WARATAH COAL

Surface Water Impact Assessment of Longwall Mining Subsidence

Galilee Coal Project SEIS Technical Report

November 2012

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www.engeny.com.au
P: 07 3221 7174 I F: 07 3236 2399
Lvl 11, 344 Queen st Brisbane QLD 4000 I PO Box 10183 Brisbane QLD 4000

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Rev 0	Client Issue	Andrew Vitale	Scott Moffett	George Khouri	16/11/2012
Signatures					

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1. INTRODUCTION

Waratah Coal has commissioned Engeny Water Management (Engeny) to undertake an assessment of the potential surface water impacts of ground subsidence associated with the proposed underground longwall mining activities of the Galilee Coal Project. This report identifies potential changes to flooding and stream flow characteristics to support the submission of the SEIS and address stakeholder concerns raised during the EIS public consultation process.

1.1 Background

Waratah Coal proposes to mine 1.4 billion tonnes of raw coal from existing tenements (EPC 1040 and EPC1079) approximately 30 km north of Alpha within the Galilee Basin. The annual Run-of-Mine (ROM) coal production will be 56 Mtpa to produce 40 Mtpa of saleable export steaming coal to international markets. The processed coal will be transported by a new standard gauge railway system approximately 453 km in length that runs from the project site to the existing Port of Abbot Point.

The mine will consist of a combination of open cut mining and longwall underground mining. Open cut operations will involve dragline, and truck and shovel operations producing 20 Mtpa ROM with coal delivered to the coal handling and preparation plant (CHPP) via heavy vehicle access roads. The underground mines will operate via continuous mines and longwall shearers producing 36 Mtpa ROM delivered to the CHPP via a conveyor system. The CHPP will be capable of producing 40 Mtpa of product coal which will be stockpiled adjacent to the CHPP for train load out. Co-disposal of coarse rejects and tailings will be utilised with disposal in the tailings dam and box cut spoil areas. Additional mine infrastructure will include:

- Mine infrastructure area consisting of administration buildings, parking areas workshop and lay down areas.
- Vehicle equipment and wash down facilities.
- A 2,000 person accommodation village and wastewater treatment plant.
- Light vehicle access roads and site access roads.
- Raw water storage for CHPP vacuum pumps, potable water supply and fire fighting.
- Environmental control dams, sediment dams, pit dewatering and underground dewatering dams and flood protection levees.
- Rail loop and train load out facilities.

The proposed mine infrastructure layout is shown in Figure A1 in Appendix A.

1.2 Scope of Works

Waratah Coal has prepared a Longwall Mining Subsidence Report (Waratah Coal, 2012) that quantifies subsidence for the mine area, estimates the impacts to surface topography and stratigraphy, estimates potential impacts to aquifers and The Great Artesian Basin, and describes remedial works required to finalise a completed rehabilitation landform.

The following report describes additional investigations undertaken by Engeny to quantify the potential impacts associated with the proposed underground longwall mining operations on surface water resources. The scope of work included in this investigation included:

- Description of existing ground topography within the proposed longwall mining area.
- Description of predicted post-subsidence ground topography within the proposed longwall mining area.
- Identification of waterways that will be impacted by subsidence.
- Flood modelling to identify potential changes to flooding characteristics within the proposed longwall mining area.
- Stream flow modelling to identify potential changes to stream flow volumes within the waterways flowing through the mine lease area. In addition to subsidence impacts, this modelling also included assessment of changes to stream flows associated with the proposed open cut mining activities and water management dams.
- Identification of management strategies to minimise the impacts of longwall mine subsidence on flooding and stream flow volumes.

1.3 Study Area

The project tenements (EPC 1040 and part of EPC 1079) cover an approximate area of 1,059 km² and are located in the south-east parts of the Barcaldine Regional Council local authority in Queensland. The contributing catchment covers an approximate area of 1,316 km² and typically drains in a north-easterly direction through the tenement areas. The majority of the tenement areas drain to the Belyando and Burdekin River basin via Lagoon Creek while the western edge of EPC 1079 drains to the Cooper Creek basin. The existing land uses within the project catchments are primarily defined as rural production with some conservation and natural environments.

The climate zone in the vicinity of the mine site is classified as Grassland (BOM, 2012), which has hot dry summers and warm dry winters. The average annual rainfall in region is 532 mm (Alpha Post Office) with a clearly defined wet and dry season. The tenement areas have both minor and major creeks flowing through them. These include Pebbly, Camp, Tallarenha, Beta, Saltbush, Malcolm and Lagoon Creeks. These creeks systems are typically ephemeral and can experience expansive flooding after sustained periods of heavy rain.

2. PROPOSED LONGWALL MINING OPERATIONS

2.1 Underground Mines

The coal mining project will consist of two open cut operations producing 20 Mtpa and four underground longwall operations producing 36 Mtpa.

The underground mines will produce coal using the retreating longwall mining system. Use of the longwall mining method will enable an annual production rate of approximately 9 Mtpa ROM from each mining area. Four mining areas are planned to be mined in parallel, with three mines operating in the D-Seam (Mines 1 to 3), and one mine (Mine 4) operating in the B-Seam. The B-Seam mine (Mine 4) will overlie the two northern D-Seam mines (Mines 1 and 2). The two northern D-Seam mines (Mines 1 and 2) will underlie the western open cut mine pits.

The proposed longwall mining blocks are approximately 470 m wide, rib-to-rib. Once extracted, and including the development roadways on either side of the longwall block, the total extracted width is 480 m. The lengths of the longwall blocks will be up to 7,000 m. Between each longwall extraction block, a coal pillar will be left with a total initial width of 20 m rib-to-rib in shallow areas and 50 m where depth of cover exceeds 400 m. The length between cut-throughs is 95 m rib-to-rib.

The project consists of 104 longwall panels all orientated in an east-west direction covering a total area of approximately 300 km^2. Initially, one longwall will commence operations with the remaining three underground mines to come on line successively over six month intervals. The underground mining operations are scheduled to occur over a period of 30 years. The proposed longwall mining schedules for the B-Seam and D-Seam mines are shown in Figure 2.1 and Figure 2.2 respectively. For the D-Seam mines, the eastern longwall panels will be mined before the western panels.

Figure A1 (Appendix A) shows the location of the longwall panels within the mine.

2.2 Surface Subsidence

As the coal seam is removed by the longwall mining method, a void, the thickness of the longwall seam remains. The roof immediately above collapses into this void. The overlying strata (or “overburden”) then sags down onto the collapsed material, resulting in an elongated subsidence “trough” developing on the surface. The cavity which has been left behind the retreating longwall face and is subsequently filled with the collapsed overlying strata is commonly called the “goaf”.

The extent of the overlying strata collapse and the associated shearing and cracking of the strata, depends upon the strata geology, the longwall block width, the seam height extracted, and the depth of cover.

Figure 2.1 **B-Seam mine (Mine 4) development**

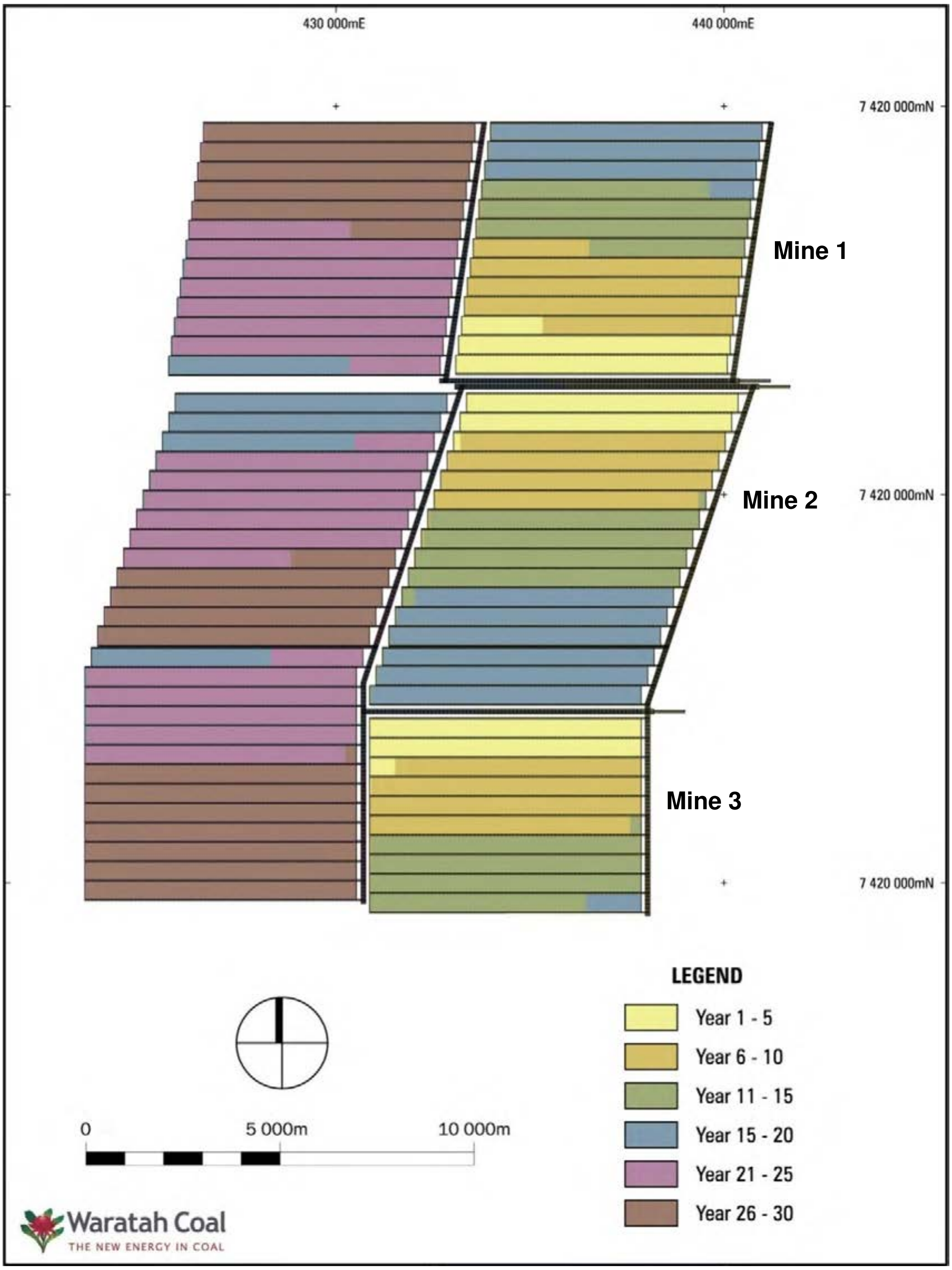

Figure 2.2 D-Seam mine (Mines 1 to 3) development

When the ground strata moves downwards sufficiently that the vertical movement reaches the surface, the surface of the land may also move downwards over the extracted mining areas. This movement is called "subsidence".

The amount of subsidence observed at the surface is dependent on a large range of factors including:

- Coal seam isopachs.
- Coal seam depth of cover.
- Rock types and properties.
- Stiffness and bulking characteristics of collapsed strata.
- Width and length of longwall blocks.

3. TOPOGRAPHY AND DRAINAGE

3.1 Waterways in Mine Lease Area

Figure A2 (Appendix A) shows the ground topography and waterways in the vicinity of the proposed mine.

The majority of the mine lease area drains to the Belyando/Burdekin River basin via Lagoon Creek which flows in a generally northerly direction through the northern parts of the mine lease area. Lagoon Creek continues to flow in a northerly direction downstream of the proposed mine lease before joining with Sandy Creek which discharges into the Belyando River 70 km downstream of the mine lease. Downstream of the Sandy Creek confluence, the Belyando River flows in a generally northerly direction before discharging into the Suttor River approximately 200 km downstream. The Suttor River continues in a northerly direction before discharging into the Burdekin River within the reservoir area of Lake Dalrymple (Burdekin Falls Dam).

Waterways that feed Lagoon Creek within the mine lease area include Tallarenha Creek, Beta Creek, Malcolm Creek, Pebbly Creek and Saltbush Creek. Spring Creek rises in the north-western corner of the mine lease area and discharges across the northern mine lease boundary before flowing into Lagoon Creek to the north of the mine.

The south-western corner of the mine lease area drains to the Cooper Creek basin via an un-named tributary of Jordan Creek which flows in a generally westerly direction into Jordan Creek approximately 10 km to the west of the proposed mine lease.

3.2 Proposed Waterway Diversions

The following waterways are proposed to be diverted around open cut mine workings or other mine infrastructure as part of the Galilee Coal Project:

- Lagoon Creek: Diversion of waterway to the east of its' existing alignment around the Mine Industrial Area. The diversion will discharge back into the existing channel of Lagoon Creek a short distance upstream of the northern mine lease boundary.
- Saltbush Creek: Will flow into the Lagoon Creek Diversion.
- Malcolm Creek: Diversion of waterway into the infrastructure corridor between the northern and southern open cut mine pits.

These proposed diversions are shown in Figure A1 in Appendix A.

The Alpha Coal Project is another new coal mine that is proposed to be developed immediately to the north of the Galilee Coal Mine. This project will involve the diversion of another section of Lagoon Creek, while Spring Creek is proposed to be diverted around the southern end of the open cut mine pit, adjacent to the common lease boundary with the Galilee Coal Project.

3.3 Existing Topography in Proposed Longwall Mining Area

An Airborne Laser Scanning (ALS) survey of the north-eastern corner of the proposed mine lease area was undertaken by Fugro Spatial Solutions in 2010, but only extends over a small part of the longwall mining area.

Existing ground topography in the proposed longwall mining area is shown in Figure A3 (Appendix A). The ground topography is based on a 90 m digital elevation model (DEM) produced from the Shuttle Radar Topography Mission (SRTM) flown by NASA in 2000. The vertical accuracy of this data is relatively poor (approximately 7 to 8 m accuracy). The data has been smoothed to remove undulations caused by differing vegetation heights and density.

The land slopes generally to the east towards the Lagoon Creek floodplain. The ground surface is relatively flat, with some steeper topography in the north-western corner of the longwall mining area at the headwaters of the Spring, Malcolm and Pebbly Creek catchments.

Waterways that flow through the proposed longwall mining area are:

- Spring Creek – flows across northern boundary of longwall mining area.
- Malcolm Creek – flows in an easterly direction through centre of longwall mining area towards the proposed open cut mine pits and Lagoon Creek.
- Pebbly Creek – flows in a south-easterly direction through centre of longwall mining area towards Beta Creek.
- Beta Creek – flows in a north-easterly direction across south-east corner of longwall mining area before joining with Tallarenha Creek to form Lagoon Creek to the east of the proposed open cut mines.

3.4 Post-Subsidence Topography in Proposed Longwall Mining Area

Subsidence calculations have been undertaken for the proposed longwall mining area by Waratah Coal (2012) and include estimates of maximum subsidence in the centre of the longwall panels and minimum subsidence over the chain pillars along the sides of the longwall panels. Table 3.1 shows the subsidence predictions for the individual underground mines, while Table 3.2 shows the combined subsidence predictions for multiple seam mining (overlying B and D-Seam mines).

The predicted maximum subsidence (centre of longwall panels) is 1.4 to 1.6 m in the northern mines (Mines 1 and 4) and 1.1 to 1.2 m in the southern mines (Mines 2 and 4). The predicted maximum subsidence for the overlying underground mines is 3.05 to 3.20 m where Mine 4 overlies Mine 1 and 2.7 to 2.8 m where Mine 4 overlies Mine 2. Predicted pillar subsidence is 0.04 to 0.15 m for the individual mines and 0.12 to 0.24 m for the overlying mines.

Table 3.1: Subsidence calculations for individual underground mines (Waratah Coal, 2012)

Mine	1		2		3		4	
Seam	DU		DL2		DL1, DLX ply, DL2		B8	
Average Seam Thickness (m)	2.50		2.00		2.00		2.66	
Depth of Cover, Minimum, Maximum (m)	100	380	120	390	100	390	90	250
Maximum Subsidence (m)	1.50	1.40	1.20	1.10	1.20	1.10	1.60	1.55
Pillar Subsidence (m)	0.04	0.15	0.05	0.15	0.04	0.15	0.04	0.10

Table 3.2: Subsidence calculations for multiple seam underground mining (Waratah Coal, 2012)

Mining Sequence	Mine 4 above Mine 1				Mine 4 above Mine 2			
Seam	B8		DU		B8		DL2	
Average Seam Thickness (m)	2.66		2.50		2.66		2.00	
Depth of Cover, Minimum, Maximum (m)	90	250	195	355	90	250	195	355
Maximum Subsidence (m)	1.60	1.55	1.60	1.50	1.60	1.60	1.20	1.10
Pillar Subsidence (m)	0.04	0.10	0.08	0.14	0.04	0.10	0.08	0.14
Cumulative Maximum Subsidence (m), Minimum Depth of Cover (m)	3.20				2.80			
Cumulative Maximum Subsidence (m), Maximum Depth of Cover (m)	3.05				2.70			
Cumulative Pillar Subsidence (m),	0.12				0.12			

Minimum Depth of Cover (m)		
Cumulative Pillar Subsidence (m), Maximum Depth of Cover (m)	0.24	0.24

The predicted post-subsidence ground topography is shown in Figure A4 (Appendix A) and has been derived by overlaying the predicted subsidence depths over the existing ground topography (SRTM topography data).

The most direct impact of surface subsidence is the formation of ponding areas where longwall panels cross waterways and drainage gullies or at the down-gradient ends of longwall panels where there is a step-up to existing ground levels.

The extent of surface ponding in the existing and post-subsidence landforms has been identified using the TUFLOW two-dimensional hydraulic modelling software (refer Section 4). The ponding extents were determined by applying a large depth of rainfall over the TUFLOW model of the proposed longwall mining area using the direct rainfall-on-grid modelling approach and allowing the corresponding runoff to drain from the model. Inundated areas at the end of the model simulations represent the ponding areas in the landforms.

The existing landform ponding areas are shown in Figure A6 (Appendix A) and indicate that there is minimal surface ponding in the existing landform. There is a number of existing farm dams within the mine lease area, however these are not defined by the low-accuracy SRTM topographic data.

The post-subsidence ponding areas are shown in Figure A7 (Appendix A) and indicate the numerous ponding areas that will be formed within the subsided landform along the surface drainage lines and at the lower (eastern) ends of the longwall panels. The deepest ponding will occur along Spring Creek and at the eastern ends of the Mine 4 longwall panels where the subsidence depths are greatest.

Minimal subsidence ponding is predicted along Malcolm Creek because the existing creek alignment is relatively straight and aligned with the longwall panels and does not cross over many longwall panels.

No subsidence ponding modelling has been undertaken where the underground mines underlie the open cut mines since the majority of this area will be occupied by the open cut pits and spoil disposal areas and will not be susceptible to subsidence effects.

4. FLOOD IMPACT ASSESSMENT

4.1 Overview

Hydraulic modelling has been undertaken to determine flooding characteristics within the proposed longwall mining area under existing and post-subsidence landform scenarios. A two-dimensional hydraulic modelling approach was adopted using the TUFLOW software. Flooding characteristics have been identified for the 50 year Average Recurrence Interval (ARI) flood event, with the main purpose of the flood modelling to identify potential changes to surface drainage patterns following completion of longwall mining.

Engeny (2012a) has also undertaken flooding investigations for the waterways that will require diversion around open cut pits and other mine infrastructure. This study utilised ALS survey of the north-eastern corner of the proposed mine lease area. The ALS data has a significantly higher accuracy than the SRTM topographic data used to define the existing and post-subsidence landforms within the longwall mining area. Given the large discrepancies between the two topographic data sources caused by the differing accuracies of the data sets, it was not possible to combine the hydraulic modelling of the longwall mining area and the downstream waterways (Malcolm Creek, Lagoon Creek and Saltbush Creek).

4.2 Existing Flooding

4.2.1 Modelling Approach

Hydraulic modelling of existing surface drainage patterns within the proposed longwall mining area was undertaken with a two-dimensional modelling approach using the TUFLOW modelling software.

The existing surface topography was defined using the SRTM topographic data (refer Section 3.3). A 20 m cell size was adopted in the TUFLOW model. The area included in the TUFLOW model is shown in Figure A5 (Appendix A) and extends to the immediate vicinity of the proposed longwall mining area.

Ground roughness was modelled using the Manning's 'n' roughness parameter with spatial variation of roughness values determined from aerial imagery. The following roughness values were utilised in the model:

- Cleared grazing land: n = 0.05.
- Medium density vegetation: n = 0.06.
- High density vegetation: n = 0.10.

The 50 year ARI flood event was simulated as a typical large flood event in the TUFLOW model. The 36 hour duration storm was adopted as the critical duration storm event for the waterways flowing through the mine lease area as determined in previous hydrologic investigations for the mine site (Engeny, 2012a).

Design flood inflows to the TUFLOW model were determined as follows:

- Design flood hydrographs entering the longwall mining area from upstream catchments (Pebbly Creek, Camp Creek and Beta Creek) were extracted from an XP-RAFTS hydrologic model of the mine catchments developed in previous hydrologic investigations for the mine site (Engeny, 2012a).
- Rainfall falling directly on the longwall mining area was simulated in the TUFLOW model using the direct rainfall-on-grid modelling approach.

For the purpose of the XP-RAFTS and rainfall-on-grid modelling, the following rainfall losses were applied based on previous hydrologic investigations (Engeny, 2012a):

- Initial loss: 55 mm.
- Continuing loss: 2.5 mm/hr.

Tailwater boundary conditions at the downstream ends of the TUFLOW model were derived using the normal depth function which automatically generates a stage discharge curve based on the boundary cross section topography, Mannings 'n' value at the boundary location, and a specified surface slope (gradient) taken from the available topographic data.

4.2.2 Modelling Results

Maps showing the extent, depth and velocity of existing flooding within the longwall mining area are provided in Appendix A. Figure A8 shows the predicted maximum flood depths and extents for the 50 year ARI flood event. This indicates that flood depths within the main waterways are relatively shallow (typically less than 1.5 m deep) with some deeper flow along Beta Creek.

Figure A10 shows the predicted maximum flood velocities for the 50 year ARI event. The flood velocities within the main waterways are predicted to be generally low (less than 1 m/s).

It is noted that the SRTM topographic data does not accurately define the bathymetry of the waterways and the flood modelling results are indicative only. Actual flooding conditions are expected to be narrower, deeper and faster flowing than those predicted from the SRTM topographic data.

4.3 Post-Subsidence Flooding

4.3.1 Modelling Approach

Hydraulic modelling of post-subsidence surface drainage patterns within the proposed longwall mining area was undertaken using a similar two dimensional TUFLOW modelling approach to that used for the assessment of existing flooding characteristics. The predicted subsided landform topography (refer Section 3.4) was utilised for the modelling.

The model simulates the flow of water through the subsided longwall mining area but not the collection of this water into drainage diversions around the open cut pits. The proposed watercourse diversion of Malcolm Creek through the open cut pits and other required drainage diversions along the up-slope (highwall) side of the open cut pits were not included in the model.

The 50 year ARI 36 hour duration design storm was simulated in the TUFLOW model.

4.3.2 Modelling Results

Figure A9 (Appendix A) shows the maximum extent and depth of flooding through the susbsided longwall mining area, while Figure A11 shows the post-subsidence flood velocities.

The post-subsidence flood modelling results are discussed in Section 4.4.

4.4 Subsidence Impacts on Flooding

Flood depth and difference maps (post-subsidence flooding relative to existing flooding) for the 50 year ARI flood event are provided in Figures A12 and A13 (Appendix A) respectively.

These figures show that the main impacts of longwall mining subsidence on flooding and drainage characteristics within the longwall mining area will be:

- Channelization of overland flows along longwall panels.
- Changes to flooding characteristics where waterways and drainage gullies cross longwall panels at an angle, including:
  - Wider flood extents, increased flood depths and reduced flood velocities in the subsidence troughs; and
  - Narrower flood extents, reduced flood depths and increased flood velocities over pillar areas.

These impacts will be most evident within Spring Creek.

- Channelization of Pebbly Creek along the southern-most longwall panel in the B-Seam mine (Mine 4). This will divert creek flows away from the existing creek alignment that follows a south-easterly direction towards Beta Creek. Post-subsidence flows in Pebbly Creek will be channelized along the longwall panels towards the highwall side of the OC1 South open cut mine.

- Only minor impacts to Malcolm Creek and Beta Creek since the existing alignment of these waterways is generally parallel to the longwall panels.

Other potential impacts of subsidence on waterway stability, geomorphology and sediment transport processes may include:

- Lowering of stream bed and banks.

- Stream bank slumping.

- Creation of in-stream waterholes within subsidence troughs.

- Riparian vegetation die-back within in-stream waterholes.

- Root shear and loss of riparian vegetation.

- Erosion of surface soils where channelization of overland flow occurs in longwall panels.

- Stream incision processes.

- Stream widening.

- Head-cutting erosion of stream banks caused by increased overbank flows due to lowering of the high banks and channelization of overland flow within longwall panels.

- Sediment deposition within subsidence ponding areas leading to reduced sediment inflows to downstream waterways.

It is noted that the subsidence impacts on flooding characteristics identified in this Section are potential maximum impacts assuming no implementation of subsidence mitigation strategies. The subsidence of longwall panels will occur gradually over the 30 year period of planned underground mining. During this time sediment transport processes in the waterways will naturally mitigate the impacts of subsidence on the waterways, with erosion over pillar areas and sediment deposition within subsidence ponding areas tending to reinstate the original stream bed profile. In addition, monitoring of subsidence impacts will occur during mining and management strategies will be implemented to mitigate these impacts (refer Section 6).

5. STREAM FLOW IMPACT ASSESSMENT

5.1 Overview

Subsidence due to underground mining has the potential to affect stream flows within and downstream of the mine. Changes to stream flows downstream of the mine could affect downstream water users and riparian ecosystems.

An assessment of the potential impact of subsidence on stream flows has been undertaken using a water balance approach. The impact of proposed open cut mining activities and the associated mine water management system on stream flows has also been included in this assessment.

Longwall mining subsidence has the potential to impact stream flows in Spring Creek, Malcolm Creek, Pebbly Creek, Beta Creek, Lagoon Creek and Jordan Creek. Malcolm Creek, Pebbly Creek and Beta Creek all discharge into Lagoon Creek within the mine lease area. Accordingly, the impact assessment of mine subsidence on stream flows in waterways downstream of the mine has involved the estimation of existing and post-subsidence (Year 30 of mine life) stream flows at the following locations:

- Spring Creek at the northern mine lease boundary.
- Lagoon Creek (including Saltbush Creek) at the northern mine lease boundary.
- Un-named tributary of Jordan Creek at the confluence with Jordan Creek (downstream of western mine lease boundary).

5.2 Existing Stream Flows

5.2.1 Modelling Approach

Existing stream flows were estimated using the AWBM daily rainfall-runoff model. The AWBM model is a catchment water balance model used to relate daily runoff to daily rainfall and evapotranspiration. The model represents the catchment using three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the baseflow store if there is baseflow in the stream flow.

The parameters used to define the AWBM are as follows:

- Partial area fractions (A1, A2 and A3) represented by the three surface stores.

- Surface store capacities (C1, C2 and C3) in millimetres.
- Baseflow index (BFI). Surface routing store recharge = (1-BFI)xExcess. Baseflow recharge = BFIxExcess;
- Daily baseflow recession constant (Kb). Baseflow = (1-Kb)xBaseflow store.
- Daily surface store recession constant (Ks). Surface runoff = (1-Ks)xSurface routing store.
- Total stream flow = Surface runoff + Baseflow.

A schematic of the AWBM process is summarised in Figure 5.1.

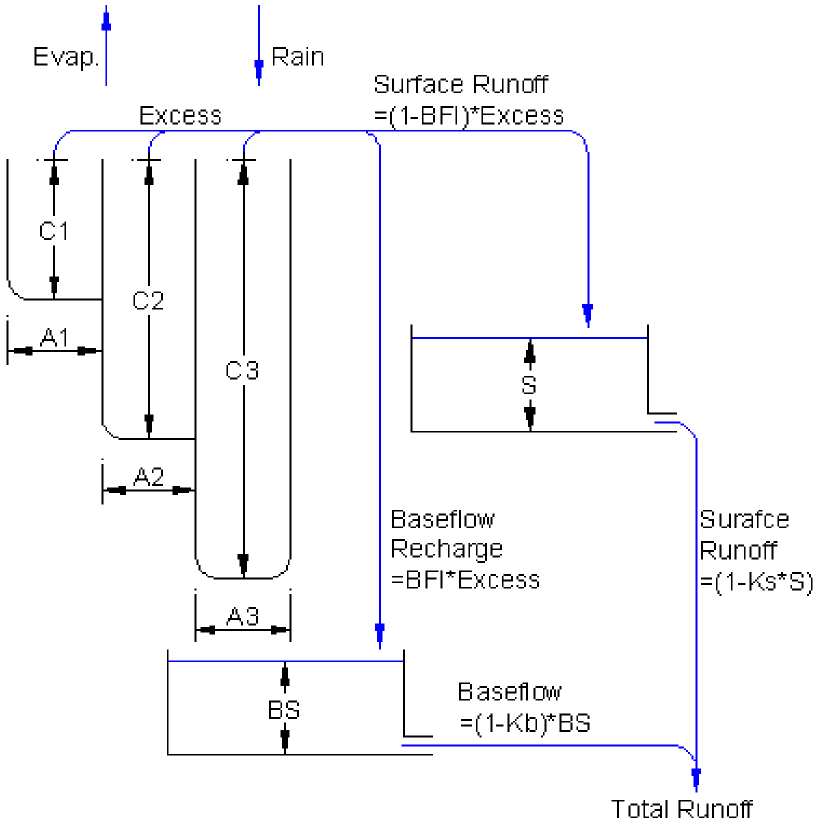

Figure 5.1 AWBM Runoff Model Schematic

The AWBM parameters for natural catchments in the vicinity of the mine were determined from calibration against gauged stream flows for the Native Companion Creek catchment which is the adjacent catchment to the east of the Lagoon Creek catchment. Details of the Native Companion Creek stream gauging station are provided in Table 5.1.

Table 5.1: Stream gauging station details

Station Number	Station Name	Catchment Area (km^2)	Period of Record	Location
120305A	Native Companion Creek at Violet Grove	4,065	1967 to current	30 km SE of mine

The AWBM calibration was undertaken for the period of gauged stream flows between January 1968 and October 2011. The predicted stream flows were compared against the stream gauging data and the AWBM model parameters were adjusted to provide a reasonable comparison between the gauged and modelled stream flow characteristics.

The modelled flow duration curve for Native Companion Creek is shown in Figure 5.2and shows a good comparison to the gauged flow statistics. The modelled cumulative stream flow volume during the period January 1968 to October 2011 is displayed in Figure 5.3. Although there are differences in the modelled and gauged stream flows for individual flow events, the modelled total stream flow volume during the period is similar to the gauged volume.

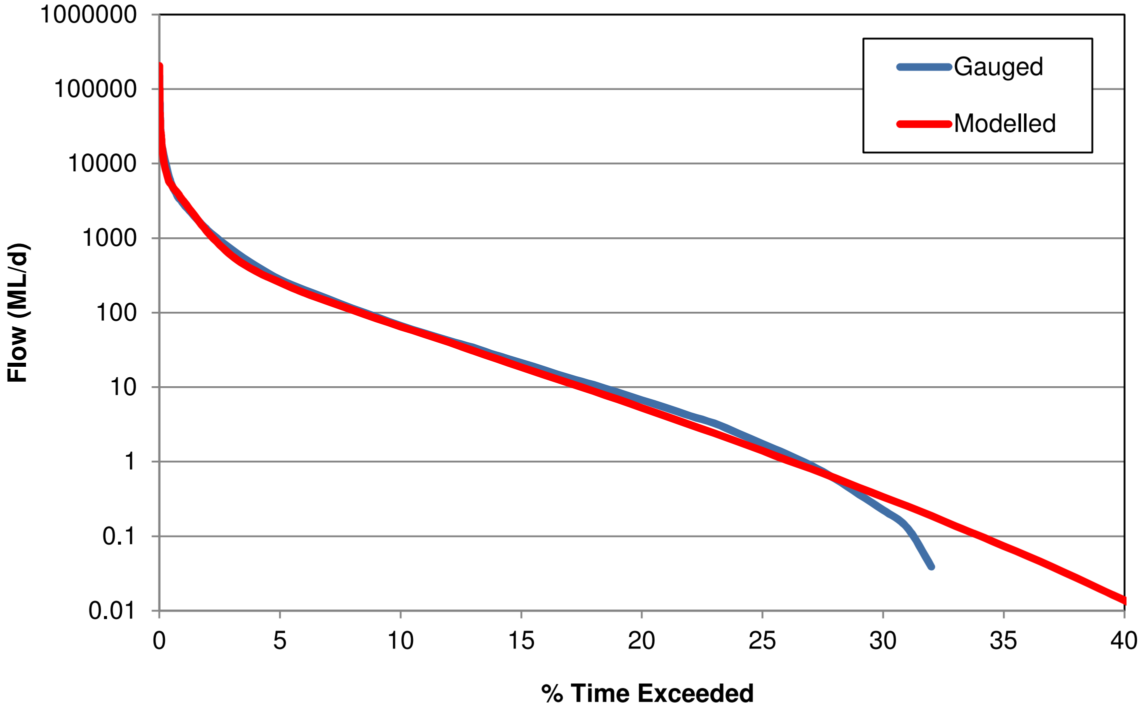

Figure 5.2 Modelled Flow Duration Curve for Native Companion Creek

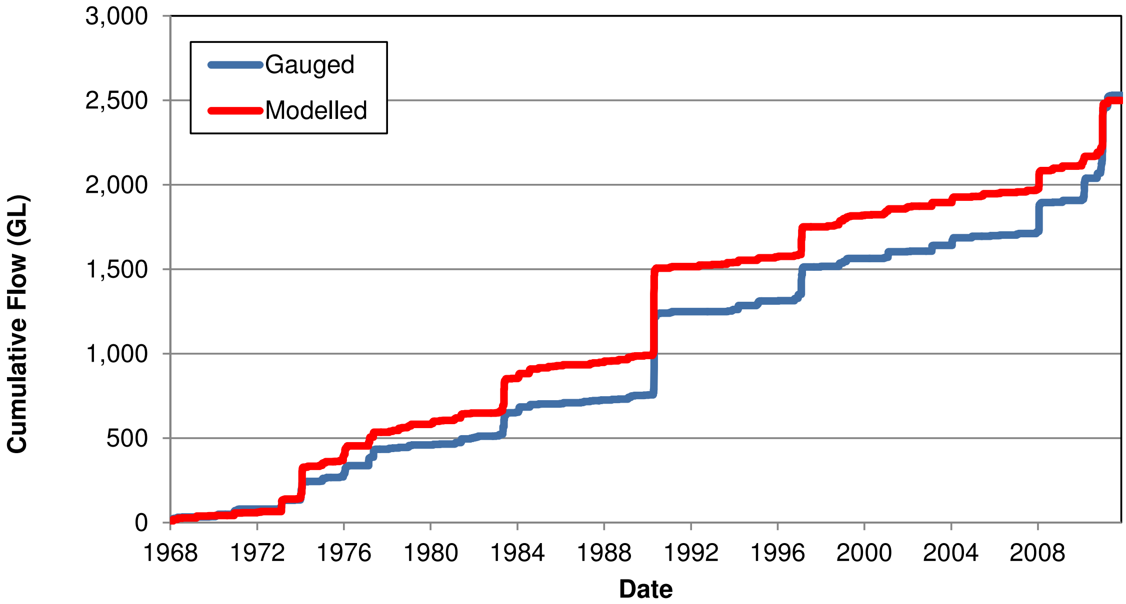

Figure 5.3 Modelled Cumulative Stream flows for Native Companion Creek

A summary of the AWBM parameters adopted for the natural catchment stream flow modelling is summarised Table 5.2 while the statistics of the annual stream flows are provided in Table 5.3.

Table 5.2: Adopted AWBM parameters for natural catchment stream flows

AWBM Parameter	Parameter Value
C1 (mm)	25
C2 (mm)	195
C3 (mm)	500
A1	0.05
A2	0.475
A3	0.475
BFI	0.4
K_b	0.8
K_s	0

Table 5.3: AWBM catchment runoff statistics

Statistic	Value
10^{th} Percentile Runoff (mm)	0.8
50^{th} Percentile Runoff (mm)	5.0
90^{th} Percentile Runoff (mm)	23.6
Mean Runoff (mm)	10.4
10^{th} Percentile Annual Runoff Coefficient (%)	0.2
50^{th} Percentile Annual Runoff Coefficient (%)	1.1
90^{th} Percentile Annual Runoff Coefficient (%)	2.8
Mean Runoff Coefficient (%)	1.6

The AWBM model was used simulate daily stream flows in the three waterways (Spring Creek, Lagoon Creek and tributary of Jordan Creek) for the period 1889 to 2011.

Rainfall and evapotranspiration data for the simulation was obtained from the Silo Patched Point dataset (http://www.longpaddock.qld.gov.au/silo/) for the Bureau of Meteorology rainfall station at Alpha Post Office (Station No. 035000).

The AWBM stream flow simulations were undertaken using the site water balance model developed by Engeny (2012b) to assess the performance of the proposed mine water management system. The water balance model was developed using the GoldSim software.

Catchment areas for the three waterways are listed in Table 5.4. The catchment boundaries are shown in Figure A2 (Appendix A).

Table 5.4: Waterway catchment areas

Waterway	Catchment Area (km^2)
Spring Creek at northern mine boundary	59
Lagoon Creek at northern mine boundary	1,257
Tributary of Jordan Creek at confluence with Jordan Creek[1]	181

[1] Location is downstream of mine.

5.2.2 Modelling Results

Predicted existing stream flows in the waterways that will be subject to underground mine subsidence impacts are shown in Table 5.5. Stream flows are presented as statistics of annual flows.

Table 5.5: Predicted existing annual stream flows for waterways discharging from mine

Waterway	10^{th} %ile Stream Flow (ML/year)	50^{th} %ile Stream Flow (ML/year)	90^{th} %ile Stream Flow (ML/year)	Mean Stream Flow (ML/year)
Spring Creek at northern mine boundary	87	305	1,580	663
Lagoon Creek at northern mine boundary	1,851	6,509	33,657	14,132
Tributary of Jordan Creek at confluence with Jordan Creek[1]	267	937	4,846	2,035

[1] Location is downstream of mine.

5.3 Post-Subsidence Stream Flows

5.3.1 Modelling Approach

The potential maximum impact of subsidence on stream flows in the waterways discharging from the mine has been assessed using a water balance approach. The assessment was based on the predicted ultimate subsided landform (refer Section 3.4).

The methodology for the water balance assessment was as follows:

- The water balance modelling of subsidence impacts on stream flows was undertaken using the site water balance model of the proposed mine water management system developed by Engeny (2012b).
- Water balance calculations were undertaken for the cumulative subsidence ponding areas within each waterway catchment. The subsidence ponding areas within the longwall mining areas are shown in Figure A7 (Appendix A) and typically occur along drainage gullies and waterways and at the downstream ends of the longwall panels. The cumulative subsidence ponding volumes and areas within each waterway catchment are summarised in Table 5.6.
- Stream flows in the waterways were only assumed to occur when catchment inflows exceeded the spare storage volume within the subsidence ponding areas within each waterway catchment. Catchment areas contributing to the subsidence ponding areas are shown in Table 5.7.
- Evaporation and seepage losses were subtracted from the subsidence ponding areas. A seepage rate of 10 mm/day was assumed for the ponding areas.
- The subsidence ponding water balance calculations were undertaken for the same historical period as the assessment of existing stream flows (1889 to 2011).
- The ultimate subsided landform was adopted for the assessment. This represents the worst case scenario for impacts to stream flows at the completion of mining. These impacts will be negligible at the commencement of mining and will increase as the underground mining area progresses.
- The reduction in catchment inflows to Lagoon Creek as a result of runoff intercepted by the open cut mine pits and other proposed water containment dams was included in the assessment. A total catchment area of 107 km^2 will drain to the mine water management system at the end of open cut mining (refer Engeny, 2012b) and will no longer contribute to stream flows in Lagoon Creek. Predicted overflows from the proposed box cut spoil and pit spoil sediment dams during high rainfall years have been included in the reported stream flows for Lagoon Creek at the northern mine lease boundary.

- The subsidence ponding volumes have been determined from the predicted post-subsidence landform which is based on the expected subsidence after longwall panels are collapsed. It is expected that the subsidence ponding areas will fill with sediment after a sufficient number of flow events have occurred. The filling of subsidence ponding areas with sediment will reduce the volume of water captured within the longwall panels and the impact of mine subsidence on waterway stream flows. The progressive filling of subsidence ponding areas with sediment has not been included in the water balance assessment.

- Mitigation options to reduce the magnitude of subsidence ponding were not modelled.

- No allowance has been made for potential reductions in catchment runoff due to subsidence-induced tension cracking of surface soils. The critical tensile strain zone caused by longwall mining will extend to about 180 m above the mining horizon (Waratah Coal, 2012). Tensile surface cracking will only occur where the depth of cover above the coal seam is less than 180 m. The depth of cover over the coal seam varies between 100 m and 400 m across the longwall mining area. Accordingly, surface cracking is not expected to occur over the entire longwall mining area. The surface soils within the longwall mining area are generally expected to be self-healing to tensile surface cracking (Waratah Coal, 2012).

Table 5.6: Cumulative subsidence ponding volumes and areas

Catchment	Cumulative Subsidence Ponding Area (ha)	Cumulative Subsidence Ponding Volume (ML)
Spring Creek	278	2,089
Lagoon Creek	771	3,146
Tributary of Jordan Creek	75	229

Table 5.7: Catchment areas upstream and downstream of subsidence ponding areas

Catchment	Catchment Area Upstream of Subsidence Ponding (km²)	Catchment Area Downstream of Subsidence Ponding (km²)
Spring Creek	59	0
Lagoon Creek	303[1]	847[2]
Tributary of Jordan Creek	15	166

[1] Excludes catchment areas of Camp Creek and Beta Creek which flow through only a small component of the total subsidence ponding volume for the catchment.

[2] Excludes catchments draining to open cut pits and other water containment and sediment dams.

5.3.2 Modelling Results

Predicted post-subsidence stream flows in the waterways that will be subject to underground mine subsidence impacts are shown in Table 5.8.

Table 5.8: Predicted post-subsidence annual stream flows for waterways discharging from mine

Waterway	10th %ile Stream Flow (ML/year)	50th %ile Stream Flow (ML/year)	90th %ile Stream Flow (ML/year)	Mean Stream Flow (ML/year)
Spring Creek at northern mine boundary	0	0	0	67
Lagoon Creek at northern mine boundary[1]	1,247	4,386	31,994	12,410
Tributary of Jordan Creek at confluence with Jordan Creek[2]	244	860	4,450	1,907

[1] Includes loss of catchment area associated with open cut pits and mine water management system.

[2] Location is downstream of mine.

5.4 Subsidence Impacts on Stream Flows

Table 5.9 shows the potential maximum changes to stream flows as a result of subsidence ponding within the longwall mining area and the interception of runoff within open cut mine pits and water containment and sediment dams.

Table 5.9: Predicted maximum changes to annual stream flows in vicinity of mine as a result of underground and open cut mining

Waterway	10th %ile Stream Flow Change (%)	50th %ile Stream Flow Change (%)	90th %ile Stream Flow Change (%)	Mean Stream Flow Change (%)
Spring Creek at northern mine boundary	100.0%	100.0%	100.0%	89.9%
Lagoon Creek at northern mine boundary[1]	32.6%	32.6%	4.9%	12.2%
Tributary of Jordan Creek at confluence with Jordan Creek[2]	8.3%	8.3%	8.2%	6.3%

[1] Includes loss of catchment area associated with open cut pits and mine water management system.

[2] Location is downstream of mine.

The water balance modelling indicates that the subsidence ponding within the Spring Creek catchment will intercept all stream flows in more than 90% of years, with overflows into the off-lease reach of Spring Creek during only very wet years. Approximately 64% of the Spring Creek catchment upstream of the mine lease boundary will be affected by longwall mining.

There are no existing water users along Spring Creek downstream of the proposed Galilee Coal Mine. The Alpha Coal Project is proposed to be located immediately to the north of the mine and will involve the diversion of Spring Creek into Lagoon Creek along the common mine lease boundary of the two mines.

There is predicted to be a 33% decrease in stream flows in Lagoon Creek in 50% of years as a result of underground mine subsidence and capture of runoff in open cut pits and dams. This impact reduces in higher rainfall years due to larger stream flows and the occurrence of overflows from box cut and pit spoil sediment dams.

The nearest surface water extraction licenses downstream of the Lagoon Creek discharge from the mine are located on the Belyando River near the confluence with the Suttor River (Engeny, 2012c). The impact of mine subsidence on stream flows at these water extraction points will be negligible.

The predicted decrease in stream flows entering Jordan Creek from the drainage gully originating in the mine lease area is 8% in the majority of years. The corresponding impact on stream flows in Jordan Creek will be negligible due to the significantly larger size of the Jordan Creek catchment.

The predicted stream flow reductions in Spring Creek and Lagoon Creek are significant. It is reiterated that the predicted subsidence impacts on stream flows are theoretical maximum values that do not take into account natural infilling of ponded areas due to sediment deposition or planned mitigation strategies to minimise the degree of subsidence ponding along the waterways and drainage paths.

6. SUBSIDENCE MANAGEMENT STRATEGIES

The potential maximum impacts of longwall mining subsidence on surface drainage, flooding and waterway stream flow characteristics have been identified in this study and are likely to include:

- Channelization of overland flows along longwall panels.
- Creation of in-stream waterholes within subsidence troughs where waterways and drainage gullies cross longwall panels.
- Channelization of Pebbly Creek along longwall panels resulting in diversion of the creek away from its' existing alignment.
- Significant reduction in stream flows in Spring Creek and Lagoon Creek due to interception of overland flows and stream flows in subsidence ponding areas.
- Sediment deposition within subsidence ponding areas resulting in decreased sediment inflows to downstream waterways.
- A range of potential other impacts to waterway stability, geomorphology and riparian vegetation.

The impacts of longwall mining subsidence will occur progressively during the 30 year life of the mine. This will provide time to monitor and evaluate subsidence impacts and implement appropriate subsidence mitigation strategies. Planned subsidence monitoring and mitigation strategies have been identified in Waratah Coal's Longwall Mining Subsidence Report (Waratah Coal, 2012).

It is intended that commercial grazing activities will co-exist with the underground mining operations and Subsidence Monitoring and Management Plans will be developed to ensure that land within the longwall mining area is suitable for agricultural activities. These plans will be developed in accordance with the Department of Natural Resources and Mines' Draft *Guideline on Watercourse Subsidence – Central Queensland Mining Industry*.

To a certain extent, many of the impacts of subsidence will be mitigated over time through natural processes such as:

- Infilling of subsidence ponding areas as a result of sediment deposition.
- Reduction of subsidence ponding areas as a result of erosion over pillar areas.
- Self-sealing and/or infilling of surface cracking.

The longwall mining area surface stratigraphy contains cohesive Quaternary alluvial and Tertiary sands, clays and laterites which are self-healing to tensile surface fracturing. Surface tension cracks which form in cohesionless creek bed alluvium and Recent Colluvium are self-healing and readily infill. Open tension cracks in surface clays will need to be ripped and compacted.

Where tension cracking occurs within waterways, blanketing and compacting will be required to minimise inflows to underlying longwall mines and maintain stream flows in downstream waterways. Materials suitable for blanking include silty alluvium and clay.

Where the formation of subsidence ponding is likely to cause unacceptable impacts to waterways, channels will be excavated through pillar zones to maintain water and sediment flow connectivity along the waterways. The waterways that are most likely to require excavation to prevent subsidence ponding are Spring Creek and Pebbly Creek. Special attention will be required where Pebbly Creek flows through the southern-most longwall panel of the B-Seam mine (Mine 4) to prevent the creek from being channelized along the longwall panel.

Monitoring of the condition of waterways will be undertaken prior to and during mining to identify impacts on waterway stability and geomorphology, and the need for waterway rehabilitation works. Waterway monitoring programs are detailed in the ACARP guidelines for watercourse diversions (ACARP, 2011). Reshaping of stream banks, timber pile fields, rock revetment and bank revegetation are all options for mitigation of bank instability.

7. CONCLUSIONS

The potential maximum impacts of underground longwall mining associated with the proposed Galilee Coal Project on flood and stream flow characteristics within the mine lease area have been identified.

Flood modelling has been undertaken to identify subsidence ponding areas and changes to flood inundation depths, extents and velocities as a result of mine subsidence. Water balance modelling has been performed to assess the potential reduction in stream flow volumes as a result of underground mine subsidence and capture of runoff in open cut pits and dams.

The proposed longwall mining panels have been aligned generally parallel to the primary drainage directions within the longwall mining area which will minimise the subsidence impacts on the waterways. As a result of stream meandering and the angle of tributary inflows, the subsided longwall panels will intersect and cause ponding within the majority of primary and tributary drainage paths.

The potential impacts of longwall mining subsidence on surface drainage, flooding and waterway stream flow characteristics are likely to include:

- Channelization of overland flows along longwall panels.
- Creation of in-stream waterholes within subsidence troughs where waterways and drainage gullies cross longwall panels.
- Channelization of Pebbly Creek along longwall panels resulting in diversion of the creek away from its' existing alignment.
- Significant reduction in stream flows in Spring Creek and Lagoon Creek due to interception of overland flows and stream flows in subsidence ponding areas.
- Sediment deposition within subsidence ponding areas resulting in decreased sediment inflows to downstream waterways.
- A range of potential other impacts to waterway stability, geomorphology and riparian vegetation.

It is noted that the flood and stream flow impacts identified in this study have been conservatively estimated on the basis of the predicted final subsided landform. The final subsided landform is a theoretical surface that superimposes the predicted subsidence from all longwall panels. In reality, longwall mining will occur progressively during the life of mine and the impact of subsidence ponding within collapsed longwall panels will reduce over time through a combination of natural sedimentation and erosion processes (erosion over pillar zones and deposition within subsidence troughs) and planned subsidence mitigation strategies.

Strategies that could be considered to reduce the impacts of subsidence on waterways include:

- Ripping and compacting tension cracks in surface clays.
- Blanketing and compacting tension cracks that form and remain open within waterways.
- Excavation of channels through pillar zones to maintain water and sediment flow connectivity along the waterways. The waterways that are most likely to require excavation to prevent subsidence ponding are Spring Creek and Pebbly Creek.
- Reshaping of stream banks, timber pile fields, rock revetment and bank revegetation for mitigation of bank instability.

Monitoring of the condition of waterways will be undertaken prior to and during mining to identify impacts on waterway stability and geomorphology, and the need for waterway rehabilitation works. Subsidence monitoring and mitigation strategies are described in more detail in Waratah Coal's Longwall Mining Subsidence Report (Waratah Coal, 2012).

8. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Management Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c. Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

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   (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

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9. REFERENCES

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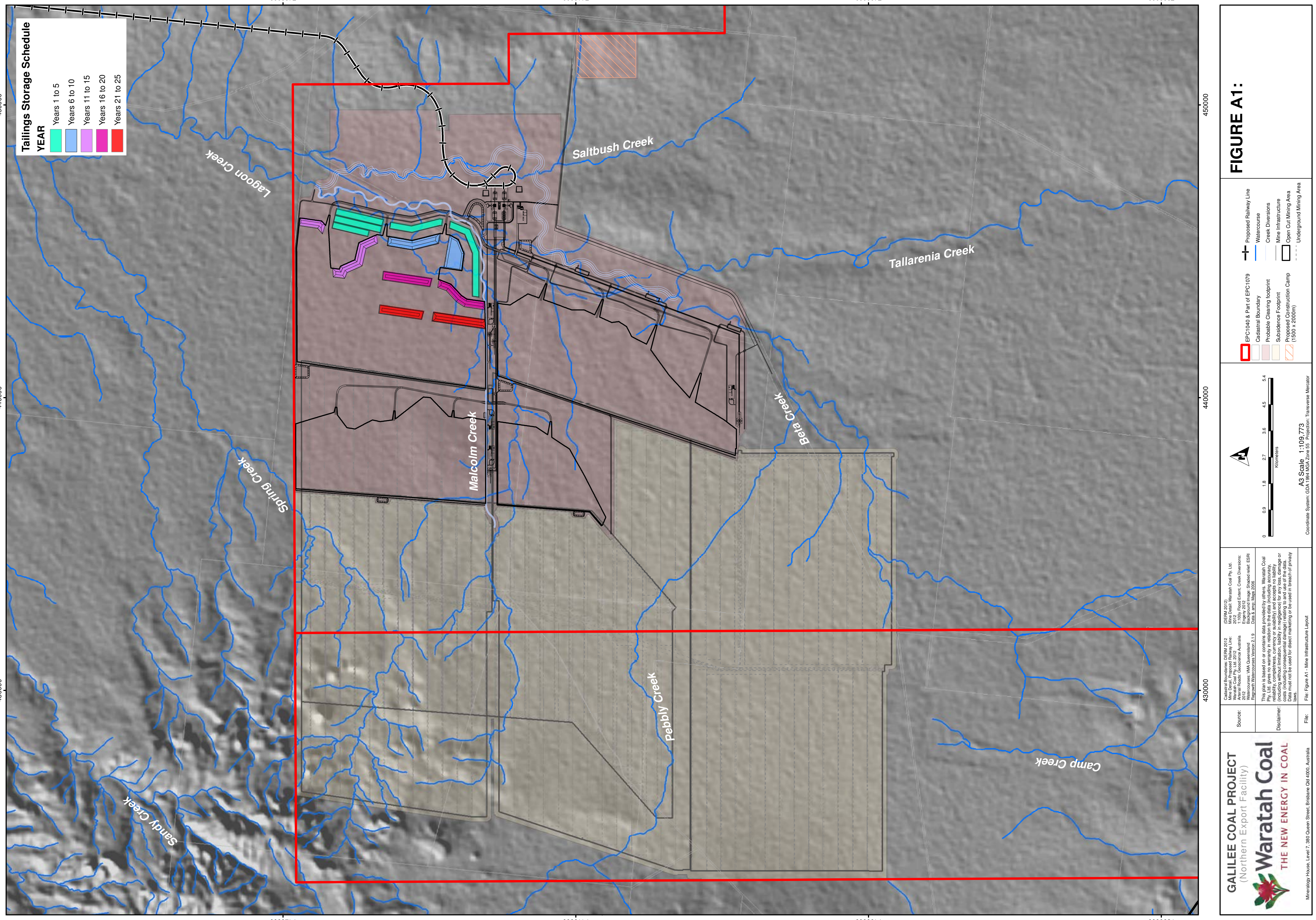
APPENDIX A

Figures


Tailings Storage Schedule
YEAR
Years 1 to 5
Years 6 to 10
Years 11 to 15
Years 16 to 20
Years 21 to 25
Saltbush Creek
Lagoon Creek
Tallarenia Creek
Malcolm Creek
Spring Creek
Beta Creek
Pebbly Creek
Camp Creek
Sandy Creek
FIGURE A1:
Proposed Railway Line
Watercourse
Creek Diversions
Mine Infrastructure
Open Cut Mining Area
Underground Mining Area
EPC1040 & Part of EPC1079
Cadastral Boundary
Probable Clearing footprint
Subsidence Footprint
Proposed Construction Camp (1500 x 2000m)
A3 Scale 1:109,773
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL

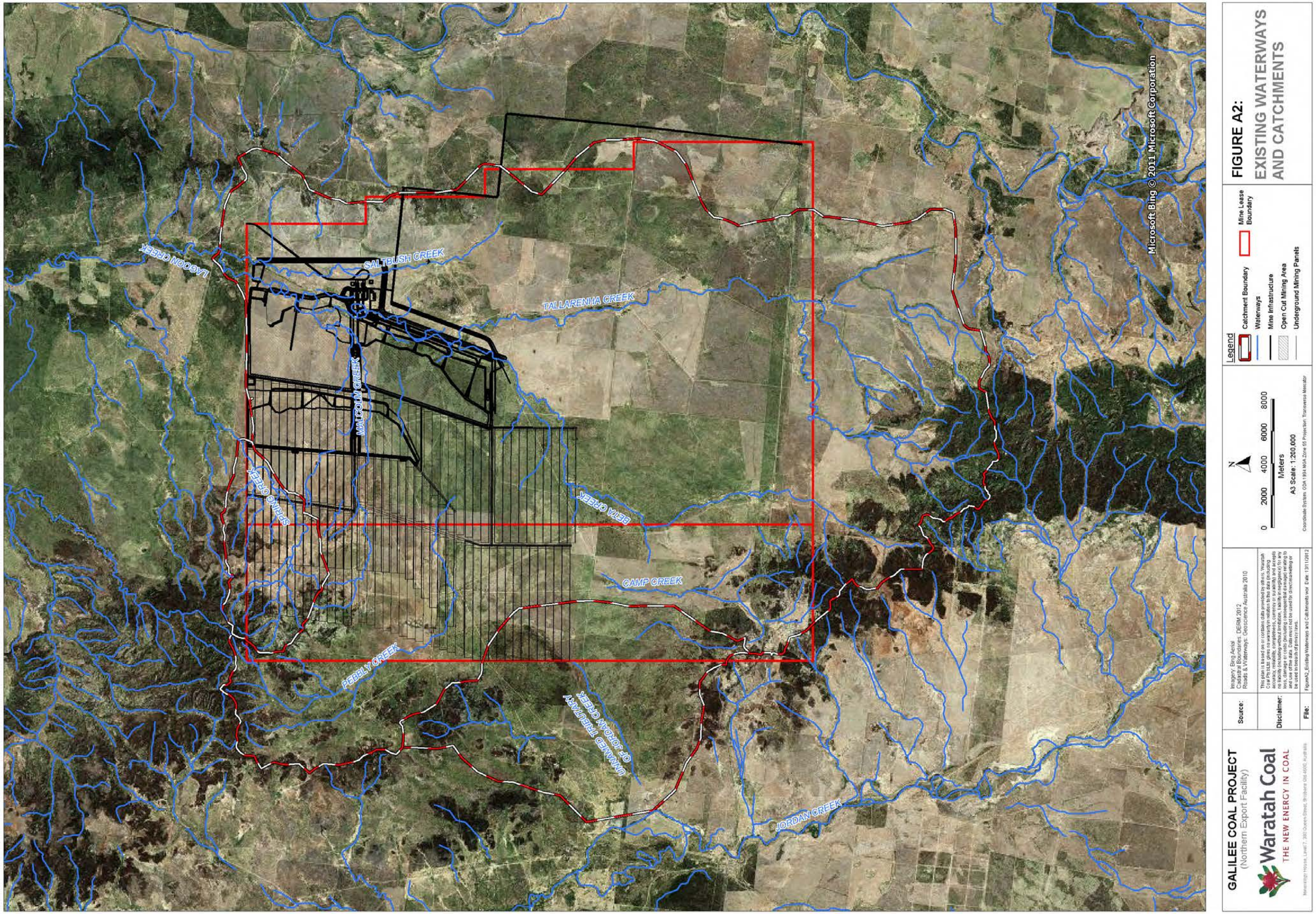


FIGURE A2:
EXISTING WATERWAYS AND CATCHMENTS
Microsoft Bing © 2011 Microsoft Corporation
LAGOON CREEK
SALTBUSH CREEK
TALLARENHA CREEK
MALCOLM CREEK
SPRING CREEK
BETA CREEK
CAMP CREEK
PEBBLY CREEK
UNNAMED TRIBUTARY OF JORDAN CREEK
JORDAN CREEK
Legend
Catchment Boundary
Waterways
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
Mine Lease Boundary
Meters
A3 Scale: 1:200,000
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
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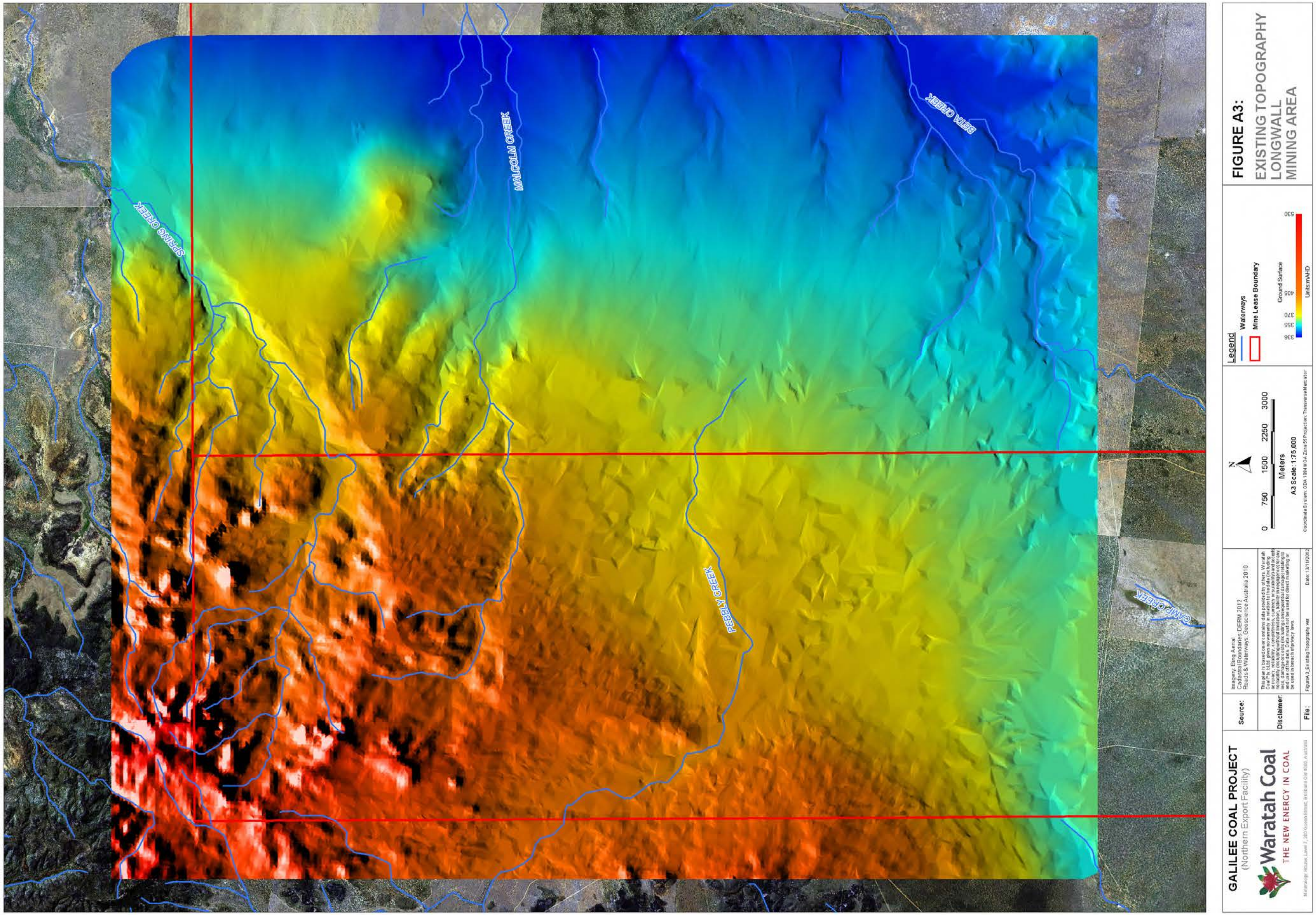
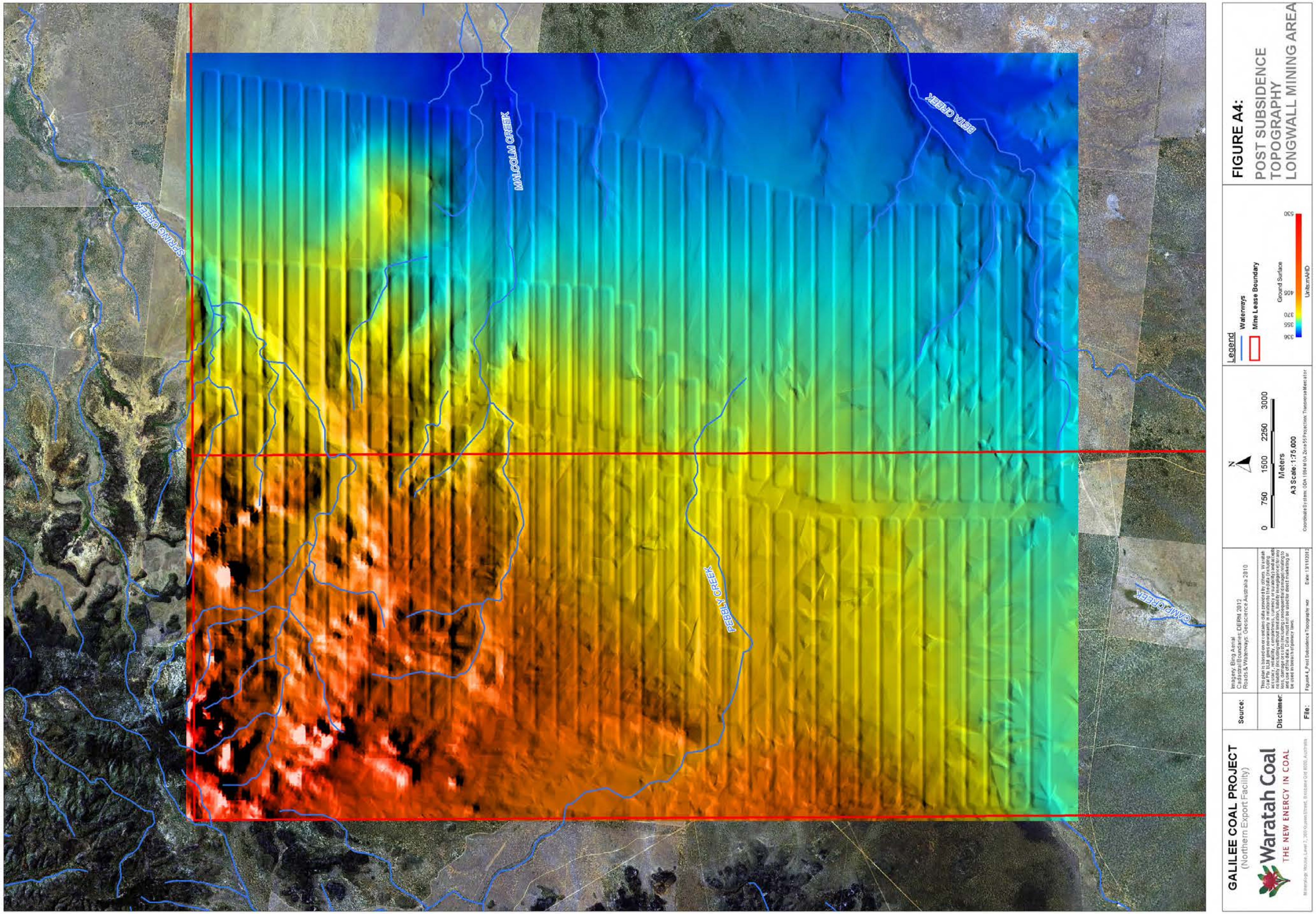
Source:
Disclaimer:
File:


MALCOLM CREEK
BETA CREEK
SPRING CREEK
PEBBLY CREEK
CAMP CREEK
FIGURE A3:
EXISTING TOPOGRAPHY
LONGWALL
MINING AREA
Legend
Waterways
Mine Lease Boundary
Ground Surface
336
355
370
405
530
Units: mAHD
0
750
1500
2250
3000
Meters
A3 Scale: 1:75,000
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Source:
Disclaimer:
File:


SPRING CREEK
MALCOLM CREEK
BETA CREEK
PEBBLY CREEK
CAMP CREEK
FIGURE A4:
POST SUBSIDENCE TOPOGRAPHY LONGWALL MINING AREA
Legend
Waterways
Mine Lease Boundary
Ground Surface
Units:mAHD
336
356
370
405
530
0
750
1500
2250
3000
Meters
A3 Scale: 1:75,000
Source:
Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
Disclaimer:
File:
GALILEE COAL PROJECT
(Northern Export Facility)
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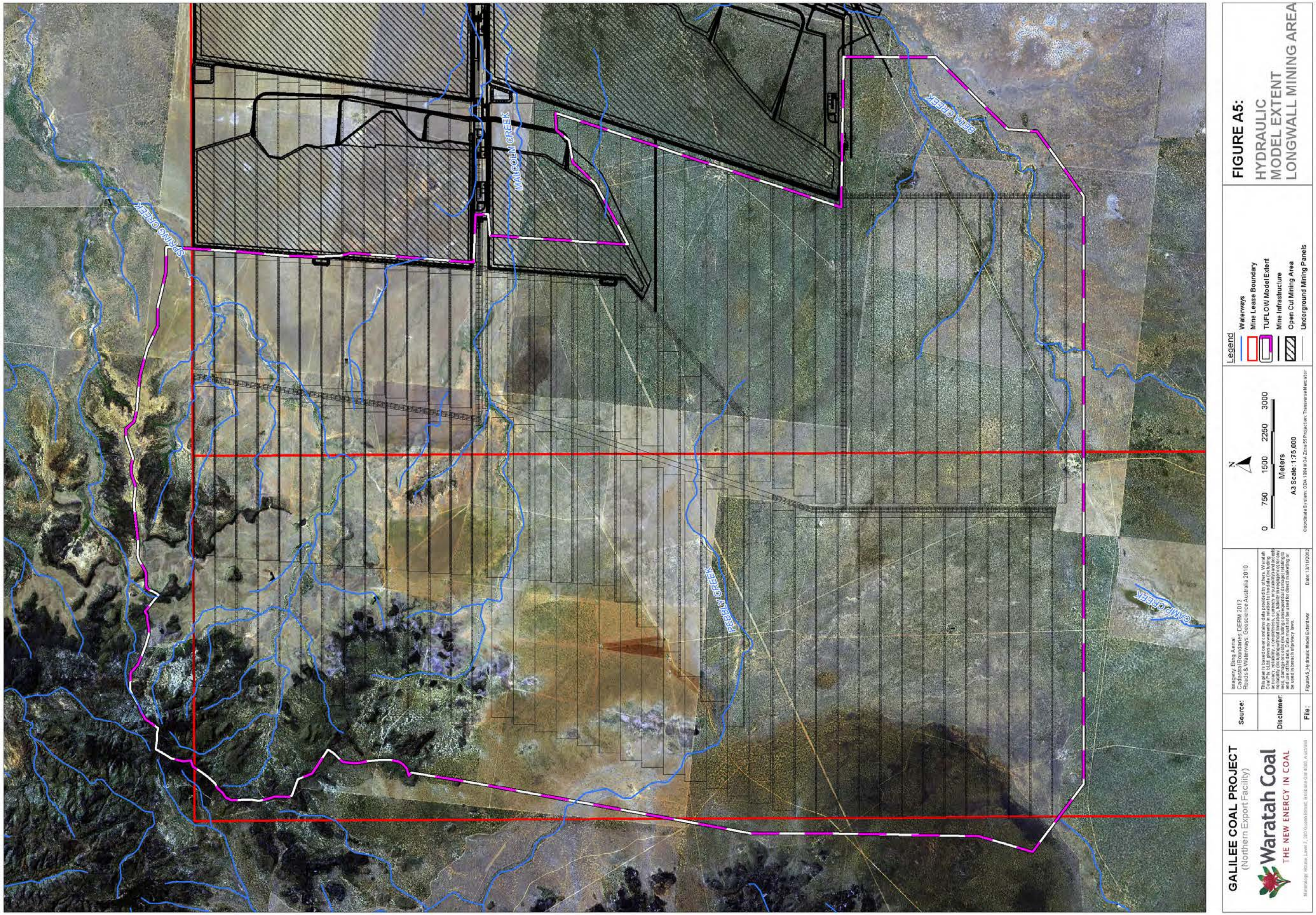
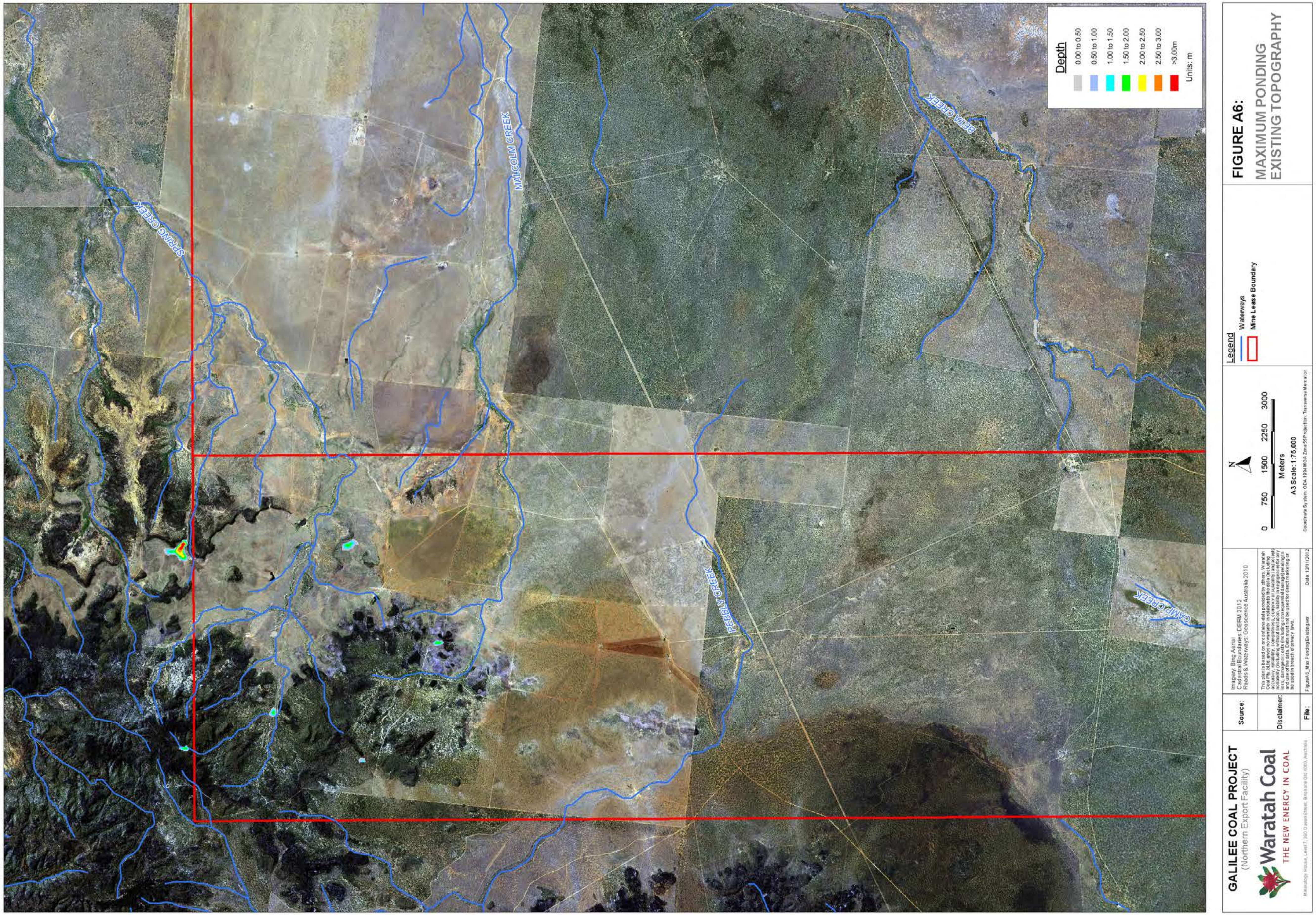


FIGURE A5:
HYDRAULIC MODEL EXTENT LONGWALL MINING AREA
Legend
Waterways
Mine Lease Boundary
TUFLOW Model Extent
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
N
Source: Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
Date: 13/11/2012
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
SPRING CREEK
MALCOLM CREEK
PEBBLY CREEK
CAMP CREEK



Depth
0.00 to 0.50
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00m
Units: m
MALCOLM CREEK
SPRING CREEK
BEJA CREEK
PEBBLY CREEK
CAMP CREEK
FIGURE A6:
MAXIMUM PONDING
EXISTING TOPOGRAPHY
Legend
Waterways
Mine Lease Boundary
N
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator
Source: Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
Disclaimer: This plan is based on or contains data provided by others. Waratah Coal Pty Ltd. gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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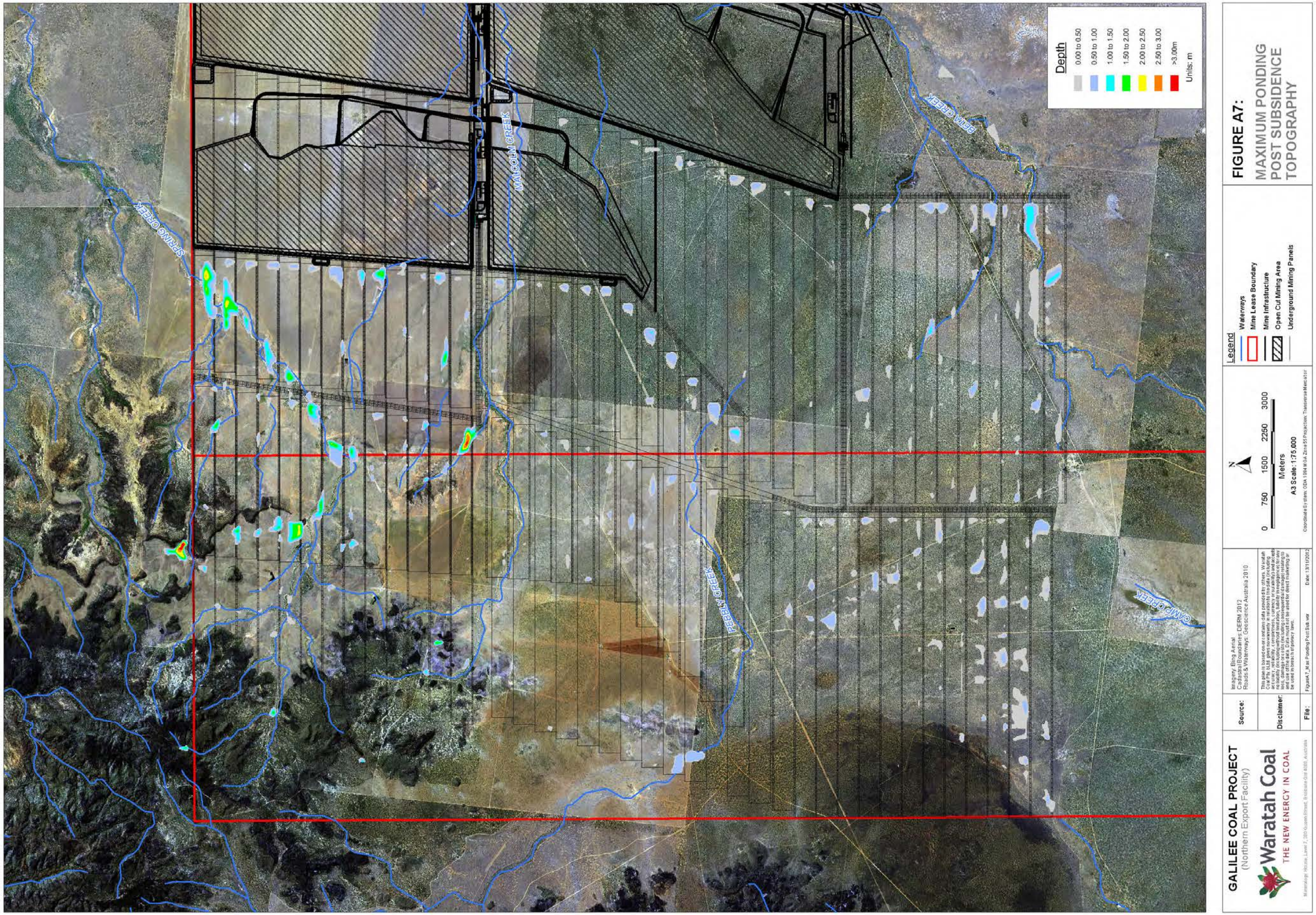

SPRING CREEK
MALCOON CREEK
BETA CREEK
PEBBLY CREEK
CAMP CREEK
Depth
0.00 to 0.50
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00m
Units: m
FIGURE A7:
MAXIMUM PONDING
POST SUBSIDENCE
TOPOGRAPHY
Legend
Waterways
Mine Lease Boundary
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
N
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator
Source:
Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
Disclaimer:
File: FigureA7_Max Ponding Post Sub.wor
Date: 13/11/2012
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(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL

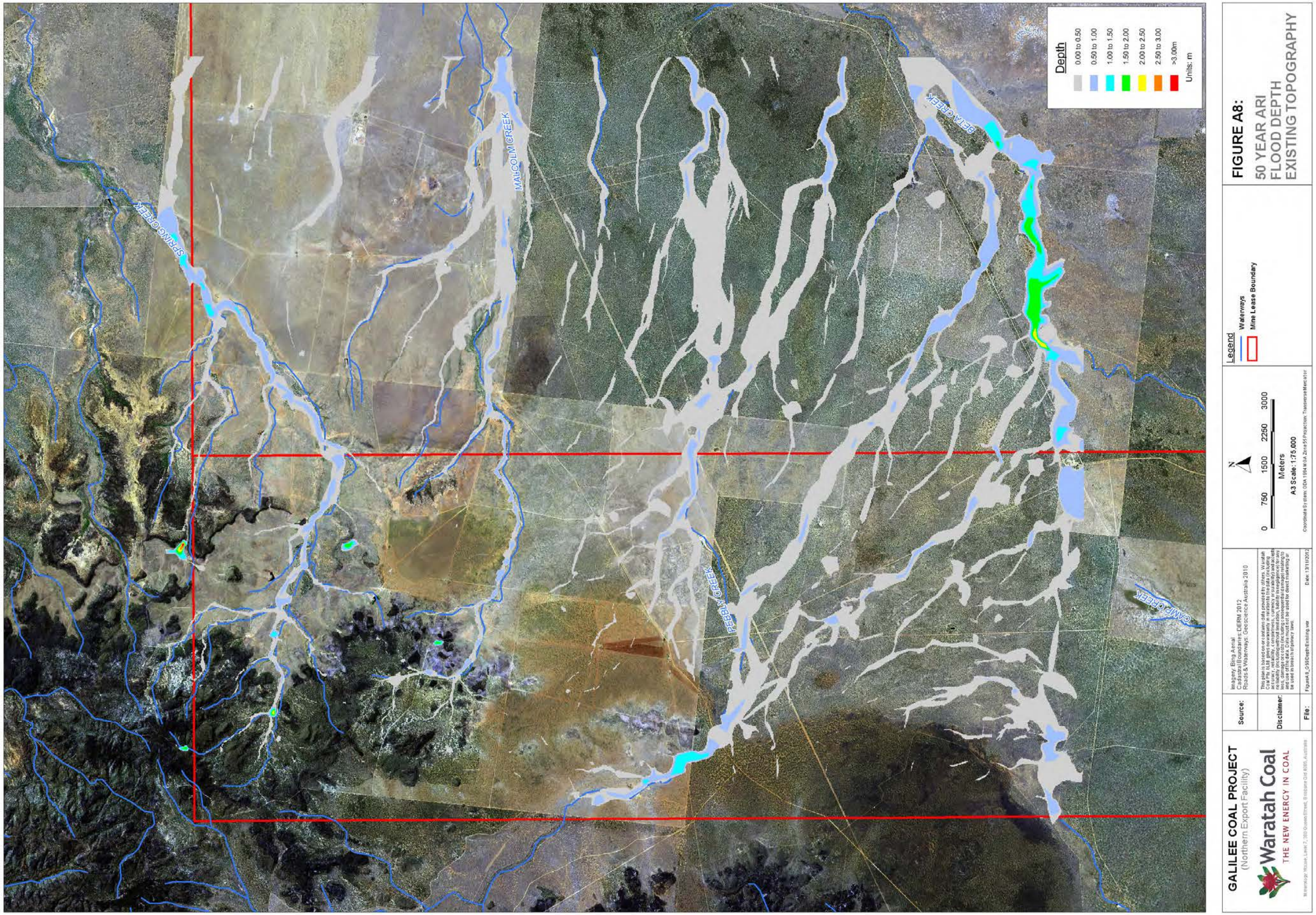


FIGURE A8:
50 YEAR ARI
FLOOD DEPTH
EXISTING TOPOGRAPHY
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Depth
0.00 to 0.50
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00m
Units: m
Legend
Waterways
Mine Lease Boundary
0
750
1500
2250
3000
Meters
A3 Scale: 1:75,000
Source:
Disclaimer:
File:
SPRING CREEK
MALCOLM CREEK
BETA CREEK
PEBBLY CREEK
CAMP CREEK

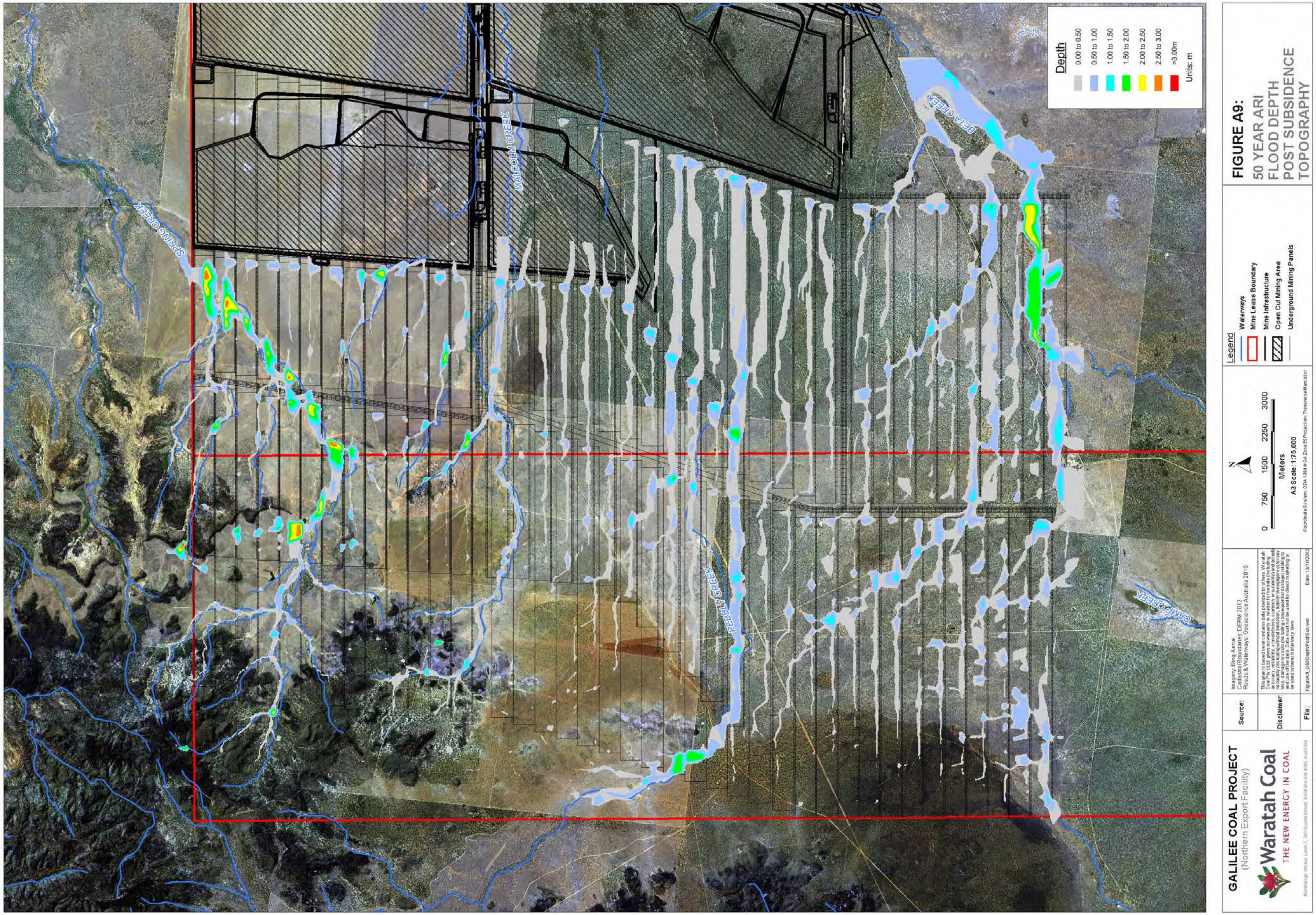
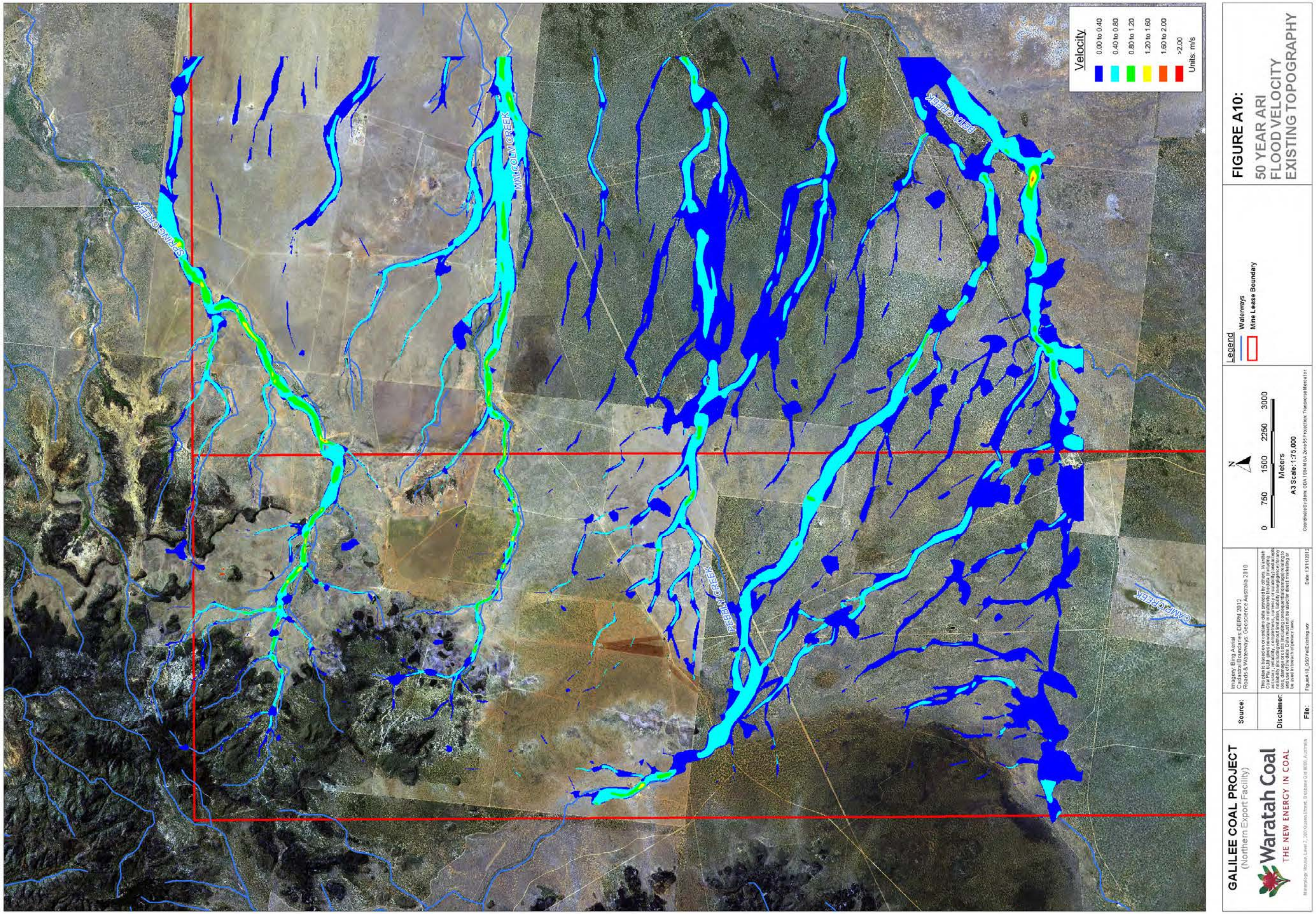
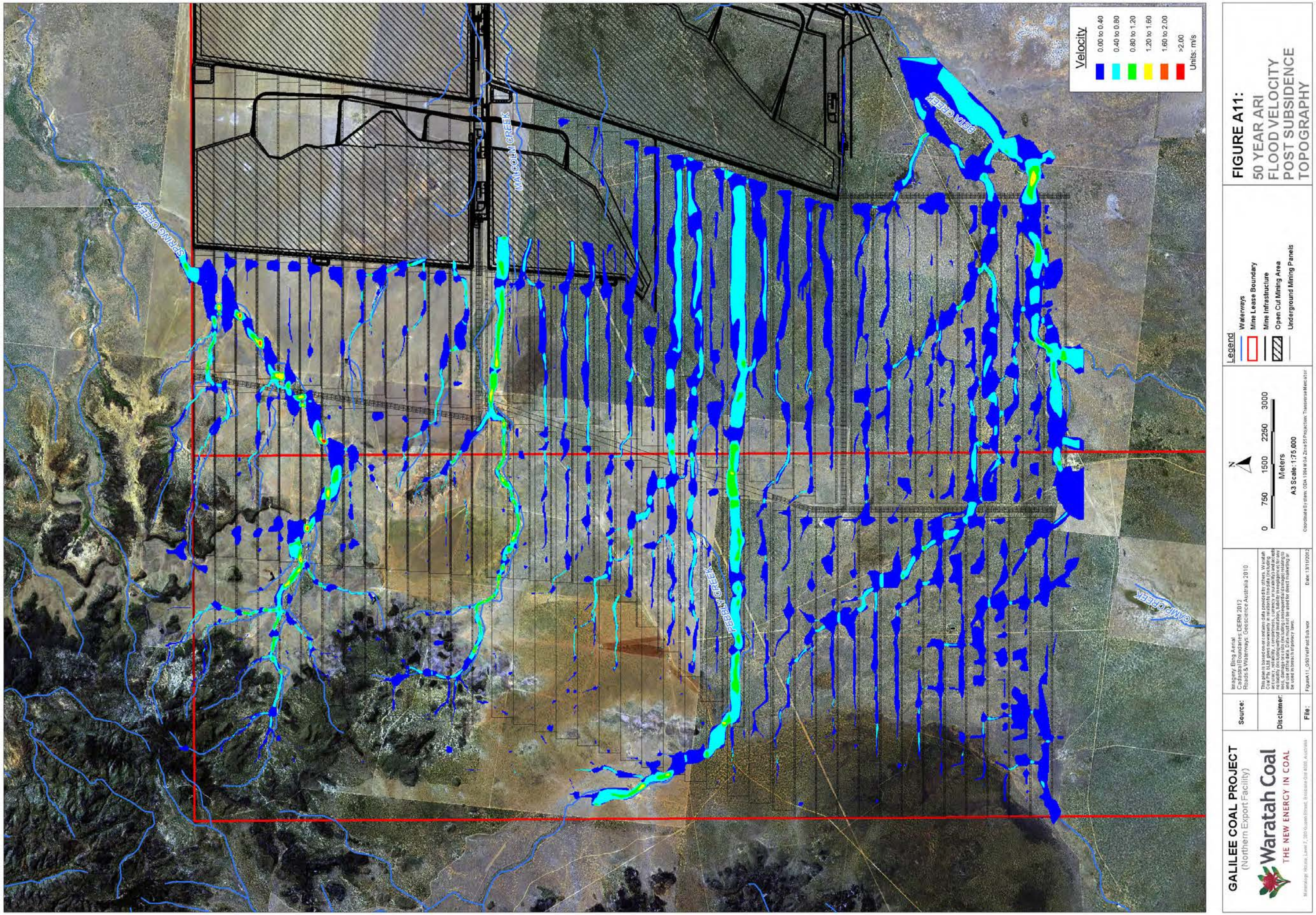


FIGURE A9:
50 YEAR ARI
FLOOD DEPTH
POST SUBSIDENCE
TOPOGRAPHY
Depth
0.00 to 0.50
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00m
Units: m
Legend
Waterways
Mine Lease Boundary
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
SPRING CREEK
MALCOLM CREEK
PEBBLY CREEK
BELYANDO CREEK
CAMP CREEK


Velocity
0.00 to 0.40
0.40 to 0.80
0.80 to 1.20
1.20 to 1.60
1.60 to 2.00
>2.00
Units: m/s
SPRING CREEK
MALCOLM CREEK
PEBBLY CREEK
BETA CREEK
CAMP CREEK
FIGURE A10:
50 YEAR ARI
FLOOD VELOCITY
EXISTING TOPOGRAPHY
Legend
Waterways
Mine Lease Boundary
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
Source: Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
File: FigureA10_Q50VelExisting.wor
Date: 13/11/2012
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL



Velocity
0.00 to 0.40
0.40 to 0.80
0.80 to 1.20
1.20 to 1.60
1.60 to 2.00
>2.00
Units: m/s
SPRING CREEK
MALCOLM CREEK
BETA CREEK
CAMP CREEK
FIGURE A11:
50 YEAR ARI
FLOOD VELOCITY
POST SUBSIDENCE
TOPOGRAPHY
Legend
Waterways
Mine Lease Boundary
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
N
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator
Source:
Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
Disclaimer:
File:
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Date: 13/11/2012
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Waratah Coal
THE NEW ENERGY IN COAL

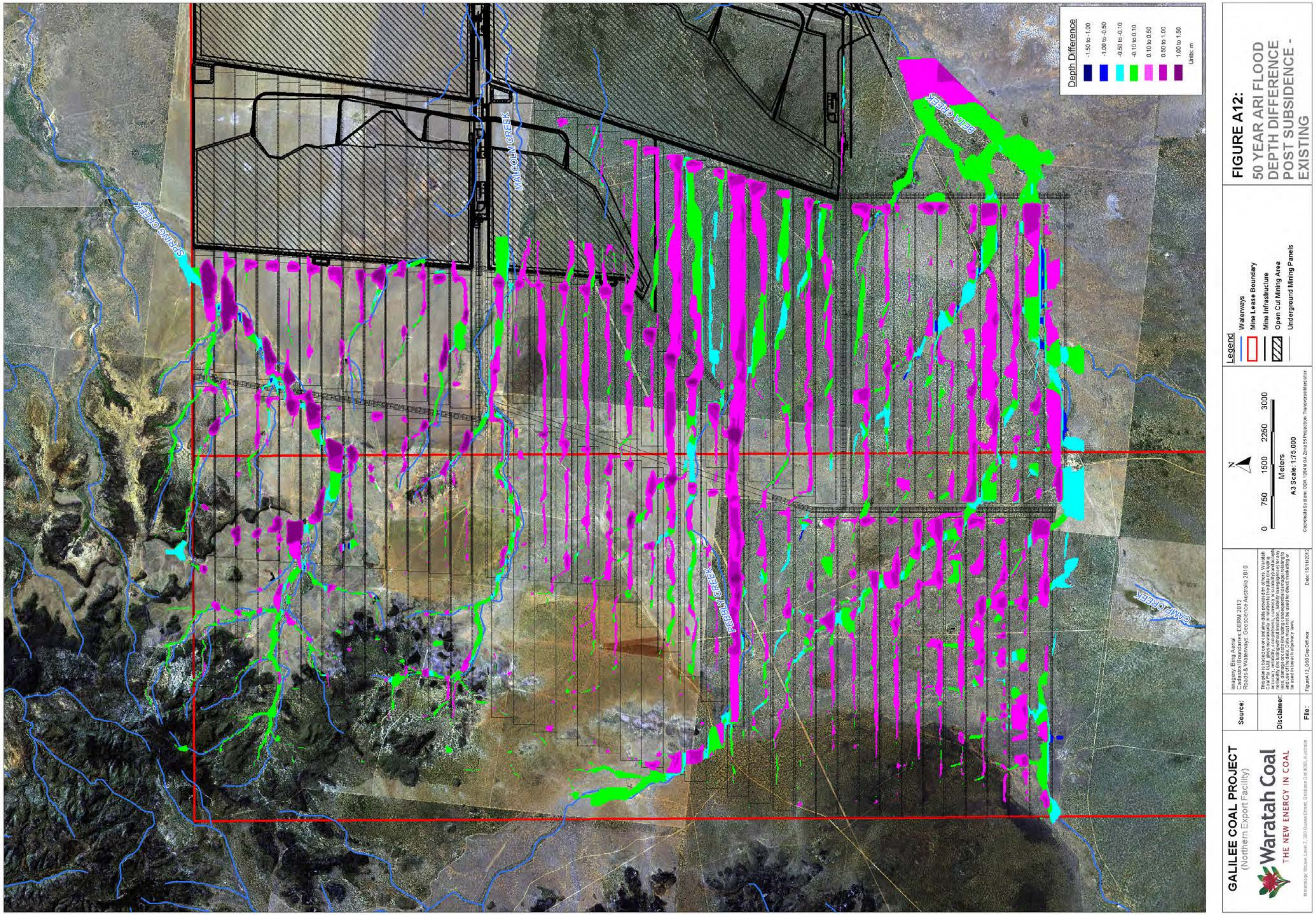
FIGURE A12:
50 YEAR ARI FLOOD DEPTH DIFFERENCE POST SUBSIDENCE - EXISTING
Depth Difference
-1.50 to -1.00
-1.00 to -0.50
-0.50 to -0.10
-0.10 to 0.10
0.10 to 0.50
0.50 to 1.00
1.00 to 1.50
Units: m
Legend
Waterways
Mine Lease Boundary
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator
Source: Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
File: FigureA12_Q50 Dep Diff.wor
Date: 15/11/2012
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
SPRING CREEK
MALCOLM CREEK
BETA CREEK
PEBBLY CREEK
CAMP CREEK

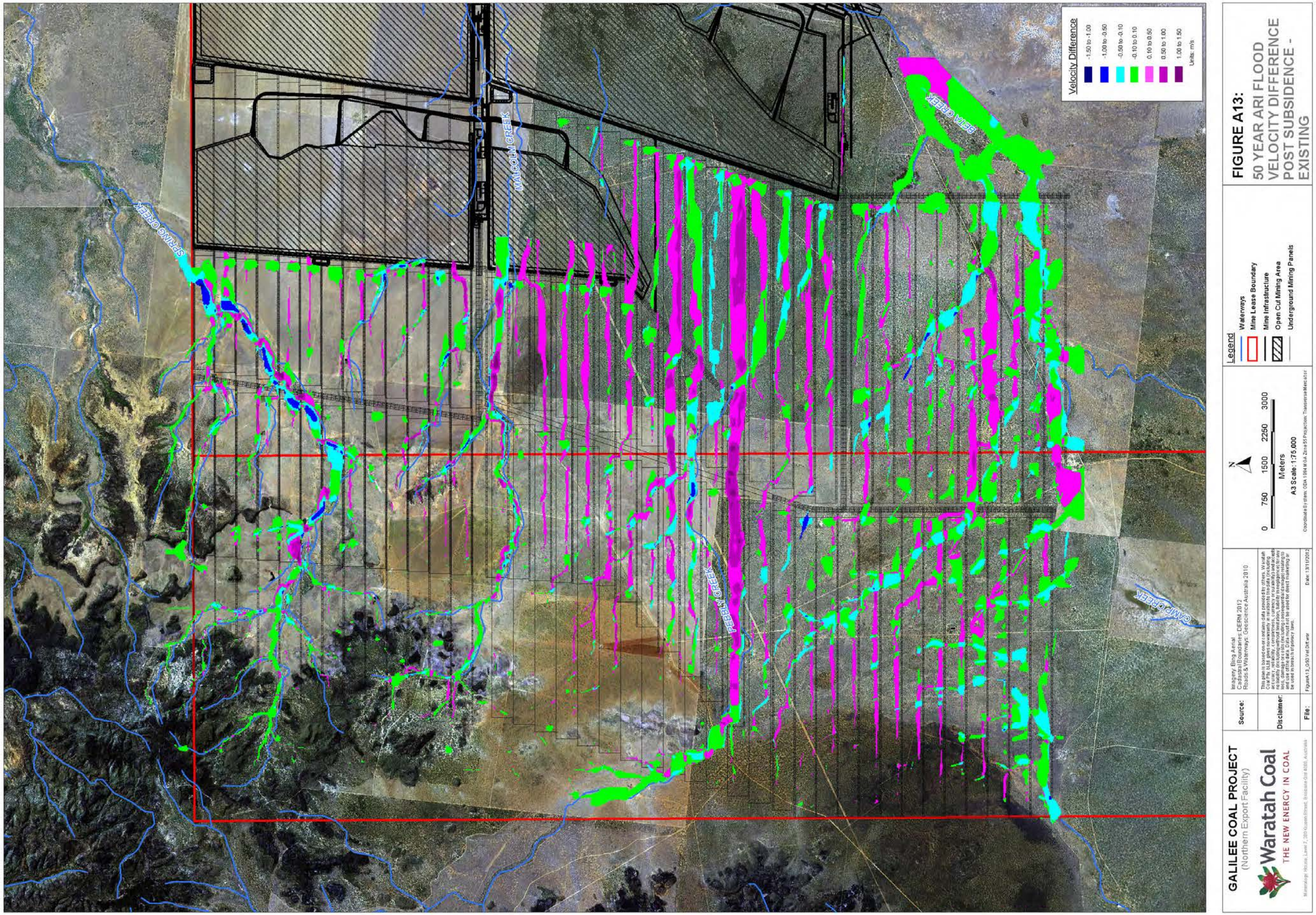
FIGURE A13:
50 YEAR ARI FLOOD VELOCITY DIFFERENCE POST SUBSIDENCE - EXISTING
Velocity Difference
-1.50 to -1.00
-1.00 to -0.50
-0.50 to -0.10
-0.10 to 0.10
0.10 to 0.50
0.50 to 1.00
1.00 to 1.50
Units: m/s
Legend
Waterways
Mine Lease Boundary
Mine Infrastructure
Open Cut Mining Area
Underground Mining Panels
0 750 1500 2250 3000
Meters
A3 Scale: 1:75,000
N
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator
Source: Imagery: Bing Aerial
Cadastral Boundaries: DERM 2012
Roads & Waterways: Geoscience Australia 2010
File: FigureA13_Q50 Vel Diff.wor
Date: 13/11/2012
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
SPRING CREEK
MALCOLM CREEK
BEDA CREEK
LAGOON CREEK
CAMP CREEK

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