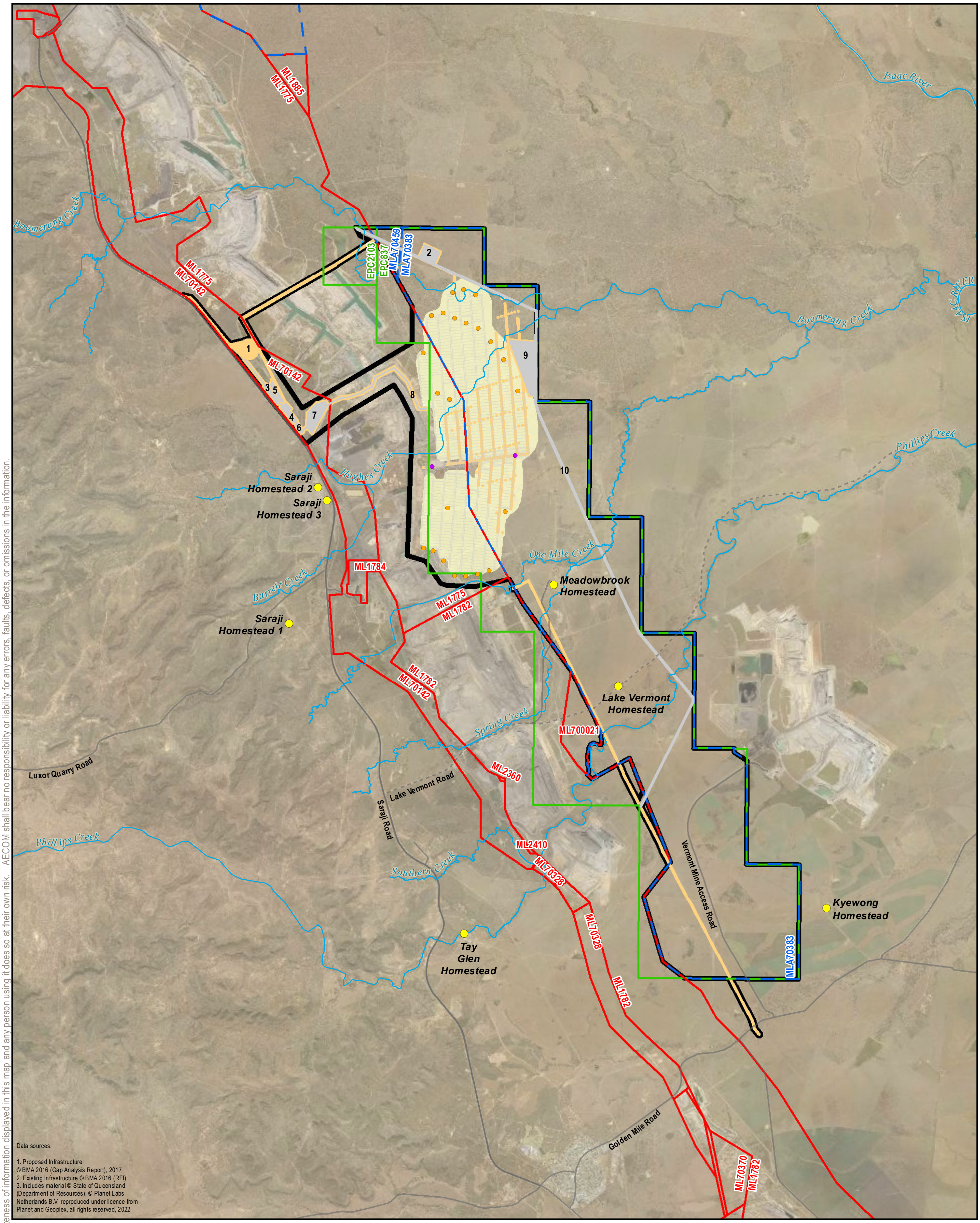


**LEGEND**

- Project Site
- Project Footprint - Direct Impact
- Project Footprint - Indirect Impact
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground Mine Layout
- Surface Infrastructure
- Watercourse
- Private Access Road
- Public Road
- Homestead
- Flare
- Vent

**Surface Infrastructure**

1 Rail Loading Balloon Loop
2 Process Water Dam
3 Product Stockpiles
4 CHPP
5 Raw Water Dam
6 ROM Pad
7 Future MIA
8 Conveyor
9 Construction Village
10 Transport and Infrastructure Corridor

N

**Figure 2**
**Project Layout**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.75 1.5 3
Kilometres

Scale: 1:158,094 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

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## 1.2 Purpose

The Project will include Environmentally Relevant Activities (ERA), including mining black coal, regulated under the Queensland *Environmental Protection Act 1994* and Environmental Protection Regulations 2019.

The Project must comply with conditions of an Environmental Authority (EA), which will require a SMP to be prepared to identify the potential environmental risks from subsidence and the controls necessary to avoid, minimise, mitigate and remediate adverse impacts on watercourses, hydrology and environmental values.

The purpose of this SMP is to identify:

- potential impacts of subsidence associated with longwall mining at the Project
- controls required to monitor, minimise and mitigate subsidence impacts.

## 1.3 Regulatory obligations

The SMP will form a part of the Project's environmental management system intended to meet the obligations of the EA and relevant guidelines:

- DEHP guideline: Application requirements for activities with impacts to land (Version 4; DEHP, 2017)
- DEHP guideline: Application requirements for activities with impacts to water (Version 4; DEHP, 2015)
- Queensland Environmental Offsets Policy (Version 1.1; DEHP, 2014).

The regulatory obligations and specific sections of this SMP in which they are addressed are summarised Table 1.

During detailed design, and progressively throughout the mining process, the subsidence modelling and SMP will be updated in response to revised predictions based on current LiDAR-derived surface level data for the most recent subsided panels.

Once stable, progressive rehabilitation can occur in accordance with the Rehabilitation Management Plan (RMP) (BMA, 2024), which will be further refined into the Progressive Rehabilitation and Closure Plan (PRCP), once finalised in accordance with EA conditions.

**Table 1 Regulatory obligations**

| Description | Reference | SMP Reference |
|---|---|---|
| Provide a drawing/site plan showing the impacts arising from subsidence associated with the ERA. | Guideline: Application requirements for activities with impacts to land (DEHP, 2017) | Figure 4 – Subsidence contours |
| Describe in detail all land disturbance associated with the ERA. | Guideline: Application requirements for activities with impacts to land (DEHP, 2017) | Section 3.0 – Potential impacts |
| Demonstrate how the ERA will be managed to minimise the extent and severity of land disturbance including any areas which are likely to experience underground subsidence are to be identified. | Guideline: Application requirements for activities with impacts to land (DEHP, 2017) | Section 5.0 – Risk assessment and preliminary TARP |
| Where contaminant release to waters or disturbance of waters (i.e. reshaping of the bed and banks of a watercourse) is proposed, the applicant must identify how the site will be rehabilitated.<br>The rehabilitation plan must provide for the following (where relevant):<br>managing subsidence to ensure that overland and surface water flows are not impacted. | Guideline: Application requirements for activities with impacts to water (DEHP, 2014) | Section 4.2 - Drainage, Section 4.4 – Surface Crack Repairs, Section 6.1.2 – Surface water and the RMP (BMA, 2024) |
| Where the proposed ERA involves, or may involve, subsidence, applicants are encouraged to provide details of how this will be managed within a subsidence management plan.<br>The management plan should address all of the potential impacts resulting from subsidence at the site, including:<br>• The physical condition of surface drainage<br>• Overland flow<br>• Land condition and future suitability. | Guideline: Application requirements for activities with impacts to land (DEHP, 2015) | Section 5.0 – Risk assessment and preliminary TARP |
| Offsets are required where impacts to remnant vegetation are unavoidable. | Queensland Environmental Offsets Policy (DEHP, 2017) | Section 6.1.4 – Ecology |

# 2.0 Predicted subsidence

As mining activities retreat along the longwall panel, overlying strata collapse into the area referred to or known as the goaf. A subsided longwall block typically settles after 6 months. The extent to which this subsidence can be observed at the surface is dependant on the type of overlying strata, the thickness of the extracted seam and the relative distance between the mining operations and the surface.

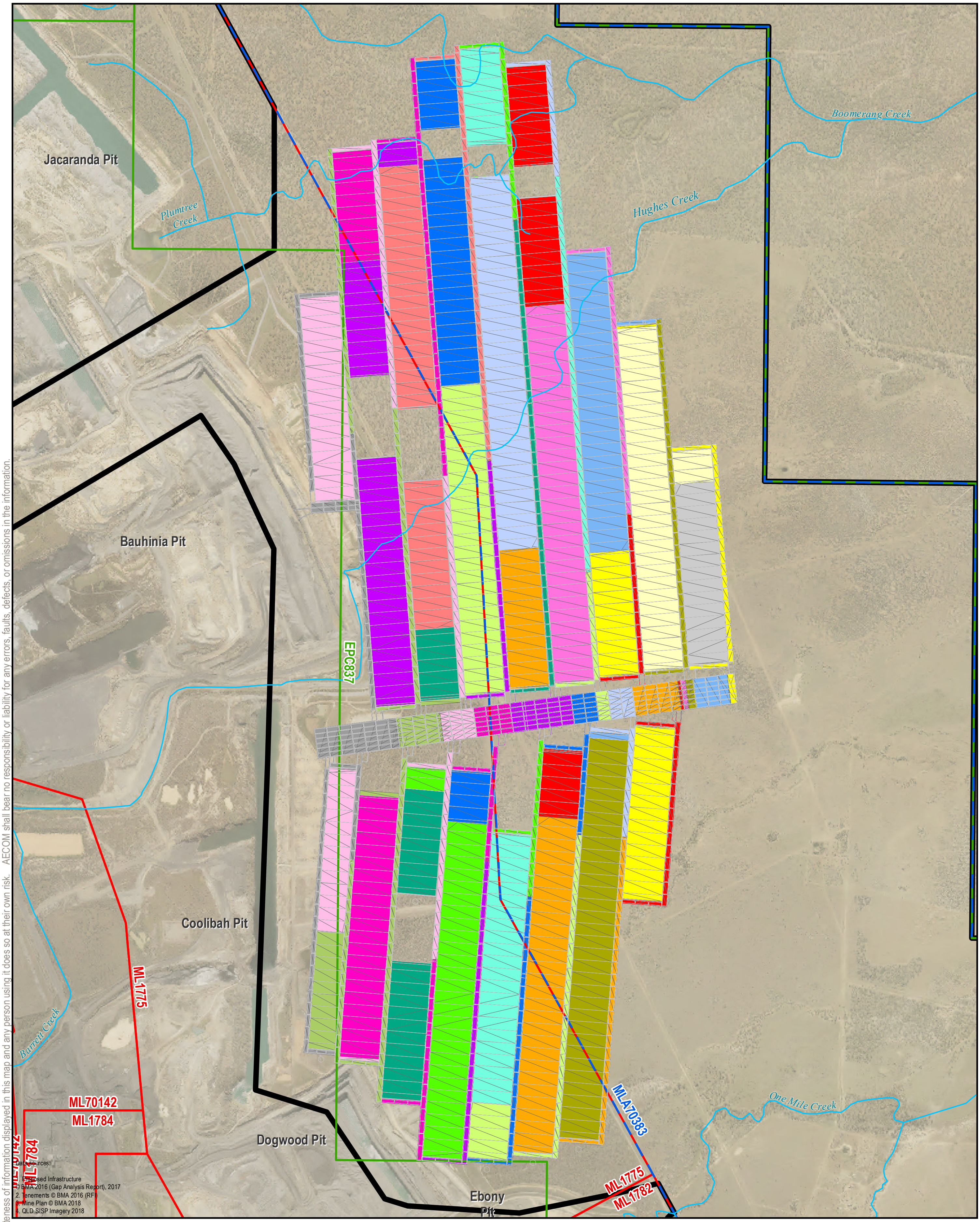
The underground mine plan depicted in Figure 3 is the subject of this SMP. All longwall panels across the Project Site will extract coal from the Dysart Lower (D24) seams.

## 2.1 Predictive model

A surface subsidence study completed for the Project has predicted the extent and magnitude of subsidence following successive stages of longwall panel excavation (Minserve, 2022), estimating potential impacts at 1, 2, 5, 10 and 20 years of the mining schedule.

The subsidence study model was set up to include the major geological strata with properties which reflected the original pre-mining conditions. The model was then stepped through the following stages to simulate the proposed mining operations:

- intact geology brought to equilibrium under applied in situ stress field and gravity
- open cut mining excavations cut into the model
- longwall panels excavated according to scheduled sequence
- longwall coal extraction to uniform height of 3.6 m
- after excavation of each stage, the stresses and deformation were equilibrated
- roof rock mass allowed to collapse onto floor of longwall panel
- histories of displacement over the longwall panels were monitored
- changes in surface elevation were calculated to establish the post-mining topography.




**LEGEND**

- Project Site
- Underground Mine Layout
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Watercourses

**Optimised Mine Plan (Financial Year)**

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

N

**Figure 3**
**Underground Mine Plan**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.25 0.5 1
Kilometres

Scale: 1:40,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

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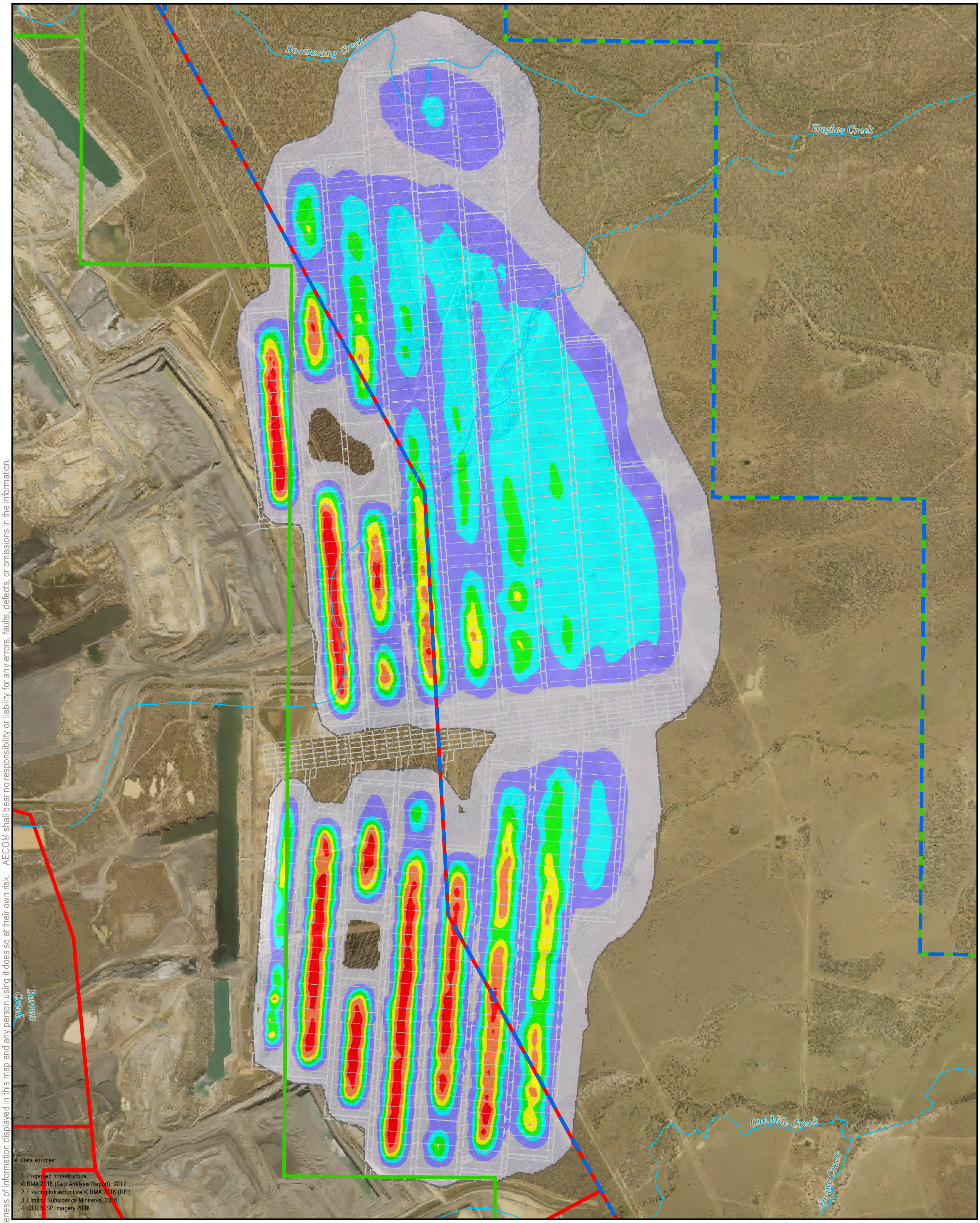
## 2.2 Model results

Modelled subsidence is depicted in Figure 4 with existing and predicted topography at the end of mining (Year 20) represented in Figure 5a and Figure 5b respectively. The modelled predicted subsidence impacts (Minserve, 2022) are summarised below:

- There is significantly more subsidence induced over the southern panels compared with the northern panels. This can be attributed to the thickness of Dysart seam overburden. Subsidence greater than 2.25 m correlates directly with overburden thickness equal to or less than 250 m.
- The fully extracted longwalls in southern panels are predicted to show maximum surface subsidence in the range 2.0 m to 3.4 m over all longwalls except where the overburden thickness exceeds 300 m limiting subsidence to 1.4 m.
- Over all longwalls in the northern panels the maximum surface subsidence ranges between 0.75 m and 2.25 m where the overburden thickness ranges between 250 m and 400 m.
- The extent of subsidence over longwalls as projected onto east-west cross-sections shows goafing of overburden strata extends through the Permian strata and up into the Tertiary sediments over longwalls where the overburden thickness is less than 250 m.
- For the mine plan presented in Figure 4, goafing is confined to Permian strata below Harrow Creek seam when the overburden thickness exceeds 250 m.
- Depending on the dimensions of the barrier pillar and thickness of overburden, subsidence is predicted to vary across their length up to 0.5 m.

Watercourses passing through potential subsidence areas include Hughes Creek, Plumtree Creek and Boomerang Creek.




**LEGEND**

- Underground Mine Layout
- Limit Of Subsidence
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Watercourses

Modelled Subsidence Contour

- < 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5 - 3.0m
- > 3.0m

N

**Figure 4**
**Subsidence Contours of the Project Site**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.275 0.55 1.1
Kilometres

Scale: 1:40,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

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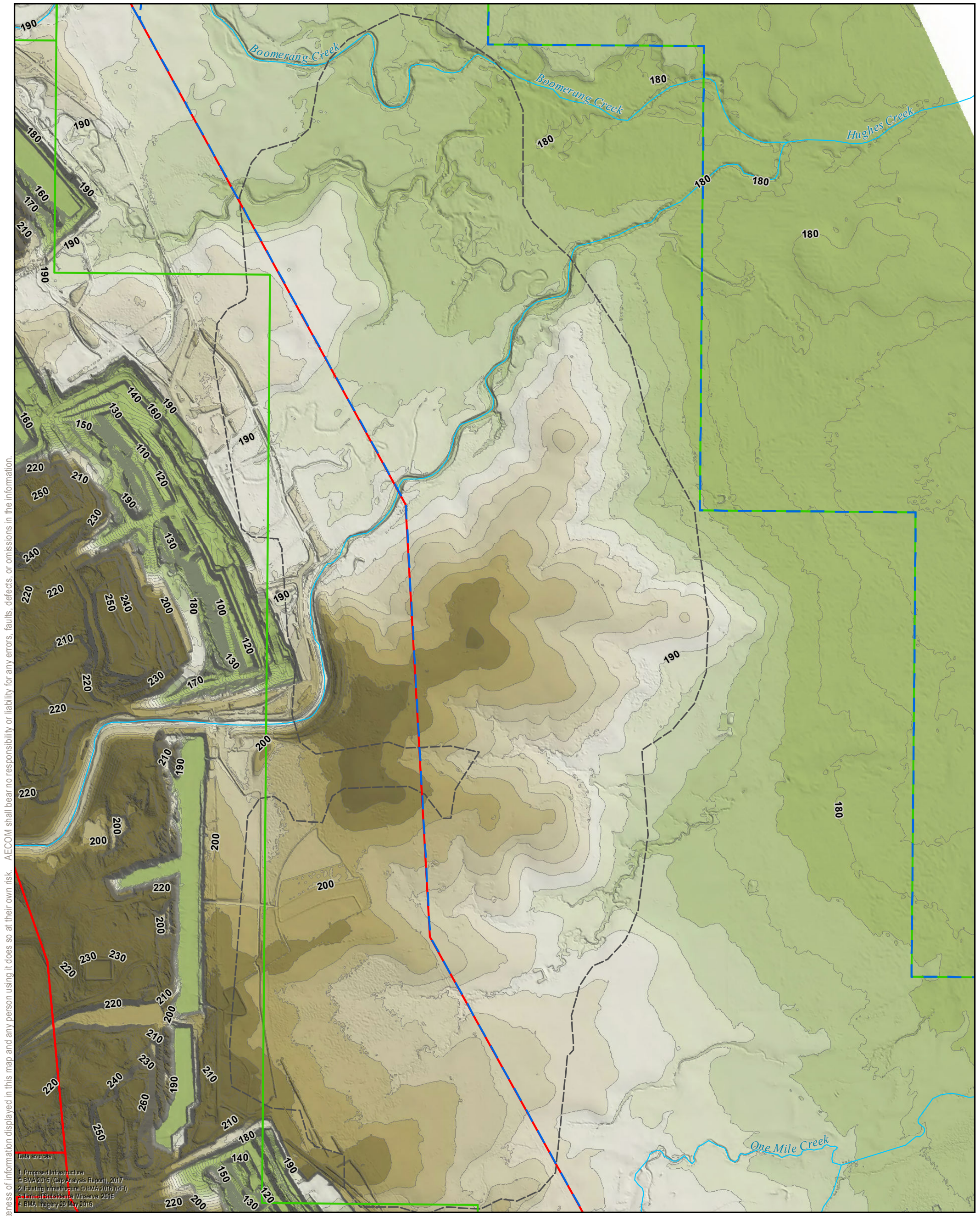


**LEGEND**

- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Limit Of Subsidence
- Watercourse
- Contour (2m)

N

**Figure 5a**
**Existing Topography**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.25 0.5 1
Kilometres

Scale: 1:39,000 (when printed at A4)
Projection: Map Grid of Australia - Zone 55 (GDA94)

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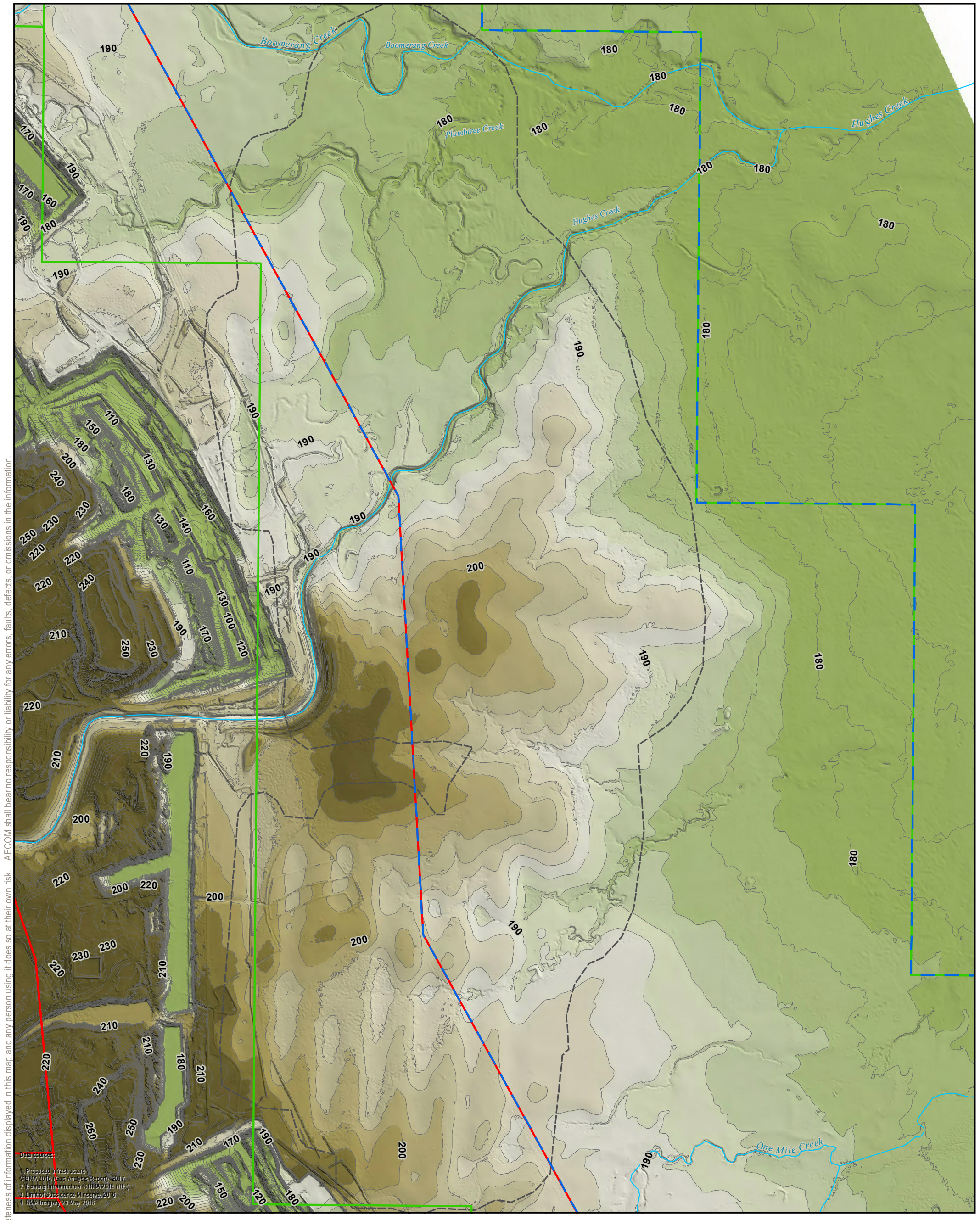


**LEGEND**

- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Limit Of Subsidence
- Watercourse
- Contour (2m)

N

**Figure 5b**
**Subsided Topography**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.25 0.5 1
Kilometres

Scale: 1:38,500 (when printed at A4)
Projection: Map Grid of Australia - Zone 55 (GDA94)

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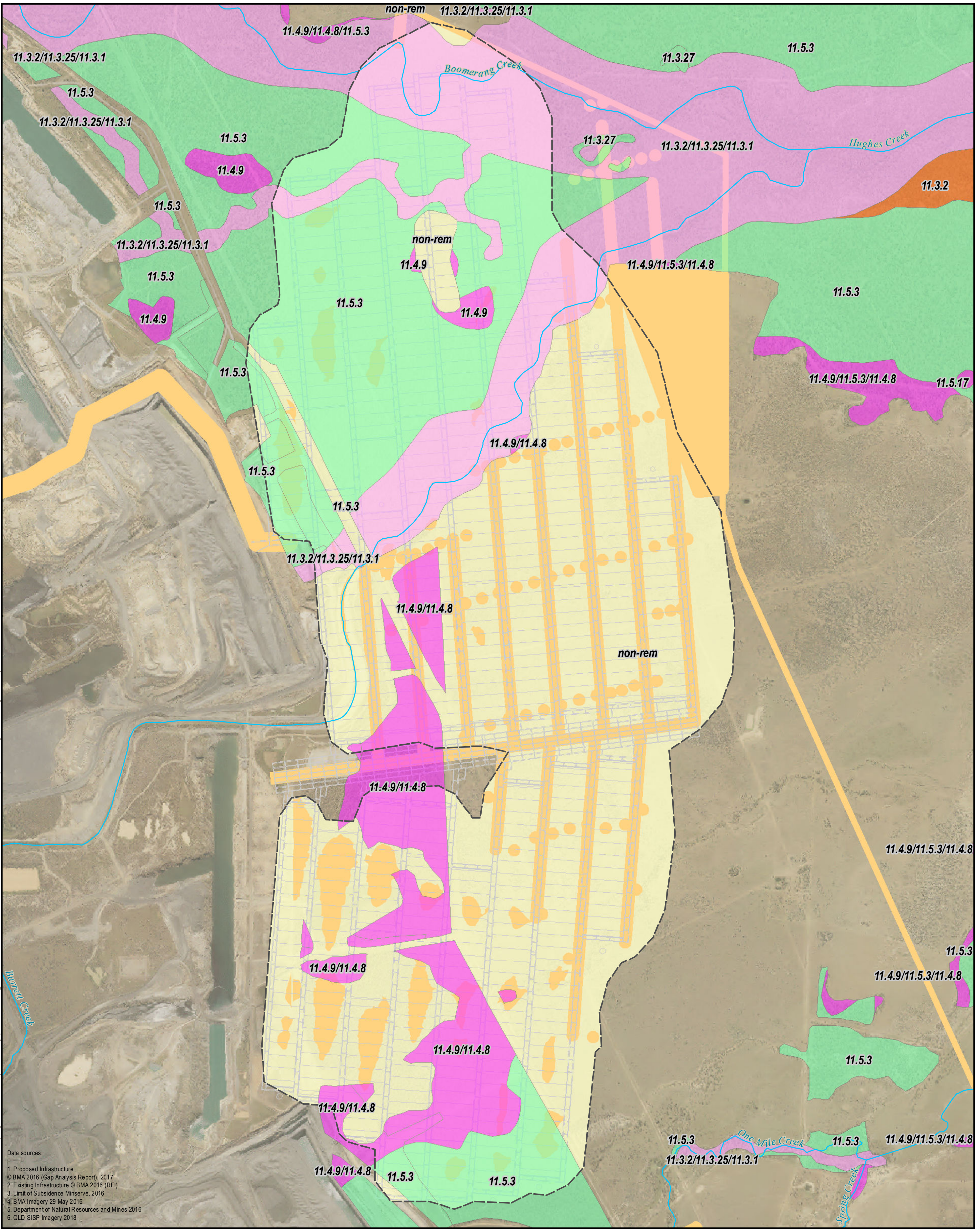
# 3.0 Potential impacts

## 3.1 Pre-mining

The topography and terrain of the Project site is predominantly flat with undulating channels associated with Hughes, Boomerang and Plumtree Creeks crossing the area of mining, as shown in Figure 6. The ecological values of the Project site are considered typical for the northern Bowen Basin with large areas of land historically cleared for grazing. The land use is predominantly grazing and mining activities. Typical of the ephemeral watercourses in the region, the waterways in the Project site flow intermittently through the year in response to rainfall and runoff, with extended periods of no flow.

Boomerang Creek, Hughes Creek and Plumtree Creek have been previously modified by open cut mining operations west of the Project site. Both Boomerang Creek and Hughes Creek flow through open cut MLs and contain diversion reaches, converging approximately 1 km downstream east of the Project Site. Plumtree Creek has no catchment upstream of the Project site as the headwaters were previously developed by the existing Saraji Mine.




**LEGEND**

Project Footprint - Direct Impact
Project Footprint - Indirect Impact
Underground Mine Layout
Limit Of Subsidence
Watercourse

**Regional Ecosystems v10.1 (DNRM)**

Engangered dominant
Engangered subdominant
Of Concern dominant
Least Concern

N

**Figure 6**
**Subsidence extent, watercourses and Regional ecosystems**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.25 0.5 1
Kilometres

Scale: 1:40,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

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## 3.2 Post-mining

Potential impacts of post-mining subsidence are discussed in the subsections listed below and summarised in Table 2:

- first order impacts – direct physical effects of subsidence
- second order impacts – geomorphic response to subsidence
- third order impacts – changes to flood regime, water quantity and quality
- fourth order impacts – impacts on flora and fauna.

Assessment of potential impacts within the maximum subsidence extent for the Project have been assessed within:

- Saraji East Mining Lease Project Technical Report: Hydrology, Hydraulics & Geomorphology (Alluvium, 2023), which includes a detailed, quantitative assessment of potential changes to the hydrologic, hydraulic and geomorphic behaviour of waterways interacting with the predicted area of subsidence (Boomerang, Plumtree and Hughes Creeks).
- Saraji East Mining Lease Project Technical Report: Terrestrial Ecology Technical Report (AECOM, 2024a) and Saraji East Mining Lease Project Technical Report: Aquatic Ecology Assessment (Hydrobiology, 2023), provides an assessment of flora and fauna responses to subsidence effects.
- Subsidence Ponding Modelling Technical Memorandum (Engeny, 2023), a detailed assessment of surface water impacts associated with subsidence ponding.

**Table 2 Potential subsidence impacts**

| Potential impact | Summary |
|---|---|
| **Landform** | • subsidence induced depressions over the longwall panels:<br>- over southern panels, maximum surface subsidence (at end of mining) range from 2.0 m to 3.4 m over all longwalls except LW208 where the overburden thickness exceeds 300 m limiting subsidence to 1.4 m<br>- over northern panels, maximum surface subsidence (at end of mining) range between 0.75 m and 2.25 m where the overburden thickness ranges between 250 m and 400 m<br>- over the mains is predicted at approximately 0.2 m.<br>• surface cracks have potential to form above the longwall abutment edge and on either side of the chain pillars:<br>- likely to be contained within the panel boundaries for shallow longwalls but may extend beyond these boundaries for the deeper panels<br>- over shallow longwalls (overburden thickness <300 m) extending to a depth of 30 m to 70 m; as a result, surface water flows over these longwalls could infiltrate the underground workings<br>- longwalls at depths greater than 300 m will induce shallow (<15 m) cracks on surface which may form tortuous connectivity with activated joints and bedding planes in the constrained zone. |
| **Surface water** | • morphological stability of watercourses<br>- the creation or alteration of riffle and pool sequences<br>- changes to flood behaviour<br>- incision processes<br>- stream widening<br>- lowering of creek bed and banks<br>- reduced flow due to increased porosity and permeability.<br>- change of water quality due to:<br>▪ reduction in dissolved oxygen<br>▪ increased salinity,<br>▪ increase iron oxides, manganese, and<br>▪ increase electrical conductivity (EC).<br>- decreased bank stability<br>- erosion and accretion until the bed profile is restored to a stable profile. |

| Potential impact | Summary |
|---|---|
| **Groundwater** | • seepage via surface cracking<br>- fractures in the Permian rock mass and overlying Tertiary sediments may provide pathways for drainage of groundwater resources. |
| **Ecology** | • surface cracking and localised changes in topography at the edges of the longwall panels<br>- where slope change is greatest a potential to affect the health of individual trees and shrubs.<br>• localised changes in topography within depressions above longwall panels<br>- potential to alter the soil composition and drainage characteristics, resulting in deep depressions becoming ephemerally wet. |
| **Infrastructure** | • existing infrastructure in the Project site<br>- will be relocated outside of the subsidence boundary as part of the Project. |

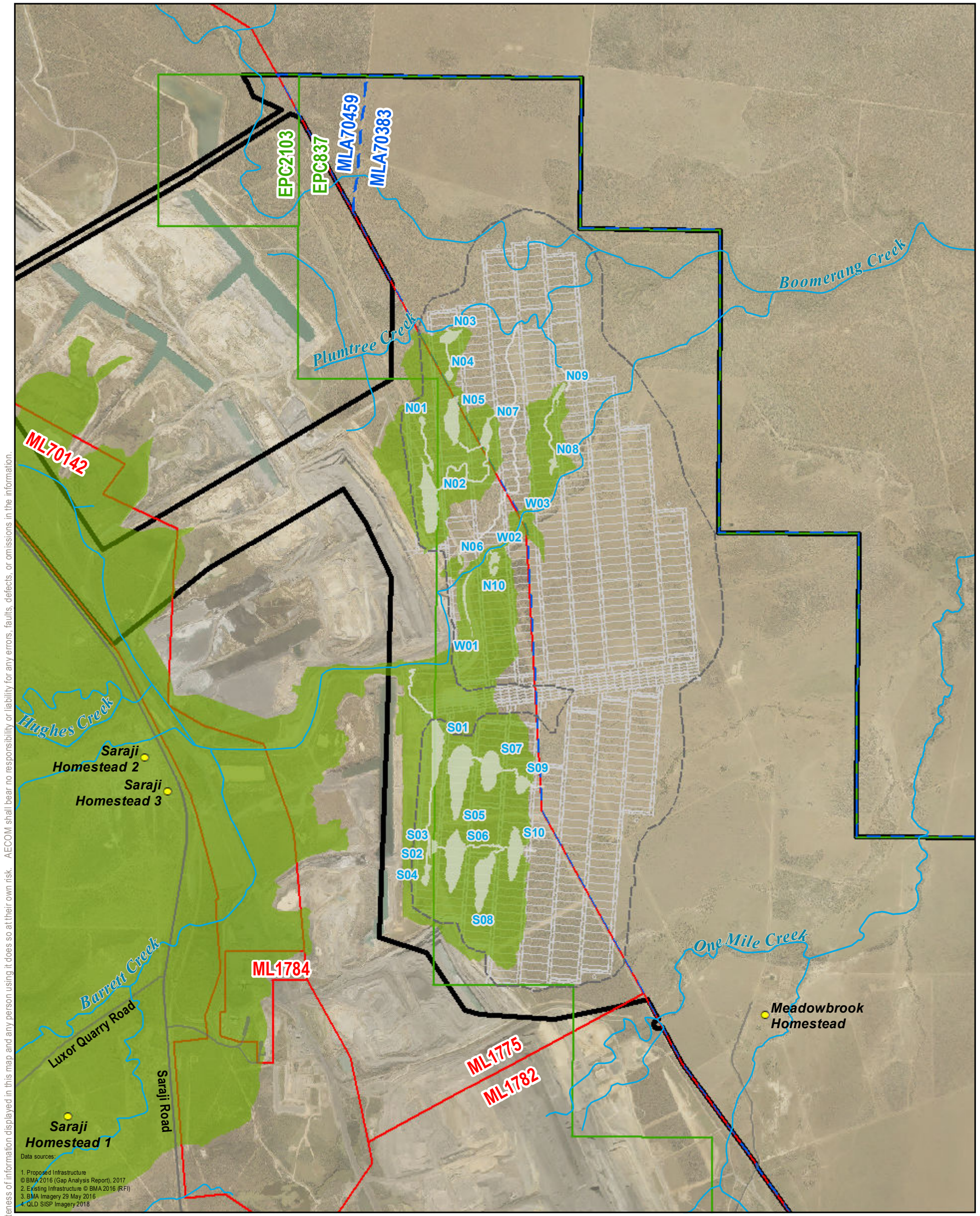
### 3.2.1 First order impacts

The main direct physical effect of subsidence is the change in landform and formation of ponding areas (i.e. subsided areas with potential to pond water) above each of the underground panels. Due to the gradual nature of the subsidence, the current land use activities namely, grazing, will continue during mining operations but out of direct operational areas where surface equipment is present or while any related subsidence occurs.

Conservative assessment to determine the maximum modelled extent of where potential future ponding areas have potential to develop within the Project area has been completed – refer to Subsidence Ponding Modelling Technical Memorandum (Engeny, 2023).

A total of 36 ponding areas were identified through modelling and mapped, including three ponding areas within Hughes Creek. Most of the ponding areas, but particularly the ponding areas to the south of Hughes Creek, are modelled to overflow into one another along existing drainage channels. Ultimately modelling showed the ponds will drain into Plumtree Creek, Hughes Creek and One Mile Creek. No ponding areas were identified within or in proximity to Boomerang Creek (on which the proposed mine water release point is located) or Plumtree Creek.

The ponding areas will develop gradually over the life-of-mine, in parallel with underground mining as topography changes are realised. Two thirds (2/3) of the ponding areas are predicted to develop during the first decade of mining (Figure 7a), while the remaining third (1/3) are predicted to develop during the second decade of mining (Figure 7b). This means, because the occurrence of ponding is progressive, any potential impacts or risks also arise progressively and will not occur all at once at the commencement of mining. The slow, progressive development of the ponds and potential impacts over the life-of-mine, aligns well and supports the need for a case-by-case adaptive management strategy during operations as outlined in Section 4.0).




**LEGEND**

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground Mine Layout
- Limit Of Subsidence
- Watercourse
- Public Road
- Homestead
- Overland Flow Paths Year 10
- Temporary Pond Areas Year 10
- Pond Catchment Areas Year 10

**Figure 7a**
**Potential Future Ponding Areas and their Catchments After 10 Years of Mining**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.35 0.7 1.4
Kilometres

Scale: 1:59,840 (when printed at A4)
Projection: Map Grid of Australia - Zone 55 (GDA94)

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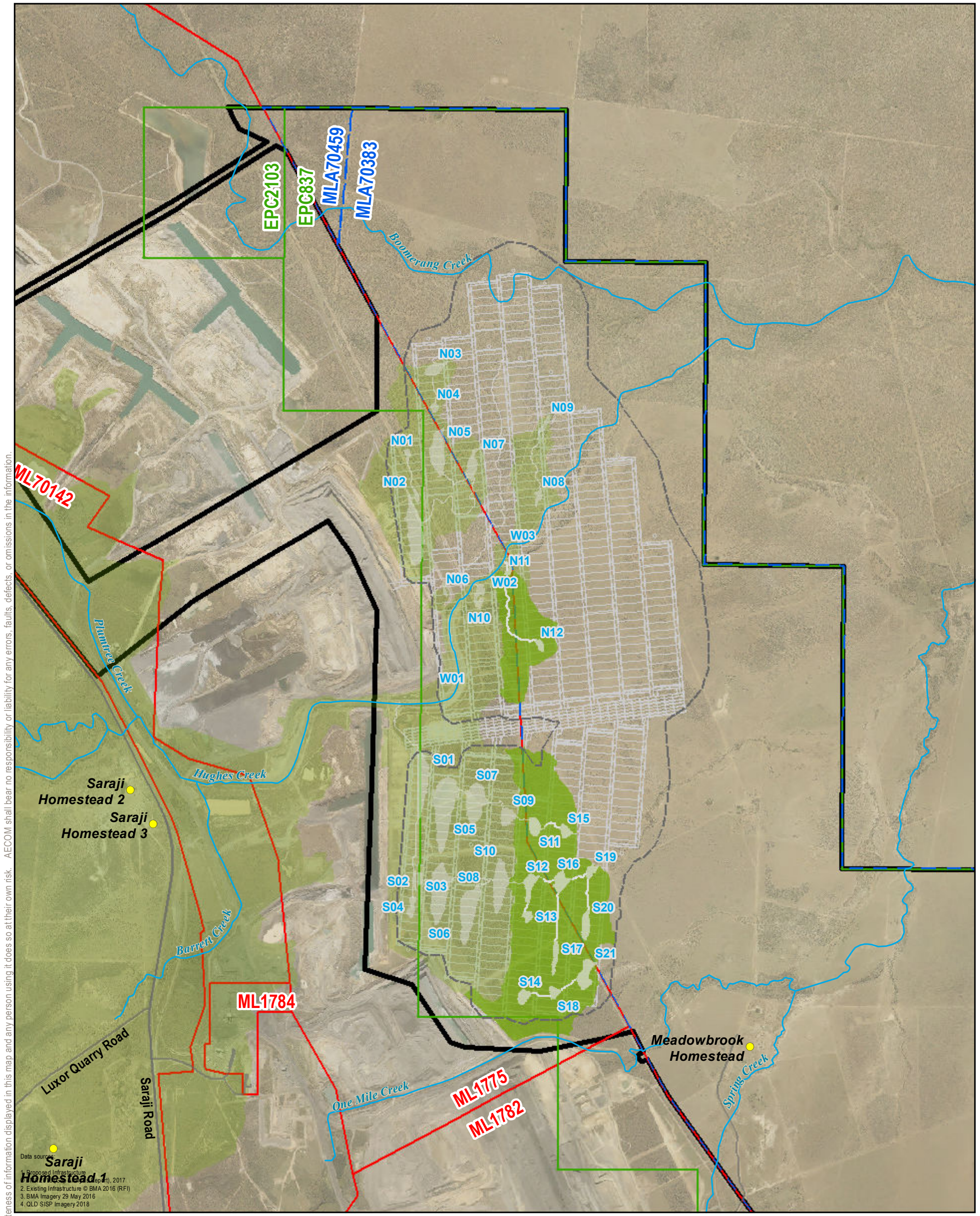


**LEGEND**

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground Mine Layout
- Limit Of Subsidence
- Watercourse
- Public Road
- Homestead
- Overland Flow Paths Year 10
- Temporary Pond Areas Year 10
- Pond Catchment Areas Year 10
- Overland Flow Paths Year 20
- Temporary Pond Areas Year 20
- Pond Catchment Areas Year 20

**Figure 7b**
**Potential Future Ponding Areas and their Catchments After 20 Years of Mining**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.35 0.7 1.4
Kilometres

Scale: 1:59,840 (when printed at A4)
Projection: Map Grid of Australia - Zone 55 (GDA94)

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The ponding areas range in depths, volumes and maximum surface areas, with a total maximum surface area of 139 hectares (ha). Without drainage intervention, the ponding areas are predicted to be up to 2.9 m deep (pond depth), with more and deeper ponding areas predicted to occur above the southern panels than the northern panels. Most of the ponding areas will form outside of watercourses, however a small number of ponding areas will form within Hughes Creek.

As shown in Table 3, the total maximum (predicted worst-case) surface area of the ponding areas represents only a small percentage of the subsidence impact area (5.5 per cent), and an even smaller percentage of the MLA 70383 area (1.5 per cent). The water balance modelling of the ponding areas predicted the ponding areas will not contain water all of the time, so (in the absence of any drainage intervention) the total surface area of water within the ponding areas at any point in time is likely to be significantly less than the 139 ha reported in Table 3. Furthermore, some of the ponding areas are predicted to occur in areas where water is already stored (e.g. where there are farm dams or dams associated with the existing Saraji Mine). Therefore, the creation of ponding areas in these areas of the Project Site will not represent a significant change from the current behaviour/use of the land.

**Table 3 Comparison of MLA 70393 area, subsidence impact area and predicted total ponding area**

| | MLA 70383 | Subsidence impact area | Predicted total ponding areas |
|---|---|---|---|
| **Maximum surface area** | 9,081 ha | 2,530 ha | 139 ha |
| **Maximum surface area of the ponding areas as a percentage of the MLA area / maximum subsidence impact area** | 1.5% | 5.5% | - |

Table note: predicted ponding area provided is in the absence of any drainage intervention.

### 3.2.2 Second order impacts

Hydraulic modelling of ponding indicates erosion and deepening processes in Hughes Creek will be ongoing until the ponding areas are filled with sediment and the creek bed is returned to a near constant grade.

The time it will take for the ponding areas to fill with sediment is dependent on the rate of underground mining (dictates how many ponding areas there are) relative to the magnitude and frequency of flow events (dictates how much and how often sediment is supplied to the ponding areas).

While the waterway ponding areas are filling with sediment, the downstream reaches of the creek will receive less sediment, increasing the potential for erosion and deepening to occur during flow events.

### 3.2.3 Third order impacts

Hydraulic modelling of ponding indicated that the ponding areas will not significantly change the flooding extent. The potential future ponding areas within the Project Site are predicted to have the ability to store water. Stored water within the ponding areas can have positive environmental outcomes including:

- General provision of habitat for flora and fauna. This outcome for subsidence ponding was supported by a recent study of the international, national, regional, environmental and socio-economic context of the Moranbah region and post-mining land uses (PMLU), given the Moranbah region landscape has lost many of its ephemeral wetlands (Côte et al, 2020).
- Alternative and/or additional water supply sources for stock or native flora and fauna. This outcome was supported in a recent study as a benefit of subsidence ponding for a grazing or wetland PMLU (Breslin et al, 2022).
- Potential to transform these areas into artificial wetlands (Xu et al, 2020). This could be especially beneficial for the Project site because, although there are mapped lacustrine and palustrine wetlands surrounding the Project site, there are currently relatively few mapped wetlands within the Project site itself. Therefore, the potential for the ponding areas to be transformed into artificial wetlands could be especially beneficial considering the current lack of wetland values. Wetlands also play a dynamic and crucial role in absorbing atmospheric carbon (DES, 2020), so increase in carbon sequestration and storage is another potential positive environmental outcome.

- Case studies of subsidence ponding providing refuge for rare species (Lewin et al, 2015) and provision of important complementary habitats for a wide array of waterbird species (Li et al, 2018).

Additionally, potential adverse impacts associated with stored water within the ponding areas such as, the evapo-concentration of salts and/or reduction in the volume of water available to downstream users. These impacts and their likelihood of occurring are discussed in Table 4 for the Project; overall, ponds must be assessed on a case-by-case basis (refer to Section 4.0).

**Table 4 Summary of ponding surface water impacts**

| Potential Impact | Summary |
|---|---|
| **Evapo-concentration of salts impacting water quality and values downstream** | • Overflows from the ponding areas are unlikely to impact on the water quality of downgradient waterways.<br>• The water balance model indicated that the ponding areas will repeatedly fill (at times, to the point of overflowing) and empty in response to rainfall, surface runoff and evaporation/evapotranspiration. However, regardless of volume, catchment area or maximum surface area, any water that was modelled as overflowing from the ponding areas was modelled to be relatively fresh (i.e. EC <1,500 microsiemens per centimeter (µS/cm)).<br>• The model also found that whilst evapo-concentration of salts in water stored within the ponding areas is likely to occur over the short-term (e.g. when there are consecutive dry years), generally, the ponding areas will receive sufficient inflows of rainfall and runoff, and overflow frequently enough, to avoid accumulation of salts over the long term (20+ years). |
| **Evapo-concentration of salts impacting water quality and stock water use on site** | • The model found the ponding areas will receive sufficient inflows of rainfall and runoff, and overflow frequently enough, to avoid accumulation of salts over the long term (20+ years). Evapo-concentration of salts in water stored within the ponding areas is likely to occur over the short-term (e.g. when there are consecutive dry years), however this is typical of any water body subject to evaporation (e.g. water holes, farm dams).<br>• The ponding areas most likely to experience high EC levels for prolonged periods of time are those that have relatively large volumes and small catchment areas relative to the maximum surface area of the ponding area, meaning they will hardly ever overflow (which is important for flushing salts out of the ponding areas and keeping the water fresh).<br>• However, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) provides guidance of the salinity levels that beef cattle can tolerate without experiencing any adverse effects. According to the ANZECC Guidelines, beef cattle can adapt to EC concentrations up to 7,462 µS/cm and can tolerate significantly higher concentrations (7,462 – 14,925 µS/cm) for short periods of time if introduced gradually. |
| **Reduction in the volume of water available to downstream users** | • The water balance model confirmed that the potential reduction in annual volume of surface water into Boomerang Creek, Hughes Creek and One Mile Creek, as a result of ponding, is unlikely to result in adverse impacts on downstream aquatic ecosystems and surface water users due to the small percentage reduction compared to the pre-mining scenario (~6% in the $50^{th}$ percentile) and the very small size of the Boomerang Creek, Hughes Creek and One Mile Creek catchments in comparison to the Isaac River Fitzroy Basin catchments (~1.1% and 0.2% respectively).<br>• Over time, as the ponding areas fill with sediment, the reduction in the total volume of water flowing through the ponded areas during rain events will decrease. |

### 3.2.4 Fourth order impacts

Subsidence has the potential to impact on native vegetation within the Project site, particularly taller trees where ground movements and surface cracking may affect root zones. Grasses (native and introduced) and smaller shrubs are expected to survive subsidence without intervention, except possibly grasses and smaller shrubs not tolerant of periodic inundation.

Without drainage, the ponding areas (on the land and within the creeks) are expected to change the nature of vegetation in these substantially depressed areas (i.e. species able to tolerate periodic inundation will remain, whereas vegetation that is intolerant of periodic inundation will die back and may be replaced with more tolerant vegetation). Over the long term, areas that do pond may cause some fauna habitat modification. Most fauna species with habitat in the Project area are generally resilient to disturbance and do not have highly specialised habitat requirements. Fauna will be able to adapt reasonably well to the habitat changes by utilising adjacent similar habitat.

The ponding areas within the creeks have the potential to restrict the movement of fish, especially during low flow conditions, potentially resulting in fish being stranded in subsided areas causing heat stress, depleted oxygen levels and mortality. The likelihood of this occurring has been assessed as low. These species have good dispersal capabilities, are tolerant of saline environmental conditions and are not sensitive to minor modifications to watercourses. In the absence of intervention, over time the ponding areas within the creeks would fill with sediment and the creek bed will be returned to a near constant grade. Restrictions to the movement of fish caused by ponding areas within the creeks will be temporary.

# 4.0 Subsidence management

## 4.1 Adaptive management approach

The timing and severity of potential subsidence impacts cannot be accurately predicted, therefore an adaptive and iterative approach towards identifying and managing potential subsidence impacts is required. The principles of adaptive management are as follows:

- **Assess the risk –** potential subsidence risks are identified and assessed in the risk assessment in Section 5.0 based on the likely impacts discussed in Section 3.0.
- **Identify mitigation measures –** mitigation measures are listed alongside potential subsidence risks in the risk assessment in Section 5.0.
- **Implement mitigation measures –** the Trigger Action Response Plan (TARP) in Section 5.0 stipulates when individual mitigation measures should be implemented.
- **Monitor key subsidence parameters –** the subsidence monitoring program in Section 6.0 outlines the pre- and post-subsidence monitoring methodologies, parameters and frequencies.
- **Evaluate effectiveness of implemented mitigation measures –** the evaluation and reporting on the effectiveness of implemented mitigation measures is outlined in Section 7.0.
- **Adjust plans and/or practices –** provisions for adjusting plans and/or practices are included in Section 7.0.

During detailed design, and progressively throughout the mining process, the subsidence modelling and SMP will be updated in response to revised predictions based on LiDAR-derived surface level data for the most recent subsided panels. The adaptive management approach accommodates for the wide range of environmental responses to subsidence that might be experienced (e.g. changes to vegetation community structure, changes to sediment transport regimes, etc.). This adaptive approach aligns with the proposed strategy during operations for routine subsidence monitoring and reporting (refer to Section 7.0). Any changes to the mining schedule during operations (which may mean that actual subsidence differs from the predicted subsidence shown in Figure 4) will also be reassessed and reflected using the adaptive management approach.

Management strategies for key subsidence risks and potential impacts are discussed below. These management strategies, in addition to other proposed controls, are reflected in the risk assessment and preliminary TARP in Section 5.0.

## 4.2 Drainage

The management strategy for ponding areas is for them to be assessed on a case-by-case basis (using the principles of adaptive management) during the operational phase of the Project to determine the likely and actual impacts (both beneficial and/or adverse) of each pond and to progressively select the most effective management strategy based on a comparison of environmental risk.

Subsidence ponding will be mitigated by the installation of minor remedial drainage earthworks to re-establish free drainage to the catchment. To achieve a free-draining landform, BMA will utilise existing overland flow paths to encourage drainage primarily by establishing earthen drains between ponded areas where appropriate, to the next closest waterway or natural flow path. With the installation of minor remedial drainage earthworks and the re-instatement of free drainage, there will be no significant residual ponding caused by mine subsidence and consequently no impact on vegetation due to ponding of water. Drainage channels will be located to avoid sensitive features and vegetation communities as far as practicable. Any design aims to utilise the topography of the landscape in defining where and what drainage mitigation is required.

Where evidence of ponding is detected, the installation of drainage channels will be considered to gravity-drain any water flowing into the ponding areas into nearby natural drainage channels, thereby re-establishing a free draining landform. Drainage serves to maintain water flows through the catchment and maintain connectivity for fish passage, sediment transport etc.

However, acknowledging that installing drainage channels may have other environmental considerations (or risks, e.g. vegetation clearing, exposure of dispersive soils and increased risk of erosion and sediment accretion) or benefit (e.g. provision of aquatic habitat values and stock water) each location must be considered individually as evidence of ponding develops.

As subsidence progresses, drainage opportunities will be reviewed by modelling subsidence of each longwall panel and subsequent interpretation of on-ground monitoring results. Where risk of retaining water outweighs risk of constructing drainage, drainage of ponding areas will be established installing appropriate measures (e.g. earthen drains, rock chutes) to facilitate water reaching the downstream catchment. The drainage strategy will consider the whole of the subsided area and apply key drainage channel design principles including:

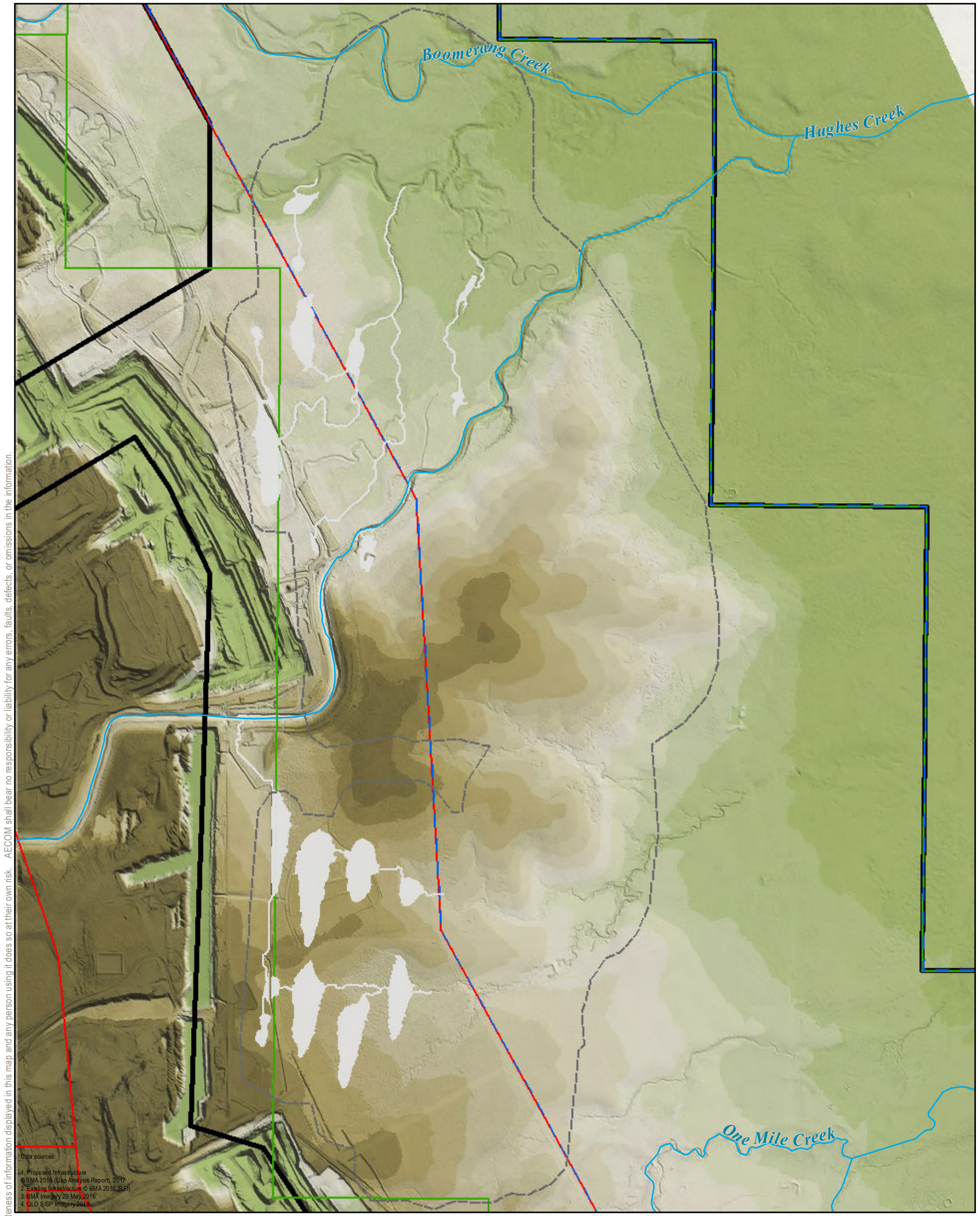
- drainage channels will be designed with gradients that protect against erosion and accretion
- where practical, drainage channels will use natural, non-dispersive materials and be reflective of natural drainage channels in the surrounding landscape
- regrading or use of rock armouring to limit head cut erosion may be required
- batter slopes will be designed to be stable and compatible with the slopes in the surrounding landscape
- where dispersive or sodic soils are identified, measures will be implemented to minimise erosion (e.g. amelioration and/or capping with non-dispersive soils).

The case-by-case assessments will be completed prior and/or immediately following subsidence that is detected as part of the routine monitoring. The adaptive approach also ensures the assessment benefits from the continued collection of monitoring data (e.g. water quality) and refinement of the water balance model over time. The water balance model of the ponding areas will be maintained and refined during the operational phase of the Project and used to assist with the case-by-case assessments. Any drainage channels installed will be permanent and incorporated into the PMLU.

Based on the conceptual water balance model of ponding areas (Engeny, 2023), natural overland flow paths were identified with potential to require minor remedial drainage works to facilitate gravity-flow of ponded water back into the catchment, as shown in Figure 8. While drainage works may not be required at all these locations, these drainage routes indicate a maximum anticipated length of drainage where works may occur as summarised in Table 5.

**Table 5 Summary of potential remedial drainage works**

| After Mining Year | Length of overland flow path with potential for remedial drainage works (m) | | Pond ID (Engeny, 2023) |
|---|---|---|---|
| **Year 1** | 3,880 | 390 | N01 |
| | | 1,600 | N02 |
| | | 920 | S01 |
| | | 710 | S02 |
| | | 120 | S03 |
| | | 140 | S04 |
| Year 2 | 960 | 270 | N03 |
| | | 80 | S05 |
| | | 610 | S06 |
| Year 5 | 5,850 | 350 | N04 |
| | | 390 | N05 |
| | | 3660 | N06 |
| | | 1400 | N07 |
| | | 50 | N10 |
| **Year 10** | 2,000 | 710 | N08 |
| | | 380 | N09 |
| | | 320 | S07 |
| | | 230 | S08 |
| | | 180 | S09 |
| | | 180 | S10 |
| Year 20 | 3,510 | 1170 | N12 |
| | | 140 | N11 |
| | | 250 | S14 |
| | | 230 | S18 |
| | | 620 | S17 |
| | | 410 | S20 |
| | | 100 | S13 |
| | | 150 | S12 |
| | | 210 | S11 |
| | | 230 | S16 |




**LEGEND**

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Limit Of Subsidence
- Watercourse
- Overland Flow Paths Year 10
- Temporary Pond Areas Year 10

**Figure 8a**

**Potential Future Ponding Areas and their Drainage After 10 Years of Mining**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.225 0.45 0.9
Kilometres

Scale: 1:39,000 (when printed at A4)

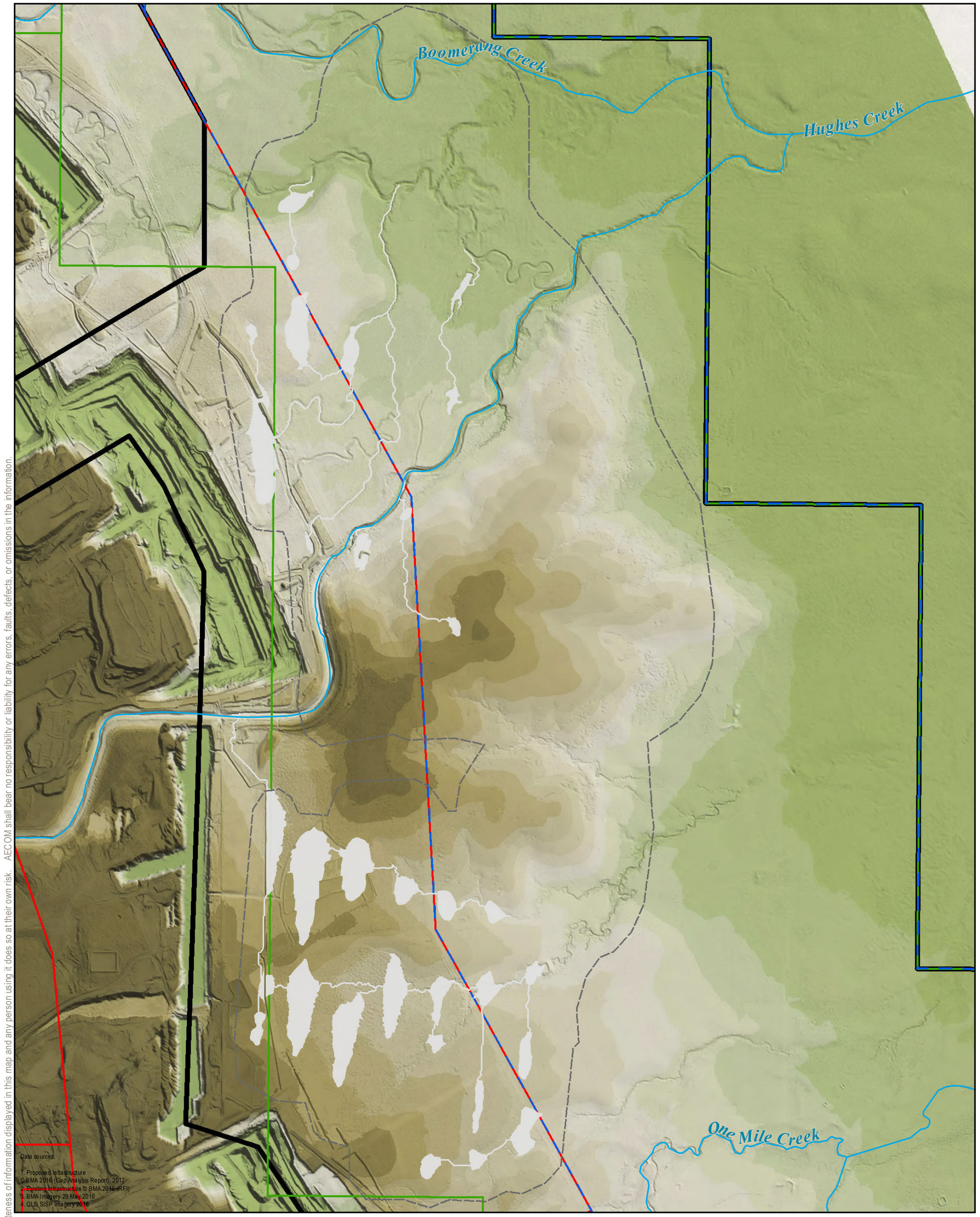
Projection: Map Grid of Australia - Zone 55 (GDA94)

BMA
BHP Mitsubishi Alliance

DATE: 21/05/2024 VERSION: 4



Filename: \\na.aecomnet.com\lfs\APAC\Brisbane-AUBNE1\Secure\Projects\605X\60507031\4. Tech Work Area\4.98 GIS 2021\02_MXDs\01 Environmental Impact Statement\K-1 Subsidence and Rehab Plans\Subsidence Management Plan\60507031_G415_v4b_A4P.mxd




**LEGEND**

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Limit Of Subsidence
- Watercourse
- Overland Flow PathsYear 20
- Temporary Pond Areas Year 20

**Figure 8b**

**Potential Future Ponding Areas and their Drainage After 20 Years of Mining**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.225 0.45 0.9
Kilometres

Scale: 1:39,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BMA
BHP Mitsubishi Alliance

DATE: 20/05/2024 VERSION: 5



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## 4.3 Fish salvage

Watercourses and drainage channels installed to establish free-draining landform will be monitored to identify instance of fish or aquatic fauna stranded in ponded water.

Relocation of fish from areas where stranding may occur, also known as fish salvage, can reduce risks associated with ponding areas should they occur. Should fish or aquatic fauna be identified, and/or stranded within the water in the subsidence areas, the fish and/or aquatic fauna should be removed by a suitably qualified person with the required permits and approvals under the Nature Conservation Act 1992 and in accordance with the State guidance on fish salvage (Business Queensland 2024). In addition to general fisheries permit, specific advice regarding site access, safety, location and timing may be required for large or complex fish salvage operations. If possible, the works should be done in the cooler months, when fish are less active and easier to handle.

Based on the Queensland Government fish salvage guidance online, fish will be captured using nets with a mesh size to minimise injury or death of the fish. After removing as many fish as possible, water level will be lowered by 25 per cent to further remove as many fish as possible. Where practical, sluicing fish is the preferred method for transferring captured fish, rather than using containers. Fish will be released into adjacent watercourses with equivalent water quality and temperatures (if notably different, exchange the water to equalise the temperature before releasing the fish). Noxious or invasive fish species removed as part of salvage will not be returned to the water.

## 4.4 Surface crack repairs

Subsidence cracks in the landscape will be managed according to erosion risk and likelihood of self-repair / healing. Mechanical ripping and disturbance within the landscape will be limited and targeted to those areas of high erosion risk and low probability of self-repair. The basis for this approach is to minimise the risk of secondary erosion issues developing from land and vegetation disturbance associated with ripping and ploughing.

The initial and least disruptive management strategy for any surface cracks that develop within the Project area is to allow them to naturally self-seal, which will be monitored as part of the routine subsidence monitoring inspections. Surface cracks that have not self-sealed within 12 months of subsidence will be repaired.

A high-level overview of the management strategy for surface cracks is as follows:

- Monitoring of the Project area, including waterways within the Project area, will occur during the operational phase of the Project to identify cracks as they develop and assess the type/amount of work needed to repair individual surface cracks. Note that cracks obscured by alluvial sediment within waterways may not be able to be identified visually, however any adverse environmental impacts that occur as a result of these cracks will be identified through other forms of monitoring (e.g. streamflow monitoring, groundwater monitoring, erosion monitoring, riparian vegetation monitoring, etc.).
- A case-by-case assessment will be conducted upon identifying smaller cracks (e.g. less than 50 mm) to determine if repair is required or if the safety and environmental risks associated with the smaller cracks are negligible.
- Repairing individual cracks may involve:
  - Ripping or ploughing the area around minor cracks using a small dozer, grader or tractor. The area will then be allowed to regenerate naturally through inherent seed resources, vegetation propagation from rootstock and recruitment from adjoining undisturbed areas.
  - Stripping the area around large cracks of topsoil, excavating and placing clean fill to stabilise the cracks and establish drainage, then respreading the area with topsoil. The area will be seeded if natural regeneration is considered unlikely to be successful.

Surface crack repair works will be staged over the life of the Project in line with the mining schedule. Therefore, the extent of disturbance caused by crack repair works will be relatively small at any one time.

Areas disturbed by surface crack repair works will be monitored to ensure that vegetation re-establishes and that it is consistent with the proposed PMLU and rehabilitation completion criteria in the RMP

(BMA, 2024) and the PRCP. Vegetation re-establishment is expected to be successful given that the extent of disturbance caused by crack repair works will be relatively small at any one time, and disturbed areas will be respread with topsoil and seeded (if required). Grasses and shrubs are expected to re-establish relatively quickly. However, canopy trees removed to facilitate crack repair works will take longer to re-establish.

## 4.5 Demonstrated success of proposed approach

The approach to subsidence management draws on the demonstrated success of measures applied at BMA's Broadmeadow Mine in the Bowen Basin, as well as industry best practice.

As part of Broadmeadow Mine operations, BMA has been monitoring subsidence impacts on the Isaac River diversion since 2007 and has continued in line with EA EPML00853413 and the Goonyella Riverside and Broadmeadow Mine Subsidence Management Plan (BMA 2017).

Qualitative assessment of subsidence effects is conducted in-line with the Goonyella Riverside and Broadmeadow Mine Subsidence Management Plan (BMA 2017) with supplementary assessment against the Index of Diversion Condition (IDC).

Where there has been a significant flow event in the watercourse, the sediment transfer and infilling of subsided panels has been observed. Minor earthworks and repairs have been required to control localised erosion within watercourses.

Only the larger channel of Isaac River has required timber pile fields to be installed and annually monitored with maintenance as required to control stream flow, provide bank erosion mitigation, and aid channel bed infilling as per the design intent; this control is not expected to be needed for the Project given the smaller watercourses at the Project Site.

At Broadmeadow, ponding of water in the panel depressions is monitored annually and is observed to occur primarily in wet years. Within the panel catchments outside of the watercourses, minor earthworks and repairs have been required to control localised erosion. Where panel ponding and overland flow is observed, progressive engineering management conveys water to existing natural overland flow paths through dedicated rock chutes to reduce recurring ponding.

Riverine vegetation impacted by subsidence at Broadmeadow has remained relatively stable since subsidence has occurred over the period of monitoring. The method employed to assess the ecological condition and function of the riparian vegetation was adapted from the "Rapid Appraisal of Riparian Condition" methodology (Jansen et al, 2005). The assessment aims to rapidly evaluate the condition of the riparian vegetation covering major aspects of the community in a concise and formatted structure. This adapted method assesses riparian condition based on point data collected from established IDC monitoring points located along the upstream, subsidence, diversion and downstream reaches.

Tension cracks in the panel areas are monitored to confirm natural infilling (self-sealing) and further vegetation clearing avoided. Self-sealing of many of the cracks on the Isaac River Terrace were observed. Some panel areas have been treated by selective surface ripping.

# 5.0 Risk assessment and preliminary TARP

A subsidence risk assessment and preliminary TARP demonstrating how potential subsidence impacts will be avoided, mitigated and monitored, have been prepared and are outlined in Table 9 and Table 10.

Based on preliminary evaluation of conditions with potential to trigger hazards causing harm or damage to environmental values, monitoring, mitigation and management actions and design responses are proposed in Table 10. The subsidence risk assessment and TARP should be read and implemented in conjunction with the risk assessment and TARP in the RMP (BMA, 2024).

A wide range of avoidance and mitigation measures are included in the risk assessment and TARP. Exactly which avoidance and mitigation measures will be implemented and where/when will be informed by the types of subsidence impacts identified during subsidence monitoring (refer to Section 6.0).

## 5.1 Risk assessment

Risks to environmental values were identified and their associated risk level determined. Mitigation measures and performance indicators were identified to address the potential impacts, and the residual risk level determined.

The risk assessment utilises the risk matrix shown in Table 6, based on evaluation of likelihood in Table 7 and consequence in Table 8. Residual risk of the potential impacts associated with subsidence following mitigation and management measures for the Project were within the acceptable range for the SMP being either 'low' or 'moderate' residual risk.

**Table 6 Risk Matrix**

| Risk | Low<br>L1 | Minor<br>L2 | Moderate<br>L3 | Major<br>L4 | Critical<br>L5 |
|---|---|---|---|---|---|
| **A – Almost Certain** | High | High | Extreme | Extreme | Extreme |
| **B – Likely** | Moderate | High | High | Extreme | Extreme |
| **C – Possible** | Low | Moderate | High | Extreme | Extreme |
| **D – Unlikely** | Low | Low | Moderate | High | Extreme |
| **E – Rare** | Low | Low | Moderate | High | High |

**Table 7 Likelihood assessment**

| Likelihood | Recurrence | Chance | Likelihood |
|---|---|---|---|
| **A – Almost Certain** | 1-2 years | 50% | 3 |
| **B – Likely** | 5 years | 20% | 1 |
| **C – Possible** | 10 years | 10% | 0.3 |
| **D – Unlikely** | 50 years | 2% | 0.1 |
| **E – Rare** | >50 years | 1% | 0.03 |
| Assume reasonable effectiveness of preventative control. Likelihood based on improved controls (if event has happened) | | | |

**Table 8 Consequence table**

| Severity level | Health and safety | Environment | Community | Reputation | Legal | Financial |
|---|---|---|---|---|---|---|
| **5** | 2-20 fatalities. Permanent impairment to >30% of body to more than 10 persons. | Serious or extensive impact(s) (<20 years) to land, biodiversity, ecosystem services, water resources or air. | Serious community health, safety or security impacts (>50 households) or human rights violations; extended disruption to people's lives (>200 households), extensive damage to >200 houses or structures, objects or places of national cultural significance. | Serious national and international media attention. General public and non-government organisation (NGO) adverse reaction with interest from regulators (<3 months). Structured campaigning from employees, NGOs or communities having a major impact on the business or asset reputation. | Impairment of legal right to develop or operate an asset. Investigation for alleged high profile regulatory breach or criminal breach. An alleged breach of compliance-related laws will be a high profile regulatory breach. Defendant to high profile civil proceeding. Public inquiry into BHP or an issue critical for the resources industry. | Between US$250 million and US$1 billion. |
| **4** | Single fatality. Permanent impairment >30% of body to one or more persons. | Major impact(s). (>5 years) to land, biodiversity, ecosystem services, water resources or air. | Serious community health, safety or security impacts (<50 households). Multiple allegations of human rights violations; extended disruption to people's lives (>50 households); extensive damage to >50 houses; moderate irreversible damage to structures, objects or places of national cultural significance. | Adverse national media attention.<br>General public and NGO adverse reaction with interest from regulators with no material outcome. Structured campaigning from employees, NGOs or communities having a major impact on the business or asset reputation. | Investigation for alleged major regulatory breach. Defendant to major civil proceeding. | Between US$25 million and US$250 million. |

| Severity level | Health and safety | Environment | Community | Reputation | Legal | Financial |
|---|---|---|---|---|---|---|
| **3** | Permanent impairment <30% of body to one or more persons. Restricted or lost days due to injury or illness. | Moderate impact(s) (<1 year) to land, biodiversity, ecosystem services, water resources or air. | Moderate community health, safety or security impacts (<50 households). Single allegation of human rights violation; moderate disruption to people's lives (<50 households); extensive damage to <50 houses; moderate reversible damage to structures, objects or places of national cultural significance. | Attention from regional media or heightened concern by local community. Criticism by community, NGOs or activists. Asset reputation adversely affected. | Legal issue resolvable with moderate consequences. Losing or not getting the legal right to develop or operate (or approval for) a non-core activity. | Between US$2.5 million and US$25 million. |
| **2** | Objective but reversible impairment. Medical treatment injury or illness. | Minor impacts (<3 months) to land, biodiversity, ecosystem services, water resources or air. | Minor community health, safety or security impacts (<10 households) or human rights infringements; inconvenience to livelihoods <6 months; moderate damage to <50 houses or community infrastructure; minor, reversible damage to structures, objects or places of regional cultural significance. | Adverse local public or media attention and complaints. Heightened scrutiny from regulator. Asset reputation is adversely affected with a small number of people. | Legal issue resolvable with minor consequences. | Between US$250,000 and US$2.5 million. |
| **1** | Low level short term subjective symptoms or inconvenience. No medical treatment. | Low level impacts to land, biodiversity, ecosystem services, water resources or air. | Single low level community health, safety or security impact; low level inconvenience <2 weeks; minor, reversible low level disturbance or minor damage to a single house or structure, object or place of regional cultural significance. | Public concern restricted to local complaints. Low level interest from local media or regulator. | Low level legal issue resolvable without legal proceedings or substantive third party engagement. | <US$250,000. |

**Table 9 Subsidence risk assessment**

| Domain | Risk | Typical Adaptive Control measures | Severity level | Likelihood | Residual risk after measure |
|---|---|---|---|---|---|
| **Subsided riverine areas** | **Landform** – surface cracking and erosion. | **Mitigate –** crack repair works (refer Section 4.4), erosion repair works. | Level 2 | B - Likely | Moderate |
| | **Surface water** – changes to the sediment transport regime (i.e. increased sediment accretion within the ponding areas and reduction in the amount of sediment being transported to the downstream reaches until the ponding areas are filled with sediment) causing stream widening and erosion downstream. | **Avoid –** installation of pile fields upstream of the waterway ponding areas, instream grading, channel re-profiling.<br>In many cases it is advised to control this risk post-subsidence to ensure controls are suitably selected and designed for post-subsidence topography. | Level 2 | C – Possible | Moderate |
| | | **Mitigate –** bed and bank stabilisation works such as rock armouring, reprofiling and revegetation (which will reduce the susceptibility of the waterway to erosion) and pile fields (which will promote sediment accretion in the waterway).<br>In addition, infilling of ponds after flow events will continue to mitigate the risk of this occurring. There may be instances where no mitigating controls are required due to rapid occurrence of infilling. | | | |
| | **Surface water** – reduction in the total volume of water flowing through the Project area due to it being stored within the ponding areas. | **Mitigate** – establish drainage to reduce volume of water stored within ponding areas (where risk of retaining water outweighs risk of constructing drainage). Consider whole of subsided area in developing drainage strategy, aiming to minimise the number of structures and drains across the landscape. Rock chutes can be used to drain panels into Hughes Creek as required, and consider erosion risks associated with new drainage. Post subsidence drainage review and modelling of each longwall panel routinely. | Level 2 | D – Unlikely | Low |
| | **Surface water** – watercourse bank | **Mitigate –** embankment armouring, installation of contour banks, installation of erosion control matting in high energy areas, riparian vegetation planting | Level 2 | C – Possible | Moderate |

| Domain | Risk | Typical Adaptive Control measures | Severity level | Likelihood | Residual risk after measure |
|---|---|---|---|---|---|
| | erosion, incision, stream widening. | In many cases it is advised to control this risk post-subsidence to ensure controls are suitably selected and designed for post-subsidence topography. | | | |
| | | **Mitigate –** installation of drop structures at head cut erosion features, revegetation, repair and stabilise head cut erosion and inflow locations for waterways (i.e rock chutes) amelioration or capping of dispersive material bank stabilisation (e.g. rock armour or revegetation) | | | |
| | **Ecology** – aquatic fauna stranded in the subsidence ponding areas limiting fish passage (most likely during low flow conditions). | **Mitigate –** fish passage must be considered in the design of any drainage feature between the subsidence panels and the Hughes Creek. Should fish become identified, and/or stranded within the water in the subsidence areas not connected to Hughes Creek the fish and/or aquatic fauna should be removed by a suitably qualified person with the required permits and approvals under the *Nature Conservation Act 1992* and in accordance with the Queensland Government guidance for fish salvage. | Level 2 | D – Unlikely | Low |
| | | **Mitigate** – the instream waterway ponding will naturally infill with sediment after flow events over time to mitigate this risk. | | | |
| | **Groundwater** – groundwater drawdown or seepage from surface. | **Mitigate –** monitor change in groundwater level, flows and quality to identify decline. Undertake investigation and where appropriate mitigate by 'make good' arrangements or other measures proposed in a TARP. | Level 2 | C - Possible | Moderate |
| | **Groundwater** – loss of groundwater flows to surface cracking resulting in a drop in water levels in the coal seam aquifer. | **Monitor** – Groundwater monitoring completed in accordance with the EA. | Level 1 | C - Possible | Low |

| Domain | Risk | Typical Adaptive Control measures | Severity level | Likelihood | Residual risk after measure |
|---|---|---|---|---|---|
| **Subsided non-riverine areas** | **Landform** – surface cracking and erosion. | **Avoid** – vegetation planting to support stabilising landforms around depressions.<br>**Mitigate –** crack repair works (Refer to Section 4.4) | Level 2 | B - Likely | Moderate |
| | **Surface water** – salts in water stored in the ponding areas evapo-concentrated to the point that it is not suitable for stock water, or will reduce downstream water quality if it overflows, or will contribute to land degradation if it seeps into the surrounding soils. | **Avoid** – consider detailed design of underground mine plan to manage subsidence and ponding impacts by reconfiguring longwall panels in the northern end of the mine towards Boomerang Creek.<br>**Mitigate** – create temporary stock exclusion zones around ponding areas that are not suitable for stock watering, pumping of water into internal mine water system as required.<br>Based on the case-by-case assessments, installation of permanent drainage channels to divert water around/through the ponding areas only if assessed as necessary and if determined to incur less impacts than the free-draining scenario (refer to Section 4.2) | Level 2 | C – Possible | Moderate |
| | **Ecology** – vegetation dieback or changes to vegetation community structure if existing vegetation cannot tolerate inundation caused by ponding or subsidence impacts. | **Avoid** – routine monitoring to support early detection of change in vegetation communities to identify unforeseen decline of vegetation condition or extent of canopy dieback for investigation and mitigation by other measures proposed in a TARP.<br>**Mitigate** – revegetate the ponding areas with species that are tolerant of inundation (if this does not occur naturally).<br>Based on the case-by-case assessments, installation of permanent drainage channels to divert water around/through the ponding areas only if assessed as necessary and if determined to incur less impacts than the free-draining scenario (Refer to Section 4.2). | Level 3 | C – Possible | High |
| | **Surface water** – reduction in the total volume of water available to downstream users | No control measures are proposed due to the low severity level of this potential impact. | Level 1 | C – Possible | Low |

| Domain | Risk | Typical Adaptive Control measures | Severity level | Likelihood | Residual risk after measure |
|---|---|---|---|---|---|
| | | As discussed in Section 3.2.3, the reduction is unlikely to result in adverse impacts due to the very small percentage of the Isaac River and Fitzroy River catchments that the Project area makes up. | | | |
| | **Surface water** – reduction in the total volume of water flowing through the Project area during flood events | No control measures are proposed due to the low severity level of this potential impact.<br>As discussed in Section 3.2.3 the reduction is unlikely to result in adverse impacts due to the very small percentage of the Isaac River and Fitzroy River catchments that the Project area makes up. | Level 1 | C – Possible | Low |
| **Surface infrastructure** | **Infrastructure** – damage to infrastructure if subsidence is beneath / near infrastructure | **Avoid** – avoid locating infrastructure at end of panel sequence and / or remove infrastructure from the predicted subsidence impact area at end of panel sequence. | Level 3 | D - Unlikely | Moderate |
| | | **Mitigate –** repair and/or relocate damaged infrastructure. | | | |

## 5.2 Preliminary TARP

Based on preliminary evaluation of conditions with potential to trigger hazards causing harm or damage to environmental values, monitoring, mitigation and management actions and design responses are proposed in Table 10.

**Table 10 Preliminary TARP**

| Level | Normal | Level 1 Response | Level 2 Response | Level 3 Response |
|---|---|---|---|---|
| **Trigger condition** | No observed impact from watercourse subsidence. | Low level impacts:<br>• minor bank erosion caused by<br>• subsidence<br>• vegetation dieback<br>• identified risk of erosion to pillar zones. | Isolated high level impact:<br>• isolated severe erosion of banks and drainage lines<br>• damage to pile field zone<br>• damage to drop structure. | Significant impact to river:<br>• mass bank failure<br>• stream migration<br>• complete failure of pile field/s<br>• complete failure of drop structure. |
| **Actions** | | Monitoring and preventive works | Isolated significant works | Large scale remediation activities |
| **Monitoring** | • annual subsidence monitoring<br>• piezometric monitoring. | • pre-wet season inspections<br>• post-wet flow event inspections. | • targeted Registered Professional Engineer of Queensland (RPEQ) inspection. | • full RPEQ inspection and review. |
| **Pre-subsidence management** | General land management activities:<br>• weed control<br>• pest management<br>• grazing management<br>• fire management. | • pillar zone pile field installation<br>• targeted bank vegetation establishment. | | |
| **Post-subsidence remediation** (indicative dependent on issue) | None required. | • minor drainage works including rock chutes<br>• minor bank remediation works including ripping<br>• targeted vegetation establishment. | • installation of additional piles and rock armouring at pillar zones<br>• review and implement (where appropriate) RPEQ recommendations<br>• targeted creek bed reshaping works and rock armouring of lower banks<br>• repair of drop structure<br>• large scale vegetation establishment campaign. | Major remediation works:<br>• review design/redesign and construction of grade control structures and pile field installations<br>• large scale whole of panel bank battering works, subsoil treatment, top soiling and vegetation establishment. |

| Level | Normal | Level 1 Response | Level 2 Response | Level 3 Response |
|---|---|---|---|---|
| **Management Strategy review** | None required. | Annual review and improvement of remediation designs and strategy. | Update of adaptive management strategy and review of SMP Risk Assessment. | Full review of SMP. |

# 6.0 Monitoring

This section of the Plan provides an overview of the monitoring requirements pre- and post-mining to ensure relevant data is captured for:

- landform
- surface water
- groundwater
- ecology
- infrastructure.

Monitoring will occur pre- and routinely post-subsidence (i.e. after signs of subsidence are recorded) of individual panels to ensure subsidence impacts are promptly identified and appropriate control measures applied (per the subsidence risk assessment and TARP). The monitoring strategies are therefore structured into 'pre' and 'post' subsidence for each aspect.

Monitoring will be conducted in accordance with the relevant Australian Standards and EA conditions. All laboratory analyses will be undertaken by a National Associated of Testing Authorities (NATA) accredited laboratory.

## 6.1 Monitoring methodologies, parameters and frequencies

The following sections outline the pre- and post-subsidence monitoring methodologies, parameters and frequencies. The monitoring parameters have been chosen to align with the:

- Potential subsidence impacts in the risk assessment.
  - The risks with high residual risk ratings in the risk assessment are changes to the existing sediment transport regime, waterway bank erosion, surface cracking, and vegetation dieback or changes to existing vegetation community structures. The landform, surface water and ecology monitoring programs include parameters that will assist in the early identification of these risks (e.g. waterway channel slope, scouring and erosion on waterway bed/banks, presence of cracks and erosion features in aerial LiDAR, riparian vegetation condition). These parameters are considered 'priority monitoring parameters' as they are essential to the early identification of risks with high residual risk ratings.
- Baseline studies completed as part of the Project EIS.
  - Wherever possible, the monitoring parameters are the same as the monitoring parameters from the baseline studies completed as part of the Project EIS. This is so the monitoring data from the baseline studies can be used as 'initial conditions' against which changes due to subsidence can be measured. This is particularly the case for the ecology and groundwater monitoring programs, where the baseline monitoring data will be carried forward and used as the pre-subsidence monitoring data. Data may be required to be contemporised depending on the timing of commencement of mining activities.
- Rehabilitation completion criteria in the RMP (BMA, 2024).
  - The subsidence monitoring program contains parameters to be used to support the achievement of the rehabilitation completion criteria in the RMP. For example:
    - A large component of the post-subsidence ecology monitoring program is targeted at trees which aligns with the rehabilitation objective of 'native bushland characteristics' for the woodland habitat PMLU.
    - A large component of the post-subsidence surface water monitoring program is targeted at geomorphic and riparian vegetation condition of waterways within the Project area which aligns with the rehabilitation objective of 'rehabilitation is erosionally stable' and 'riparian vegetation' for the watercourse PMLU.

The subsidence monitoring methodologies, parameters and frequencies will be refined upon issue of the EA for the Project, prior to any subsidence. Detailed aerial survey will take place and establishment of such as baseline this will assist in intensively mapping subsidence crack formation and ripping success. This will map subsidence cracking with greater precision and provide a more accurate forecast. The monitoring methodologies will also be refined and aligned as part of the development of the future PRCP.

### 6.1.1 Landform

**Pre-subsidence**

The pre-subsidence monitoring will involve geomorphologic condition/status surveys including photographic recording of waterway reach condition. Monitoring will extend along the length of the potentially affected drainages.

Monitoring will include documenting:

- soils
- sediment accretion
- watercourse stability
- land use related to water availability or quality (e.g. cattle grazing).

The pre-subsidence surveys will be completed prior to subsidence to provide an indication of the natural processes at work and will continue periodically during mining. The pre-subsidence survey will involve aerial LiDAR to establish the pre-subsidence landform conditions.

**Post-subsidence**

Monitoring of drainage and stability will be conducted through the operational (as subsidence develops) and closure phases of the Project. Aerial LiDAR will be flown routinely to validate subsidence model predictions and identify risk areas. The extent of subsidence cracks at a given point in time can be mapped by reviewing the successive aerial photography images. A follow up ground survey is required to determine the exact width, depth and density of the aperture or hole. If cracking is particularly significant, some earth works may be required to import material for crack filling and stabilisation.

Once the landform is stable (predicted to be approximately two years from panel mining completion) rehabilitation activities can occur, typically through ripping, fertiliser and seeding in accordance with the RMP.

### 6.1.2 Surface water

**Pre-subsidence**

Pre-subsidence LiDAR surveys will characterise the baseline channel geometry of specific reaches of Boomerang Creek and Hughes Creek.

Baseline characterisation has been completed for these waterways, however it is important to continue to assess pre-subsidence condition over time to ensure changes due to existing land uses are documented and understood (e.g. erosion caused by grazing). The pre-subsidence surveys will include a detailed pre-mining photographic record of the creeks as they pass over the subsided area.

Photographic monitoring will be:

- conducted on the channel reach for 1 km upstream of the subsidence area
- conducted downstream of the subsided areas to the extent of the ML
- should include a geomorphologic assessment of the entire reach
- include photos of:
  - each proposed pillar intersection
  - the intersection of proposed centre of each longwall panel

- any additional points of likely impact identified during the recording process.

The monitoring locations will be identified and mapped in GIS and will form the basis of a consistent monitoring program.

The assessment may segment the watercourses in distinct reaches (e.g. lower, middle and upper reaches). Monitoring reference site locations will be established and will capture any catchment-wide variations.

The pre-subsidence surveys will quantify:

- pool/riffle sequences
- bed controls
- entry points of other watercourses and localised tributaries
- existing bed and bank scour points
- any infrastructure located within the watercourse
- channel slope
- channel description including flow channel dimensions
- riparian vegetation conditions
- flow
- peak release flow
- erosion points
- overflow and flood points
- floodplain description
- catchment size
- catchment relief.

Rainfall and flow event monitoring in each creek will be carried out prior to the subsidence of any panel to establish pre-subsidence flow conditions.

**Post-subsidence**

The post-subsidence monitoring program aims to quantify any changes to the pre-subsidence conditions and will look for changes in accretion and increased erosion and riparian vegetation die back. The program will comprise:

- erosion or accretion processes that have occurred as a result of subsidence
- migration of head cut erosion within watercourses and tributaries
- localised changes to stream bed slope
- localised widening of channels
- destabilisation of stream bed and banks including fracturing and incision
- localised changes to bank heights
- active searches for cracks within a 50 m radius of monitoring locations
- monitoring of ponding including water quality for select ponds (ec, water level at minimum)
- water quality monitoring (ph, ec and turbidity at minimum).

Post-subsidence monitoring will occur at locations outlined in the pre-subsidence monitoring (based on modelled predictions of cracking areas) as well as any other areas that were affected by subsidence that were not monitored as a part of the pre-subsidence survey. Remote sensing technology may be utilised where applicable to assist with selection of monitoring locations and/or assessment of post-subsidence conditions. Monitoring will occur at least annually. Monitoring data will be reviewed as necessary to determine when stability has been established and rehabilitation activities can commence in accordance with the RMP.

The water balance model used to assess the behaviour of the predicted ponding will also be updated as part of the ongoing surface water monitoring program and refined overtime using water quality and water level data collected through the surface water monitoring program to inform the case-by-case assessments of the ponds.

### 6.1.3 Groundwater

#### Pre-subsidence

The Groundwater Technical Impact Assessment (AECOM, 2024) completed as part of the Project EIS provides pre-subsidence data for this Project.

The study describes the pre-subsidence groundwater conditions prior to any panel being subsided and provides data for comparison (as well as predicting groundwater impacts of the Project). This forms a key part of understanding the changes occurring in the groundwater and will enable appropriate measures to mitigate environmental harm to be implemented.

Groundwater monitoring reference site locations will be established as part of a Project-wide groundwater monitoring program. This will capture any broad-scale variations in groundwater levels and chemistry which may not be associated with subsidence impacts.

Trigger levels and compliance limits against which monitoring during operations and closure can be compared have been determined in the Groundwater Technical Impact Assessment (AECOM, 2024). All groundwater monitoring data (level and chemistry) will be entered into a BMA environmental monitoring database to enable a regular assessment of impacts.

Monitoring will be presented in the Groundwater Management and Monitoring Plan.

#### Post-subsidence

The groundwater monitoring program will be developed in accordance with DES guidance and the Project EA.

Monitoring will include:

- water level measurement
- water quality field conductivity measurement
- chemical analysis of water samples (to meet the requirements of the EA as a minimum)
- groundwater level rebound
- groundwater flow patterns.

Groundwater monitoring will occur in accordance with EA conditions.

### 6.1.4 Ecology

**Pre-subsidence**

The ecological studies completed for the Project's EIS provides pre-subsidence data for the Project.

Vegetation surveys were conducted to determine the ecological values of the Project area. These studies mapped seven regional ecosystems (REs) with potential to be impacted by subsidence. The pre-subsidence study of vegetation collected data including:

- height class and life form of the dominant species within each strata (emergent, canopy, subcanopy and understory)
- foliage projective cover of each strata
- coarse woody debris
- groundcover composition
- native and introduced plant species richness
- native and introduced plant species relative abundance
- tree health parameters.

The pre-subsidence study for fauna collected data through:

- habitat assessment
- intensive trapping
- microhabitat search program to characterise the faunal usage of the ground layer.

This information provides pre-subsidence conditions for comparison against potential changes to vegetation community structure due to subsidence. The information will also inform species selection and seeding density for rehabilitation activities (to be documented in the RMP).

**Post-subsidence**

On an annual basis (or as required by EA Condition), ground cover (%), pasture biomass (kg/ha) and remnant vegetation will be monitored to assess adequacy of mitigation measures compared to previous annual inspections. Remnant vegetation within subsidence impacted areas will be assessed for foliar discolouration, partial defoliation, increased pathogenic attack, or tree death as signs of vegetation impacts from subsidence. Tree deaths and regrowth in areas affected by subsidence will be monitored to assess appropriate management responses (for example revegetation or ponding drainage installation). Any revegetation activities will be aligned with the RMP and proposed PRCP.

### 6.1.5 Infrastructure

**Pre-subsidence**

Existing infrastructure in the Project site will be relocated outside of the subsidence boundary as part of the Project. The construction accommodation village will be decommissioned prior to subsidence occurring. Predicted extent of subsidence and Project infrastructure are shown in Figure 9.

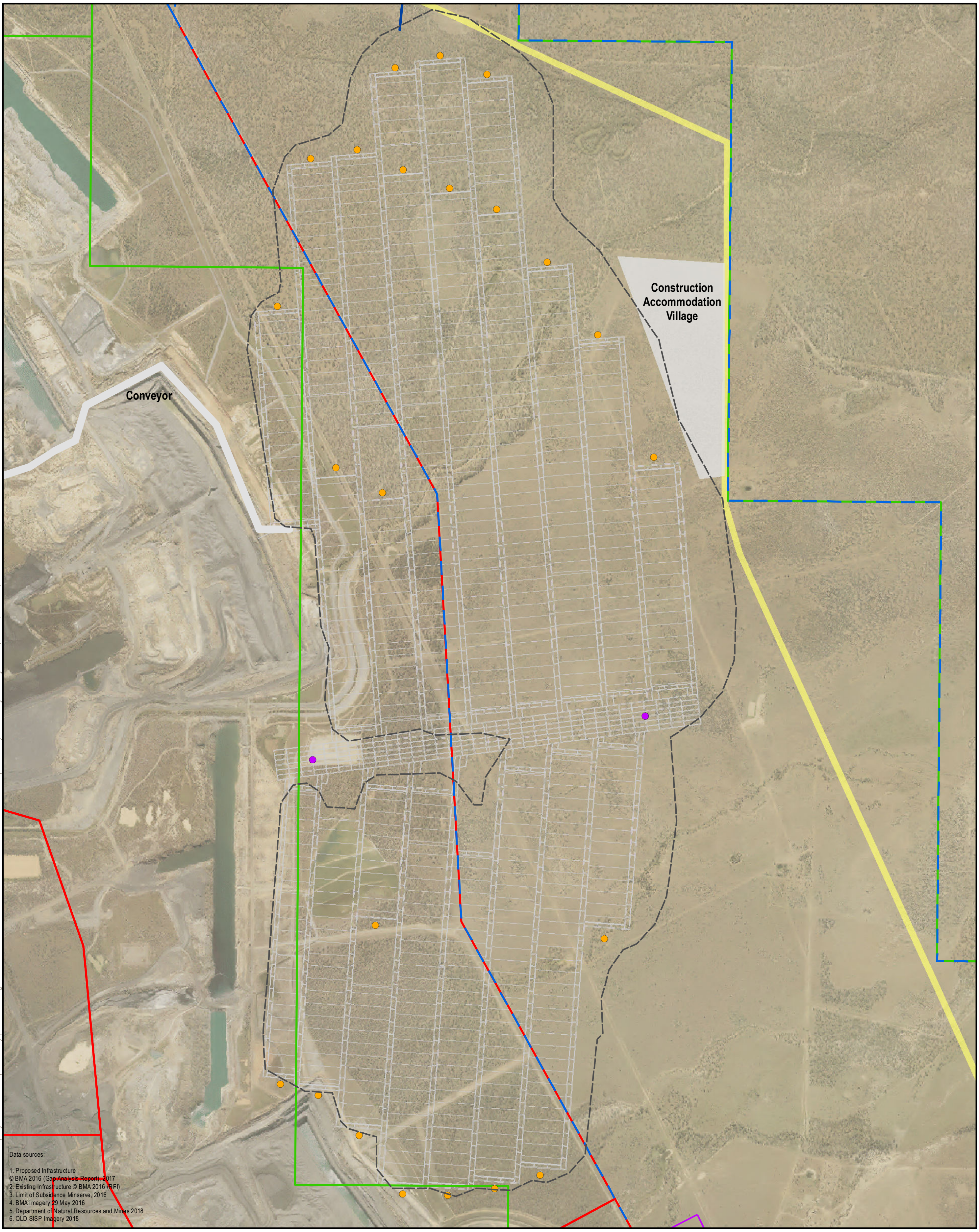
BMA will engage with the relevant landholders to determine the extent of removal of infrastructure. Agreement with landholders would be developed to retain infrastructure. Any infrastructure not removed prior to subsidence will be monitored photographically. As pipeline and electricity transmission infrastructure will be removed, the only remaining infrastructure that may require monitoring for impacts will include:

- watercourse crossing related infrastructure
- dams and collection ponds
- bores
- windmills

- fencing
- tracks and roads
- livestock infrastructure.

**Post-subsidence**

Any infrastructure within the predicted subsidence area to be retained will be photographically monitored for impacts. Monitoring will be undertaken at least annually until subsidence is stabilised and rehabilitation management can occur in accordance with the Rehabilitation Management Plan (BMA, 2024).




**LEGEND**

- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground Mine Layout
- Limit Of Subsidence
- Surface Infrastructure
- Transport and Infrastructure Corridor
- 66kV Powerline
- Pipeline
- Flare
- Vent

N

**Figure 9**
**Expected Subsidence and Project Infrastructure**

**Subsidence Management Plan**
**Saraji East Mining Lease Project**

0 0.225 0.45 0.9
Kilometres

Scale: 1:40,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP Mitsubishi Alliance

DATE: 6/06/2024 VERSION: 2

## 6.2 Monitoring summary

**Table 11 Monitoring summary**

| Subsidence impact | Methodology | Parameters | Frequency |
|---|---|---|---|
| **Landform** | • geomorphological condition/status surveys<br>• photographic recording of reach condition<br>• aerial LiDAR and/or remote sensing technology where applicable | • assessment of impacts on:<br>- soils<br>- sediment accretion<br>- watercourse stability<br>- land use related to water availability or quality (e.g. cattle grazing). | • prior to subsidence<br>• aerial LiDAR to be flown annually<br>• annually or in accordance with EA conditions during the operational and closure phases of the Project. |
| **Surface Water** | • pre-subsidence surveys of the channel geometry of specific reaches of Boomerang, Plumtree Creek and Hughes Creek and their surroundings<br>• photographic recording of the creeks as they pass over the subsided area, as well as for 1 km upstream of the subsidence area and downstream of the subsided areas to the extent of the ML | • pre-subsidence:<br>- pool/riffle sequences<br>- bed controls<br>- entry points of other watercourses and localised tributaries<br>- existing bed and bank scour points<br>- any infrastructure located within the watercourse<br>- channel slope<br>- channel description including flow channel dimensions<br>- riparian vegetation conditions<br>- flow<br>- peak release flow<br>- erosion points<br>- overflow and flood points<br>- floodplain description<br>- catchment size<br>- catchment relief<br>• post-subsidence:<br>- erosion or accretion processes that have occurred as a result of subsidence<br>- migration of head cut erosion within watercourses and tributaries<br>- localised changes to stream bed slope | • prior to subsidence<br>• annually or in accordance with EA conditions during the operational and closure phases of the Project. |

| Subsidence impact | Methodology | Parameters | Frequency |
|---|---|---|---|
| | | - localised widening of channels<br>- destabilisation of stream bed and banks including fracturing and incision<br>- localised changes to bank heights<br>- active searches for cracks within a 50 m radius of monitoring locations<br>- monitoring of select ponding water quality (EC) and level<br>- monitoring of surface water quality (pH, EC and turbidity). | |
| **Groundwater** | • Groundwater Technical Impact Assessment completed as part of the Project EIS (AECOM, 2024)<br>• groundwater monitoring program. | • water level measurement<br>• water quality field conductivity measurement<br>• chemical analysis of water samples to be taken annually<br>• groundwater level rebound<br>• groundwater flow patterns. | • prior to subsidence (already completed as part of the Project EIS)<br>• annually or in accordance with EA conditions during the operational and closure phases of the Project. |
| **Ecology** | • ecological studies completed as part of the Project EIS (AECOM, 2024a)<br>• remnant vegetation and regrowth monitoring. | • pre-subsidence:<br>- flora:<br>▪ height class and life form of the dominant species within each strata (emergent, canopy, subcanopy, understory)<br>▪ foliage projective cover<br>▪ coarse woody debris<br>▪ groundcover composition<br>▪ native and introduced plant species richness<br>▪ native and introduced plant species relative abundance<br>▪ tree health parameters.<br>- fauna:<br>▪ intensive trapping<br>▪ microhabitat search program.<br>• post-subsidence:<br>- remnant vegetation: | • prior to subsidence (already completed as part of the Project EIS)<br>• annually or in accordance with EA conditions during operational and closure phases of the Project. |

| Subsidence impact | Methodology | Parameters | Frequency |
|---|---|---|---|
| | | ▪ discoloration<br>▪ partial defoliation<br>▪ increased pathogenic attach<br>▪ tree death.<br>- regrowth. | |
| **Infrastructure** | • photographic recording | • photographic records of:<br>- pipelines<br>- electricity transmission infrastructure<br>- watercourse related infrastructure<br>- dams and collection ponds<br>- bores<br>- windmills | • prior to subsidence<br>• annually or in accordance with EA conditions during operational and closure phases of the Project. |

## 6.3 Monitoring program reviews

The subsidence monitoring program will be reviewed every two years or after any major change to operations (e.g. change of mine plan). The following aspects of the subsidence monitoring program will be reviewed:

- monitoring locations
- monitoring parameters
- monitoring methodologies
- monitoring frequencies.

The purpose of reviews of the subsidence monitoring program will be to ensure that the program:

- is capable of identifying subsidence impacts in a timely manner, and assessing the effectiveness of any measures implemented to mitigate/manage subsidence impacts
- is collecting data that can support implementation of the RMP and proposed PRCP
- ensures that the landform performance after mining provides a safe and stable landform
- meets all of the relevant legislative requirements and EA conditions.

# 7.0 Reporting

Internal reporting will be carried out to maximise the efficiency of BMA's subsidence management activities and external reporting will aim to meet the requirements of the EA. Internal reporting will be completed following each monitoring event, with external reporting delivered annually.

The monitoring data will be compiled in the Project's monitoring database for internal reporting purposes. Monitoring will be carried out in stages designed to mirror the development of the mining areas and predicted development of subsidence.

Key aspects of the annual reporting will include:

- description of mining activities undertaken in the preceding 12 months
- description of subsidence management activities undertaken in the 12 months since the last report
- presentation of pre-subsidence monitoring data results from the preceding 12 months
- assessment of monitoring data to identify and document changes
- assessment of monitoring data to identify current and future risk locations, mitigation or management actions and their priority (immediate, mid-term, long term)
- mitigation measures and associated action plan to be implemented in the subsequent 12 months to achieve completion criteria.

As a minimum, the report will address:

- watercourse condition and geomorphic processes
- the condition of remnant vegetation in riparian zones and in areas of subsidence
- examination of pillar zones in watercourses
- location and extent of any ponding
- groundwater impacts.

The report will also include updates on:

- the integrity and effectiveness of the pre-subsidence mitigation measures implemented
- the current state of the groundwater and surface water resources
- vegetation health assessment
- any impacts on these features
- a commitment to implement the findings of the report.

Reporting will occur annually.

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