Appendix 3: Rehabilitation Strategy and Final Landform

Bowmans Creek Diversion

Rehabilitation Strategy

May 2010

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1 INTRODUCTION

On 9th December 2009 an Environmental Assessment (EA) was submitted to the Department of Planning by Ashton Coal Operations Limited (ACOL) in support of an application for modification (MOD 6) of the existing development consent (DA 309-11-2001-i) for the Ashton Coal Project (ACP) located near Camberwell in the Singleton local government area of New South Wales. ACOL seeks to modify the 2002 development consent to provide for:

1. Underground mining operations which may result in a direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurring due to subsidence cracking;
2. The relocation of sections of Bowmans Creek as shown on **Figure 1** to mitigate subsidence impacts resulting from 1. above; and
3. Extraction of coal from the Upper Liddell Seam, Upper Lower Liddell Seam and the Lower Barrett Seam in the western most area of the approved underground mine (proposed Longwall 8 on **Figure 1**).

The ACP underground mine is a descending longwall operation targeting four coal seams in an area that is bounded to the north by the New England Highway and to the south by the Hunter River. Underground mining at the ACP commenced in December 2005 and it is expected that mining of the Lower Barrett seam will be completed by 2024.

In the light of extensive groundwater monitoring and better understanding of subsidence, ACOL has prepared a revised mine plan for the more efficient extraction of the coal resource in the vicinity of the Bowmans Creek alluvium which addresses the key issues of concern at the time that the original consent was granted. ACOL now considers that options are available that would allow diversion of the creek and the implementation of alternative mining plans which would result in acceptable environmental impacts whilst providing reserve optimisation, business sustainability and employment security. The potential impacts and the proposed mitigation measures are summarised in **Table 1** (which contains relevant extracts from the Executive Summary in the EA).

Table 1: Summary of Potential Impacts and Mitigation Measures

Aspect	Impact	Mitigation and Offset
Aquatic	Loss of **198m** in stream length, or 3.2% between existing and diversions.	– Increase width of diversions, such that there is an increase in pool area. – Incorporation of additional aquatic habitat (large woody debris) in the diversions. – Incorporation of fish friendly riffle and rock bar structures. – Provision of backwater resting pools to assist fish migration.
	6.7ha of existing riparian habitat area to be isolated by the block banks and diversions.	Diversions to incorporate **6.4ha** riparian habitat Excised sections of creek will progressively evolve to flood plain woodland and add to the diversity of habitat.
	Loss of floodplain grassland for construction of channels and other areas incorporated into fenced riparian zones.	The existing ACOL *Land Management Plan* proposes to fence and manage approximately 62ha of the Bowmans Creek riparian corridor (this includes 31ha of creek line and banks). This project will improve existing fencing and increase the fenced area by **41.6ha** (making a total riparian corridor of **103.6ha**) to exclude livestock, and permit the natural regeneration of floodplain and riparian vegetation.
Fauna	Loss of three (**3**) trees containing hollows.	Provision of replacement hollows or nesting boxes at a ratio of **3:1** within the riparian corridor.
Flora	Removal of **1.8ha** of existing riparian woodland at the connection points of the diversions.	The diversions will be planted with **7.3ha** of terrestrial riparian woodland of similar or better composition.
	Disturbance of **28.5ha** of pasture grasses from the diversions, stockpiles, haulage and site compounds.	**9.9ha** of this area will be returned to pasture for livestock grazing, while the remainder (**18.6ha**) will be planted as riparian woodland and/or actively managed.

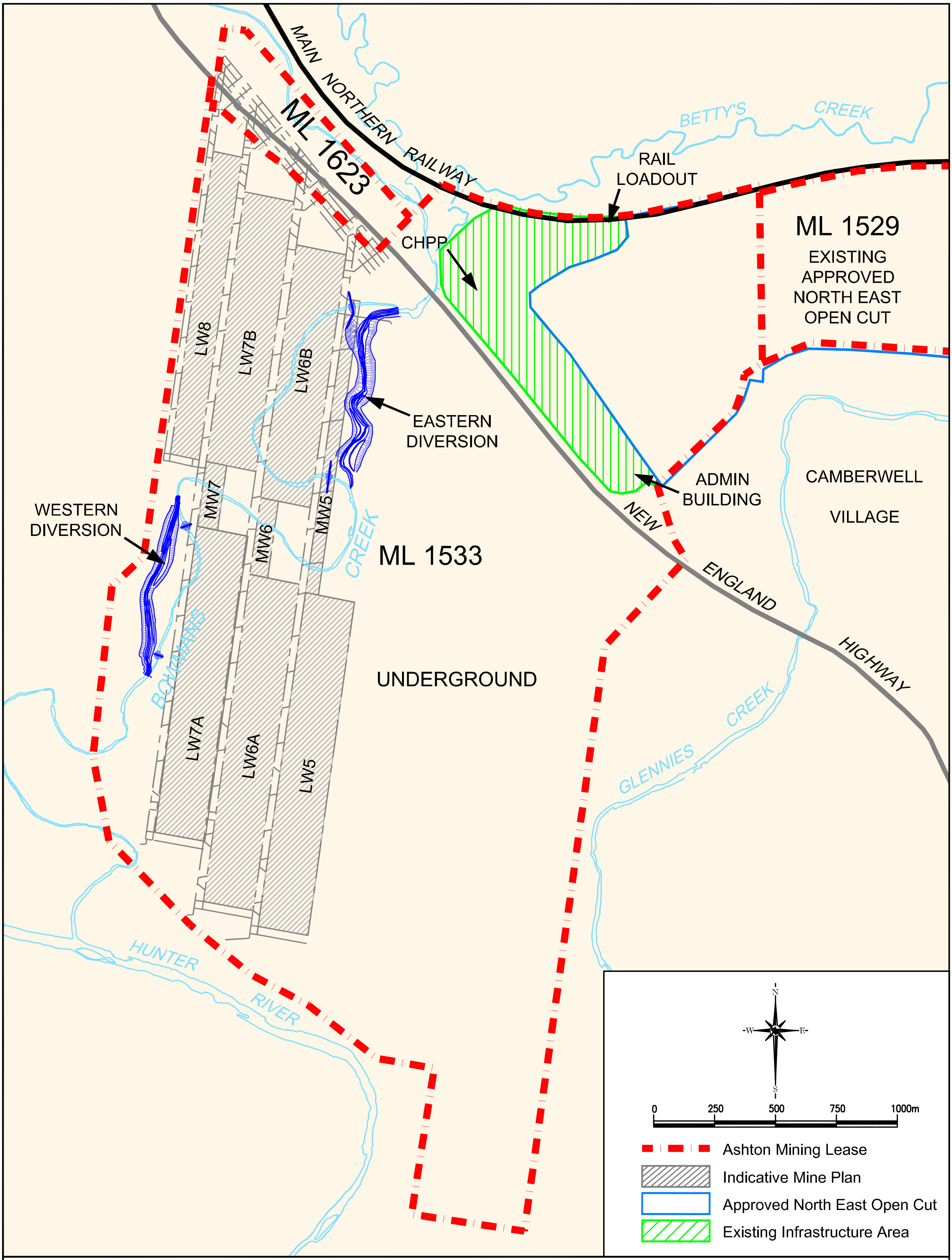
Table 1: Summary of Potential Impacts and Mitigation Measures

Aspect	Impact	Mitigation and Offset
Agriculture	Temporary loss of **9.9ha** of pasture for grazing of livestock from stockpiles, haulage roads and site compounds.	These areas will be progressively revegetated. Stockpiles will be used over time as a source material to remedy subsidence troughs and correct drainage. These areas will be returned to pasture grasses.
	Permanent loss of **72.6ha** of pasture for grazing of livestock from the improvement of fencing on the riparian corridor to exclude livestock, which includes the two diversions and northern-most stockpile.	In the case of the diversions these areas will be replanted with woodland, while the fenced riparian corridor will naturally revegetate and be managed for weed and erosion control measures.
Surface Water Flow	Baseflow reduction progressively increasing to a total of 47.5 ML/year by the end of mining and about 20 ML/year after 100 years recovery.	Impermeable barrier under the diverted sections to minimise loss. Residual loss will be off set against existing licences.
Surface Water Quality	Potential for degradation of surface water quality.	Salt load to the Hunter reduced by 36t/year. Exclusion of stock from riparian zone will reduce sediment load resulting from stock trampling. Diversion channels will be provided with erosion protection matting and dense planting in zone immediately adjacent to the channel below the 1 year flood level Temporary low block banks (overtopped in 6 month flow) to reduce the risk of flood damage in early stages of rehabilitation in diversion channels.
Subsidence	Subsidence induced strains, tilting and cracking of excised section of creek and alluvials.	Construction of diversion channels to minimise impacts to the creek. Partial extraction under the functional sections of creek
	Ponding of runoff or floodwater in subsidence troughs	Create free draining landscape by construction of drainage or filling of subsidence troughs.

In its submission to the Department of Planning, Industry and Investment NSW (I&I) sought further detail in relation to the rehabilitation of the proposed creek diversions and associated soil emplacements. In particular, I&I requested measurable completion criteria for the phases of the rehabilitation program and contingency strategies that could be implemented in the event that key elements of the rehabilitation fail to meet the requirements of the design.

This document provides a consolidated account of the overall design and rehabilitation strategy including the staging of construction and rehabilitation works, the safeguards and contingency measures embedded in the proposal, draft high level completion criteria and the proposed procedures for defining agreed final completion criteria with the relevant agencies. Much of the material contained in this document has been extracted from the EA and presented in a manner that focuses on the rehabilitation strategy, anticipated outcomes and monitoring activities.

Cross reference to the original EA documentation is provided where necessary. For clarity, references to tables and figures in this document are in **bold**, while cross references to the EA are generally in *italics*.



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Bowmans Creek
Diversion Project

Figure 1
Proposed Creek Diversions and Longwall Layout
Assuming Stacked Arrangement

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2 REHABILITATION PLANNING

2.1 Introduction

Ashton Coal Operations Ltd (ACOL) acknowledges that rehabilitation of mined land is an integral part of the mining process. It is also acknowledges that the best long term environmental, social and economic outcomes for the Bowmans Creek Diversion project will be achieved through integrating rehabilitation objectives into project design and planning. Further, that on-ground rehabilitation works must commence as soon as practicable following mine disturbance and be progressively carried out throughout the life of the project. This will enable ACOL to meet its rehabilitation and mine closure objectives, following the completion of underground mining related to the Bowmans Creek project (Longwalls/Miniwalls 5-8).

The approach adopted in developing the concept for the construction and rehabilitation associated with the diversion of Bowmans Creek and the subsequent rehabilitation of the diversion channels and subsidence impacts on the alluvial floodplain is based on the hierarchy of processes identified by Tongway (CSIRO Sustainable Ecosystems) in relation to the rehabilitation of mined landscapes (see **Figure 2**).

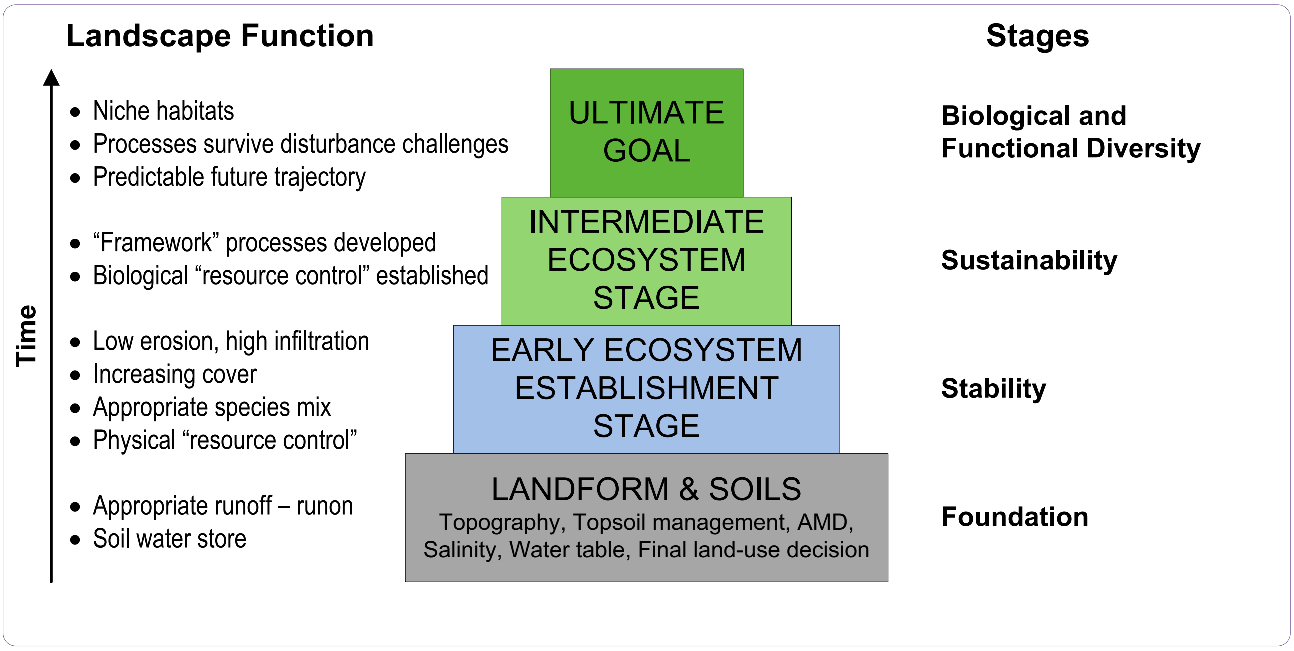


Figure 2:
Hierarchy of Processes on Rehabilitation Sites Over Time
(after Tongway, Undated)

The concepts illustrated in **Figure 2** have been adapted to the requirements of the Bowmans Creek Diversion project by recognising the following hierarchy:

• **Foundation**	Appropriate physical form of the diversion channels to provide the required hydraulic and geomorphic characteristics together with aquatic habitat opportunities**;**
• **Stability**	Initial stabilisation of the landscape with physical methods (rockwork, erosion control matting, etc) and selected vegetation;
• **Sustainability**	Further planting to provide vegetation community structure;
• **Diversity**	Augmentation of vegetation to provide functional diversity and resilience.

The development of the concept design and rehabilitation strategy for the Bowmans Creek Diversion project recognised the importance of a sound physical foundation, as illustrated in **Figure 2**. The approach taken was to copy the geomorphology and habitat of the existing creek. The first step was to characterise the geomorphology and physical habitat (hydraulics) of the existing creek. Characterisation of the geomorphology and physical habitat is reasonably straightforward because the fundamental processes are governed by basic physical laws of hydraulics and sediment movement that have been understood for centuries. Industry standard methods for analysing the creek's hydrology, hydraulics, and potential for sediment movement were utilised meaning that there is little complexity and uncertainty associated with recreating the geomorphology and habitat of Bowmans Creek.

The progressive development of the rehabilitation hierarchy for Bowmans Creek not only provides a robust basis for creation of a long term sustainable ecosystem, but also takes account of the progressive changes in the floodplain that will occur as a result of mining of successive coal seams and provides a basis for the staging of rehabilitation.

Completion of underground mining operations in the vicinity of Bowmans Creek will be undertaken in consultation with government authorities and key stakeholders and be consistent with ACOL's rehabilitation objectives and commitments. The overall rehabilitation objectives for the Bowmans Creek Diversion project are to:

- Rehabilitate the diverted sections of Bowmans Creek to a naturally vegetated state using appropriate endemic species to provide improved riparian and aquatic habitat compared to that which exists at present (as demonstrated by comparison to reference sites and baseline monitoring undertaken to date);
- Restore land affected by subsidence to a free draining landform suitable for agriculture and native vegetation establishment to complement the riparian vegetation and vegetated corridor linkages.

In addition to rehabilitating mine impacted areas, the project will also improve existing degraded sections of Bowmans Creek including the existing River Red Gum communities to provide significantly improved riparian and aquatic habitat compared to that which exists at present (as demonstrated by reference to monitoring undertaken to date).

The Bowmans Creek Diversion project will potentially disturb an area of 30.3 ha (1.8 ha of riparian woodland and 28.5 ha of pasture grass – see **Table 1**), comprising the two sections of creek diversion (total 1,734m in length), the areas of the Bowmans Creek alluvial floodplain affected by subsidence and areas to be used for temporary placement of alluvial spoil extracted during the construction of the diversion channels.

The vision for the final rehabilitation associated with the Bowmans Creek Diversion project is shown on **Figure 3** (which is a copy of *Figure 10.3* from the EA). Rehabilitation will be undertaken in a progressive manner as soon as practicable after construction of the diversion channels and as subsidence affects the areas of the Bowmans Creek floodplain. At completion of underground mining associated with Bowmans Creek Diversion project (Longwalls/Miniwalls 6-8), it is envisaged that Bowmans Creek and the associated riparian restoration areas will be used for conservation and potentially for the purposes of passive recreation and environmental education. Other areas of the alluvial floodplain that have been subject to subsidence will be restored to provide a free draining landscape capable of being used for grazing or cropping purposes.

The specific rehabilitation objectives for the Bowmans Creek Diversion project are:

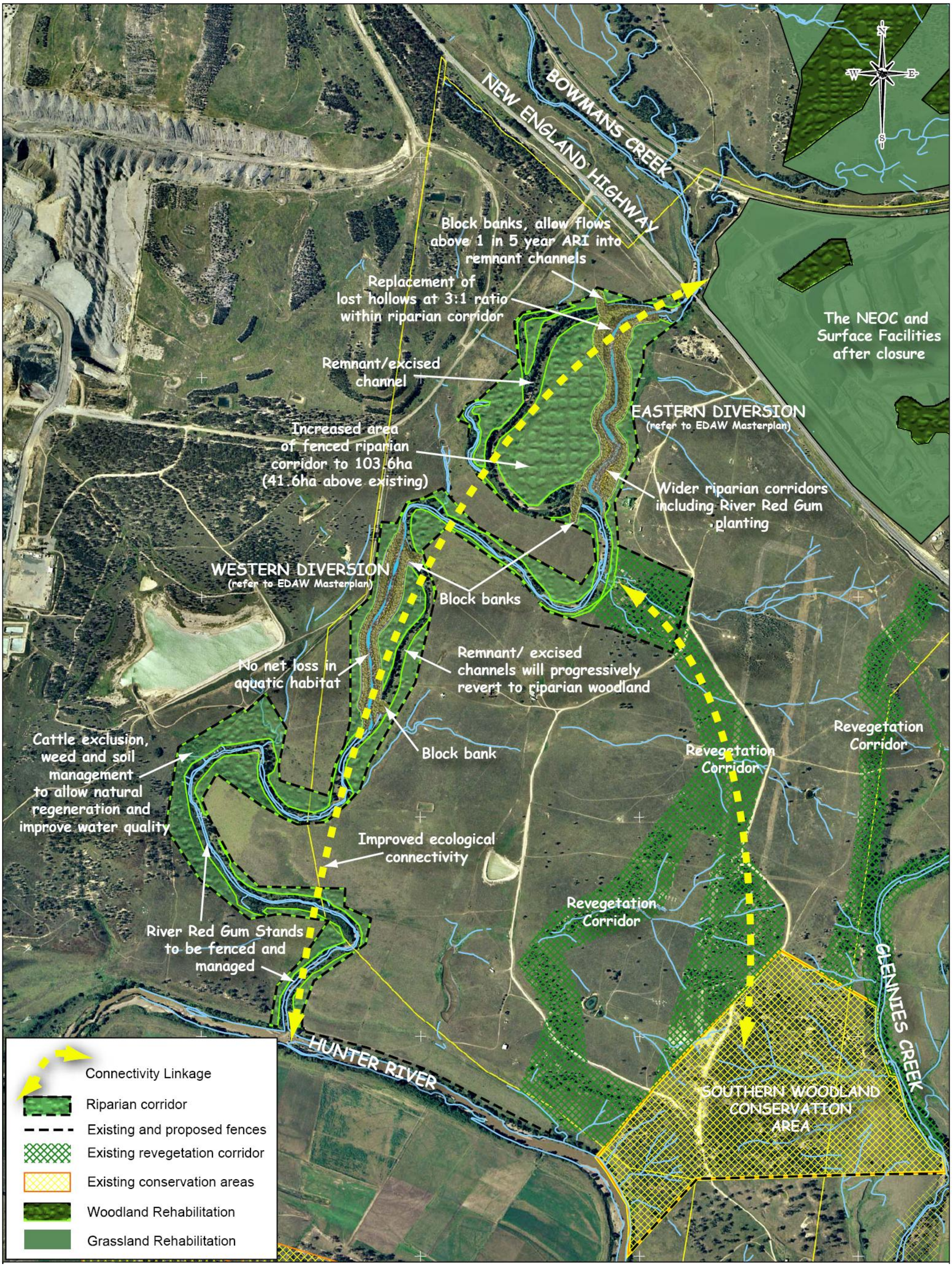
- Creating a natural looking, stable creek that mimics the geomorphic form of the existing channel of Bowmans Creek and provides increased areas of aquatic habitat as well as improved diversity and quality of aquatic habitat (pools and large woody debris) whilst maintaining the fish passage characteristics of the original creek;

- Creating a self sustaining and ecologically diverse riparian corridor along the length of Bowmans Creek between the Hunter River and the New England Highway including revegetating and enhancing remnant riparian vegetation on non-mine affected land with endemic native species including River Red Gums so as to increase the area and quality of native riparian woodlands, particularly along the section of Bowmans Creek located between the Hunter River and the Western Diversion;
- Creating revegetation links and habitat corridors between existing remnant vegetation (to the east of Bowmans Creek near the southern end of the Eastern Diversion) and the Southern Woodland Conservation Area that connects to the Hunter River and Glennies Creek (located on ACOL land – see **Figure 3**);
- Maintaining the diversity and genetic resource of flora currently existing within the locality;
- Maintaining and enhancing habitat for native fauna;
- Reinstating surface drainage to create a free draining landform by filling areas of subsidence on the alluvial floodplain and provision of minor drainage works on adjoining land;
- Preventing soil erosion and sedimentation as a result of construction works, placement of temporary stockpiles or as a result of changes in land slope as a result of subsidence;
- Fencing designated riparian and revegetation corridors so as to prevent impact from domestic stock;
- Providing access for monitoring and adaptive management, control of competitive native and exotic flora and fauna species and suppression of fires;
- Progressing towards meeting closure and post-mining land use objectives in a timely and cost effective manner.

These rehabilitation objectives provide an opportunity to enhance and improve the ecological value of the area Bowmans Creek riparian zone and floodplain by re-establishing native vegetation along the length of the creek between the Hunter River and the New England Highway as well as across an area between the existing creek and the Eastern Diversion that has previously been cleared for agriculture.

To achieve these objectives, ACOL will:

- Progressively revegetate the diversion channels in order to provide initial stabilisation against scour followed by further augmentation to provide community structure and subsequent enrichment of species diversity;
- Continue to manage weeds (willows, blackberry, etc) and undertake supplementary planting along retained sections of the creek in order to provide enhanced riparian community structure and species diversity in line with the standard of rehabilitation proposed for the diversion channels;
- Exclude domestic stock from the riparian zone along Bowmans Creek between the Hunter River and the New England Highway;
- Revegetate the temporary stockpiles of alluvial spoil to stabilise against erosion from rainfall and flowing water;
- Re-distribute the material from the temporary stockpiles as subsidence of the floodplain occurs in order to maintain a free draining landform. All filling of subsidence areas will be revegetated in a manner consistent with the final land use (riparian floodplain forest or agriculture);
- Continually refine a monitoring and maintenance program to guide rehabilitation success and provide continual improvement to meet the long-term post-closure land use objectives.



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Bowmans Creek
Diversion Project

Figure 3
Post Mining Landscape, Connectivity and Offsets

2.2 Rehabilitation Principles

Mine rehabilitation generally comprises two stages: design and construction of a stable landform, and establishment of a sustainable post-mining land use which, in this case, involves the provision of four key elements:

- Channel geomorphology that mimics the existing channel;
- Provision for fish passage and a rich diversity of aquatic habitat;
- An ecologically diverse naturally vegetated riparian corridor;
- A free draining floodplain that is vegetated to a standard consistent with the final intended land use.

Successful rehabilitation of Bowmans Creek and its alluvial floodplain will be achieved through the application of the following guiding principles:

- Adoption of mine completion criteria based on creek and landform design, erosion control, drainage, soil processes, flora, fauna and ecosystem function as set out in **Section 6** of this report;
- Progressively implement the rehabilitation strategy in line with the sequence of underground mining and consequential subsidence of the floodplain;
- Selectively stockpile gravel/cobbles, topsoil and other alluvial fill extracted during construction of the diversion channels. These materials will be re-used in the construction of the diversion channel (gravel/cobbles for bed and bars, topsoil for upper batters) and filling of floodplain subsidence areas with mixed alluvial material followed by topsoil for enabling successful establishment of relevant plant species;
- Seed and manage temporary stockpiles with appropriate species to provide erosion control;
- Retain as much of the existing riparian vegetation as possible as well as habitat trees with hollows;
- Where possible, reuse removed trees for large woody debris within both the retained and new sections of the creek;
- Use other vegetation for respreading on the batters of the constructed channels and temporary stockpiles, in either a mulch or directly spread form;
- Re-fill and re-contour subsided areas of the floodplain to create a stable, adequately drained landscape that complies with rehabilitation and erosion control guidelines and post-mining land use objectives;
- Continue the existing pest and weed control program to eliminate existing weeds and prevent the introduction of pests and noxious weeds in rehabilitated areas;
- Use an adaptive management approach with continuous improvement;
- Provide necessary access for the suppression of fires, control of competitive native and exotic fauna and noxious weeds, and monitoring of rehabilitated areas.

2.3 Completion Criteria

In line with best practice rehabilitation, ACOL intends to develop agreed completion criteria in consultation with the relevant agencies based on the process suggested by Nichols (2005) and illustrated in **Figure 4**.

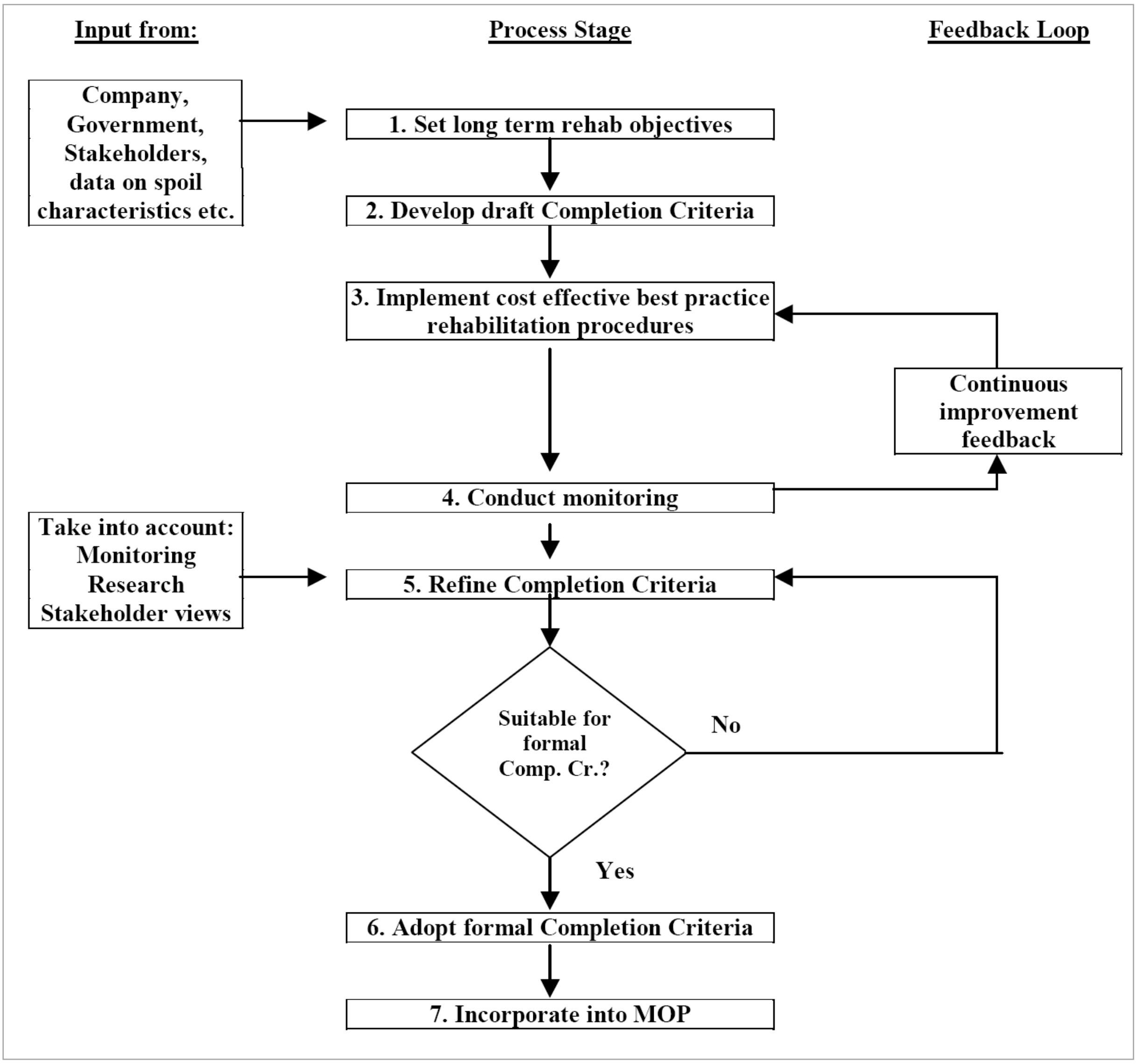


Figure 4:
Suggested Process for Developing Completion Criteria
(from Nichols, 2005)

The proposed long term rehabilitation objectives for Bowmans Creek and its associated alluvial floodplain are set out in **Section 2.1** above. The key indicators that ACOL proposes to take into account in developing completion criteria are set out in the following sections of this document. In line with the process suggested in **Figure 4**, ACOL proposes to develop detailed completion criteria based on:

- The use of reference (or "analogue") sites where available, or baseline monitoring results as applicable as benchmarks against which the relevant completion criteria will be measured;
- Monitoring the key indicators over time so as to track their trajectory towards the benchmarks defined by the reference sites or baseline data (see **Error! Reference source not found.**).

Details of the proposed reference sites, relevant baseline data and key indicators that reflect different facets of the various domains within the project area are provided in subsequent sections of this report.

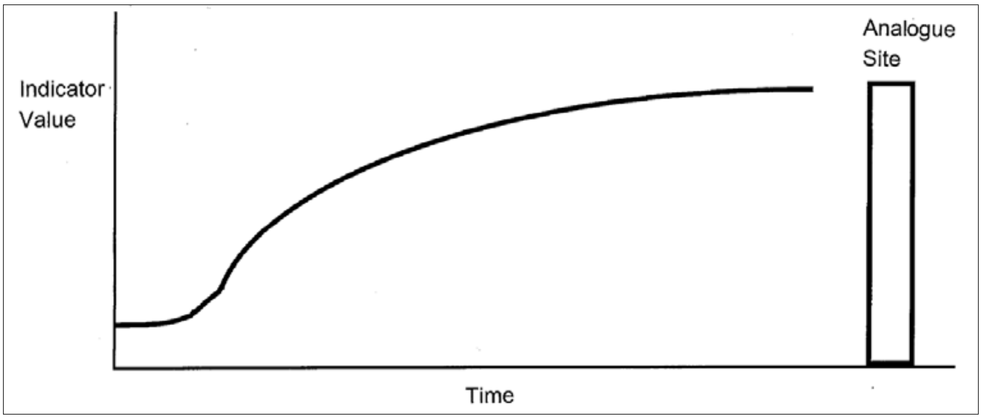


Figure 5:
Classic Successional Trajectory Following Disturbance
(after Nichol, 2005)

2.4 Project Staging

The Bowmans Creek Diversion project involves a series of stages that reflect the sequence of underground mining which, in turn, have been taken into account in the planning and scheduling of the rehabilitation program.

Figure 2.5 and *Figure 2.8* of the EA provide indicative schedules for mining of the four coal seams over 15 years and the construction and initial rehabilitation of the diversion channels. An overall indicative project schedule that illustrates the interdependence of mining (and the ensuing subsidence), channel construction, flow diversion and stages of rehabilitation (that reflect the hierarchy in **Figure 5**) is shown in **Figure 6**.

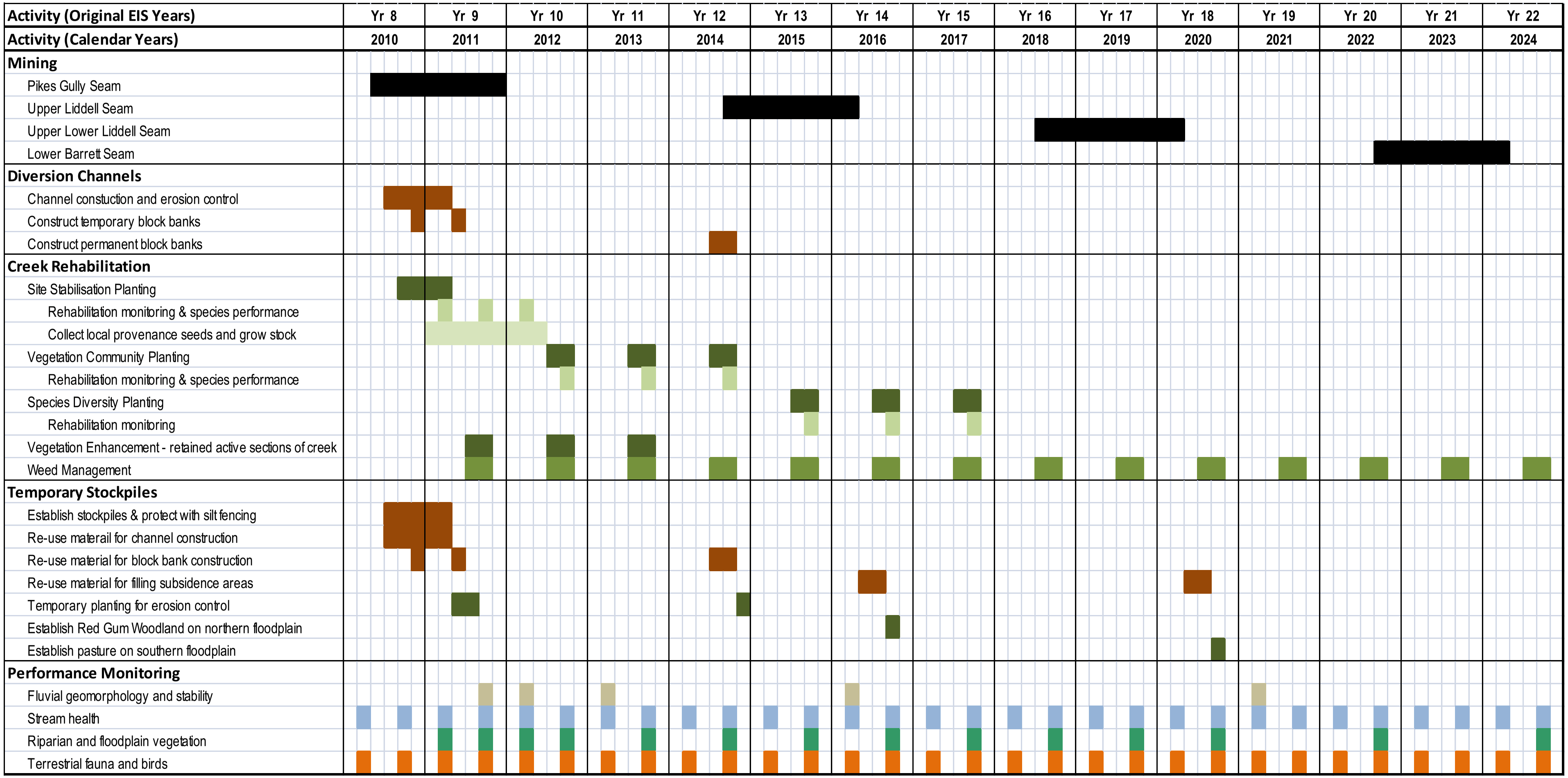


Figure 6:
Indicative Schedule for Mining, Rehabilitation and Monitoring

3 CHANNEL AND LANDFORM DESIGN

Details of the proposal to divert two sections of Bowmans Creek have been developed taking into consideration significant monitoring of the channel form, surface water quality and stream health that has been under taken since 2002. This monitoring has taken the form of;

- Routine water quality monitoring;
- Spring and autumn monitoring of stream health (see Marine Pollution Research 2005, 2007a, 2007b, 2008a, 2008b, 2009a);
- Geomorphic assessment including two sets of detailed topographic survey of the channel at 51 locations before and after the flood of June 2007 (approximately 35 year average recurrence interval) (see ERM 2006a, Maunsell Australia 2008).

As a result of the 2007 flood, 42 cross sections showed negligible change. Of the others:

- Four locations at which bed lowering occurred were in the reach of the creek immediately upstream of the Hunter River (as least 1.3 km downstream of the Western Diversion);
- One location at which bed lowering occurred was in the reach of the creek upstream of the proposed Eastern Diversion;
- Two were located in the section of channel to be retained between the two diversion channels;
- One, located in the channel adjacent to the Western Diversion, exhibited bed lowering of 0.17 m and the other, located in the creek adjacent to the Eastern Diversion showed an accretion of 1.38 m.

The effects of the 2007 flood on channel stability and scour have been taken into account in the development of an integrated set of engineering and rehabilitation works that are designed to retain the key geomorphic characteristics of the creek and provide an opportunity to significantly enhance the quality and diversity of riparian and aquatic habitat. The fact that the existing creek channel was relatively stable in a significant flood provides a high level of confidence that the diversion channels, which mimic the existing channel form, will remain stable in major floods.

The concept for the diversion of Bowmans Creek has been based on the following hierarchy of measures to ensure that the diversion channels are resilient and perform in the same manner as the existing creek in the long term:

- **Robust design** based on sound technical analysis of the hydraulic and geomorphic characteristics of the existing creek (as endorsed by Erskine, 2006) and best practice for stream rehabilitation (eg. Raine & Gardiner 1995, Rutherfurd et al 2000). In this instance, the survey cross sections from the existing creek were used as templates for the diversion channels with adjustment in bed elevation to conform to the required pool and riffle sequence. Stability analysis under different flow conditions (taking account of the observations from the 2007 flood) has been used to ensure that the channel has sufficient depth of cobble bed to accommodate natural changes as a result of floods while ensuring that bed load transport will continue in the same manner. In addition, rock bars and ramps have been added to the design to provide fixed control points for bed elevation and channel location.
- **Construction staging and methodology** that will involve close supervision by an experienced geomorphologist to ensure that all elements of the construction are carried out in accordance with designs and sound geomorphic principles. The construction program also provides for staging of construction of block banks to initially only divert moderate flows (up to 6 months average recurrence interval) into the diversion channels.
- **Staged rehabilitation** that commences with extensive use of erosion control matting to provide initial stability supplemented with extensive dense planting on the low active floodplain and inset benches.

3.1 Channel Design

The proposal involves the construction of two diversion channels on Bowmans Creek between the New England Highway and the Hunter River to mitigate the impact on Bowmans Creek that would result due to subsidence:

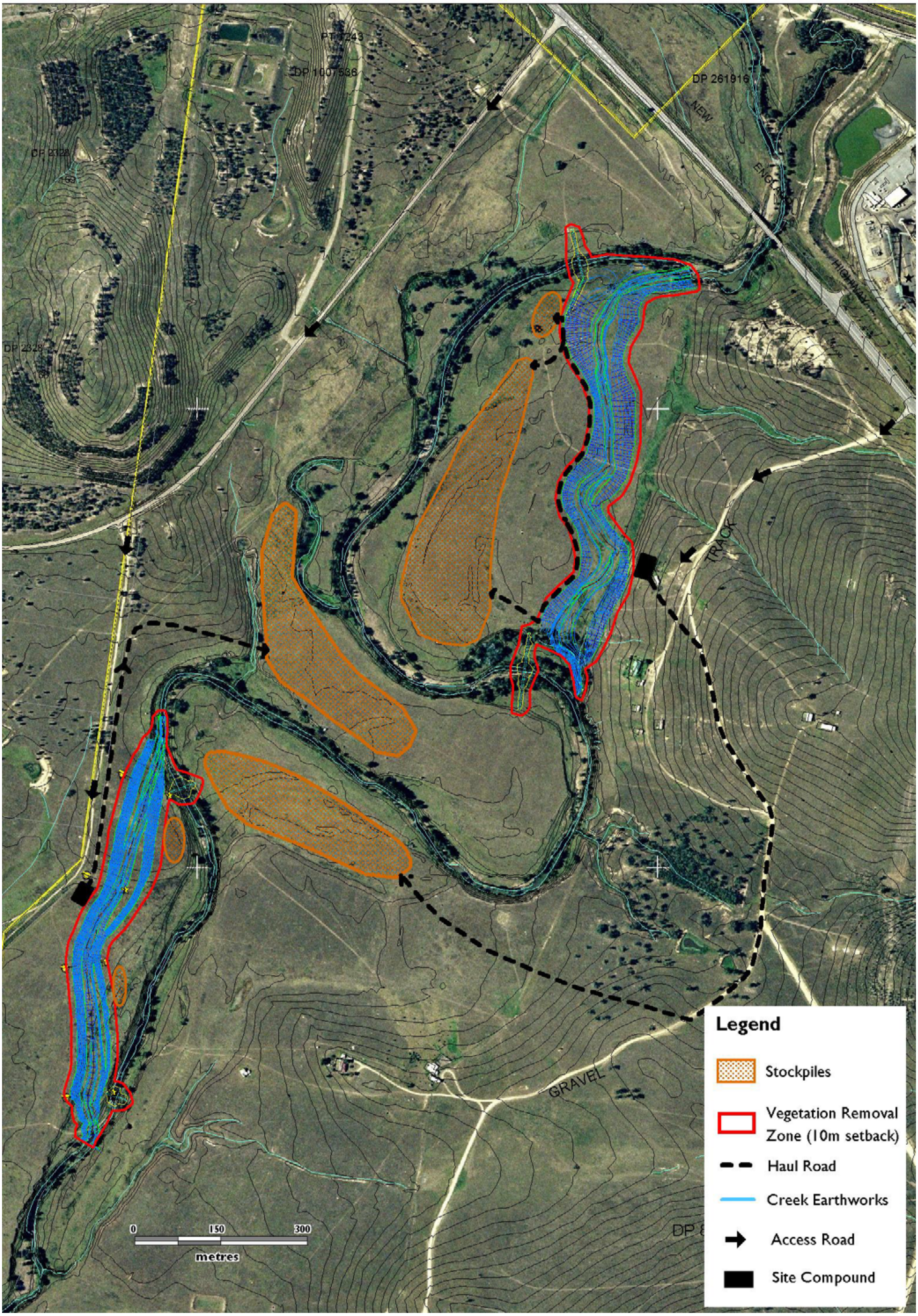
- Eastern Diversion which will start about 175m south of the New England Highway and extend for about 955m approximately along the eastern edge of the alluvial floodplain to join an existing oxbow channel (approximately 125m long) and then drain into the existing creek. This diversion will involve excavation of a meandering channel that mimics the geomorphic features of the adjacent reach of Bowmans Creek, including variable width (about 35m to 100m) and variable bed levels to create pools and riffles. Typical maximum excavation depth in this diversion varies from 4.0m to 5.5m. The volume of material to be excavated includes approximately 140,000m^3 of bulk earthworks to form the macro-channel and 20,000 m^3 of detailed earthworks to create the detailed topography of the stream bed zone (low flow channel, low active floodplain and inset benches); and
- Western Diversion which will start just downstream of the existing streamflow monitoring station (operated by the Office of Water). This diversion, which will extend for approximately 780m, will also mimic the geomorphic characteristics of the adjacent reach of Bowmans Creek which is typically about 7m deep. The top width of this diversion channel varies from 45m to 70m. The volume of material to be excavated is approximately 180,000m^3 bulk earthworks to form the macro-channel and 15,000 m^3 of detailed earthworks to create the detailed topography of the stream bed zone.

Figure 7 (copy of *Figure 2.6* from the EA) provides an overview of the proposed diversion channels and associated block banks (to redirect flow) together with the location of temporary stockpiles for excavated material that will subsequently be used to fill subsidence troughs in order to create a free draining landscape. The stockpiles are located:

- Mainly in areas that are not affected in a flood with an average recurrence interval (ARI) of 20 years.
- In areas that do not require haulage across the existing creek channel or the diversion channels either for initial placement of material or for subsequent re-use of stockpiled material for construction of block banks or filling of subsidence troughs.

Where the stockpiles have a minor encroachment onto areas affected by a 20 year ARI flood the encroachment is only into flood fringe areas that would be subject to low flow velocities.

On the basis of the cross-section data, and the field survey, the main cross-sectional dimensions of the two sections of existing creek corresponding to the two proposed diversion channels have been characterised in terms of mean and standard deviation (see *Tables 9.1 and 9.2* of the EA). These data form a basis for the design of the diversion channels. The data indicate that the two sections of the creek that will be excised are quite different in many geomorphic respects with the upper (Eastern) section of creek corridor being broader and less incised than the lower (Western) section.



Bowmans Creek
Diversion Project

Figure 7
Site Works Overview

The design of the diversion channels (see *Plan Set 2* in Volume 3 of the EA) incorporates a high degree of geomorphic and landscape complexity which is intended to:

- Mimic the important geomorphic characteristics of each of the sections of the creek to be excised. This is illustrated in **Figure 8** (*Figure 2.7* in the EA) which shows perspective views of the existing and proposed channels;
- Provide comparable fish passage and comparable, or better, quality aquatic habitat than the existing creek including pools and riffles, supplemented with large woody debris (largely absent from the existing creek);
- Provide the basis for significantly improved riparian habitat quality compared to the excised creek sections; and
- Provide comparable hydraulic conveyance to the existing creek.
- The key criteria for developing the channel design relate to geomorphic and ecological considerations rather than the primarily functional hydraulic objectives of earlier proposals.
- **Table 2** summarises the key physical objectives, the numerical criteria or strategy adopted for the design of the diversion channels while **Table 3** provides the design objectives for aquatic habitat and the low active floodplain.

Table 2: Key Physical Design Objectives

(Source EA Table 2.4)

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Conveyance**		
1.1	Divert flows up to 5 year ARI	152 m^3/s	152 m^3/s
1.2	Minimise seepage losses in 80th – 100th percentile low flow range	Seal under low flow channel (80th percentile flow =2 ML/day (0.023 m^3/s)	Seal under channel to convey flow up to 10 m^3/s
2	**Channel Morphology and Stability**		
2.1	Channel shear stress	Comparable to existing	Comparable to existing
2.2	Low flow channel cross section and long profile	Mimic existing	Channel sections copied. Longitudinal profile with similar variation
2.3	Floods inundate low level floodplain	Inundation at least once per year	Low level floodplain inundated once per year
3	**Channel Alignment and Geometry**		
3.1	Maximise channel length with sinuosity within defined corridor	Existing E channel grade 0.17% Existing W channel grade 0.39%	E channel grade 0.24% W channel grade 0.40%
3.2	Batter slopes comparable to existing channel	1:3.5 - 1:11	Typical batter slopes 1:4 – 1:7
3.3	Maintain comparable lower active flood plain	Range 21 - 35+m	Channels sections copied
3.4	Maintain comparable width of incised creek corridor	Range 50 - 100m	Channels sections copied
3.5	Sinuosity	Mimic existing channel sinuosity as far as possible	Comparable channel alignment
4	**Flood Levels and Flood Storage**		
4.1	100 year ARI flood level at Highway	No increase	No increase
4.2	Flow velocity at Highway	Peak 100 year ARI velocity 4.3 m/s	Peak 100 year ARI velocity 4.5 m/s
4.3	Flood storage volume	No significant loss	Increased flood storage

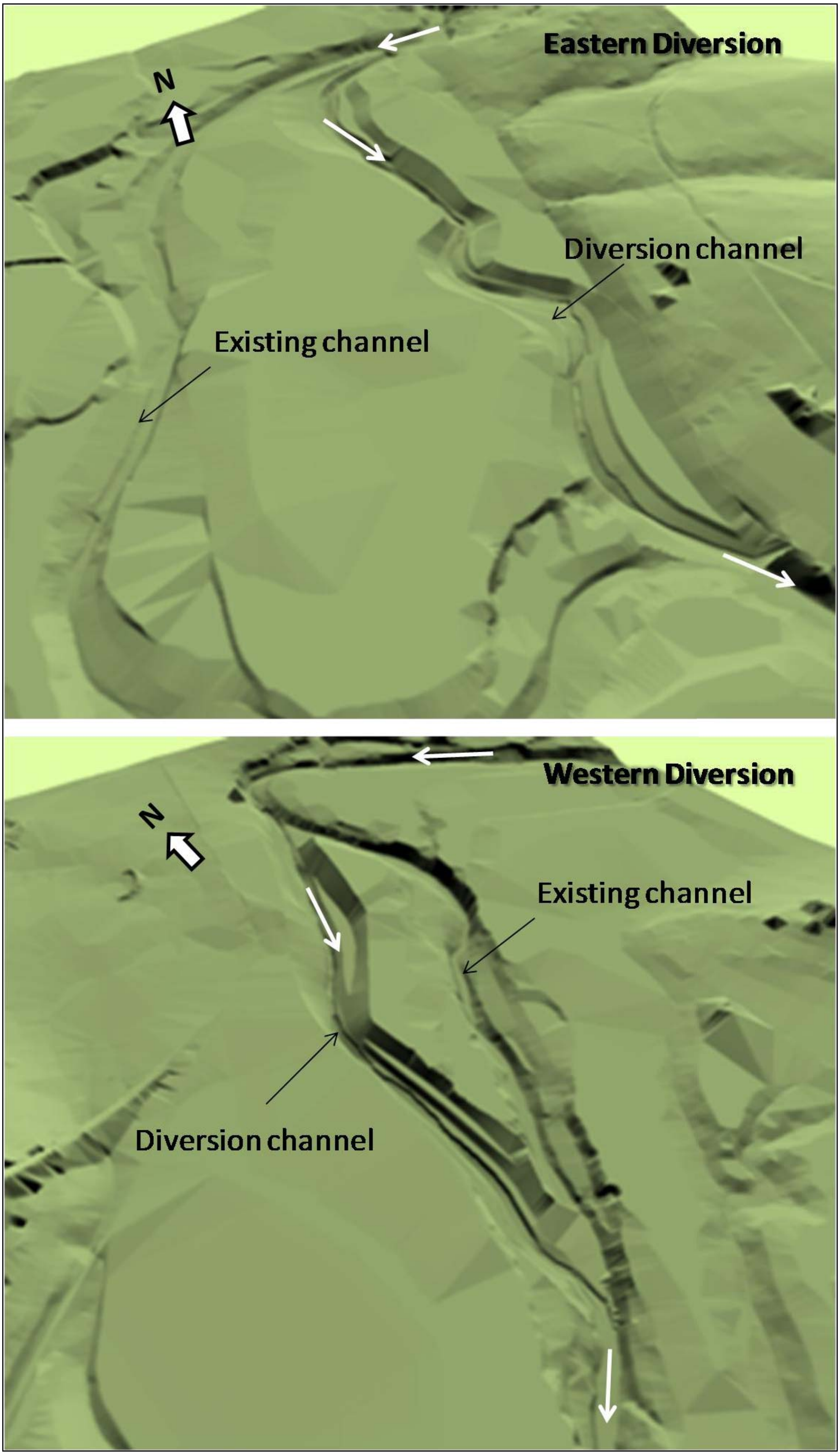


Figure 8
Landscape Perspective Showing
Diversion Channels

(Source: Fluvial Systems)

Table 3: Key Design Objectives for Aquatic Habitat and Low Active Floodplain
(Source EA Table 2.4)

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Fish Passage and Aquatic Habitat**		
1.1	Fish passage when creek flowing	Passage possible in moderate flow	Flow conditions similar
1.2	Provide appropriate pool and riffle sequence	Mimic existing channel	Pool and riffles mimic existing creek
1.3	Maximum bed slope of riffles	Approximately 5%	Approximately 5%
1.4	Maintain comparable pool area	0.9 ha	1.1 ha
2	**Riparian and Low Active Floodplain Ecology**		
2.1	Maintain area of lower active floodplain area inundated in 1 year ARI flood	6.7 ha	6.4 ha
2.2	Improve habitat value of lower active floodplain	Revegetate and exclude domestic stock	Establish plant communities characteristic of those present prior to European colonisation
2.3	Ecosystem resilience	Create robust, relatively self-sustaining ecosystem	

Flow will be directed into the diversion channels by means of block banks across the existing creek. These block banks will ultimately be constructed to a level approximately the same as the surrounding floodplain which corresponds to about the 5 ARI flood level. Floods in excess of 5 years ARI will spill over the block banks and floodplain and into the existing creek channel.

In order to prevent leakage from the diversion channels, a geosynthetic clay liner (GCL) will be installed. Importantly, the cross section shape and bed levels of the diversion channels have been designed to mimic the geomorphic and aquatic habitat characteristics of the existing creek. To achieve this, and to ensure that flow velocities and scour potential are managed, a stream bed zone has been specifically designed using suitably graded cobble material to replicate the existing natural stream bed conditions.

The Bowmans Creek diversion channels have been designed to replicate the flow conveyance characteristics of the existing channel as well as mimic its geomorphic characteristics and maximise the area of riparian and aquatic habitat. While the diversion channels have been located to provide acceptable hydraulic characteristics, the block banks have been placed as far downstream or upstream as possible in order to maximise retention of the existing creek habitat. As a result of these considerations, the proposed project includes retention of a total of 385m of existing pools that will become backwater resting pools while remaining connected to the creek system. Overall the total length of creek between the Hunter River and the New England Highway will be reduced by 3% (195m see *Table 3.3* and *Table 3.4* of the EA for details).

3.2 Floodplain Landform

Longwall mining of all four coal seams will lead to subsidence above the longwall panels. The proposed measures to mitigate the consequences of these changes include:

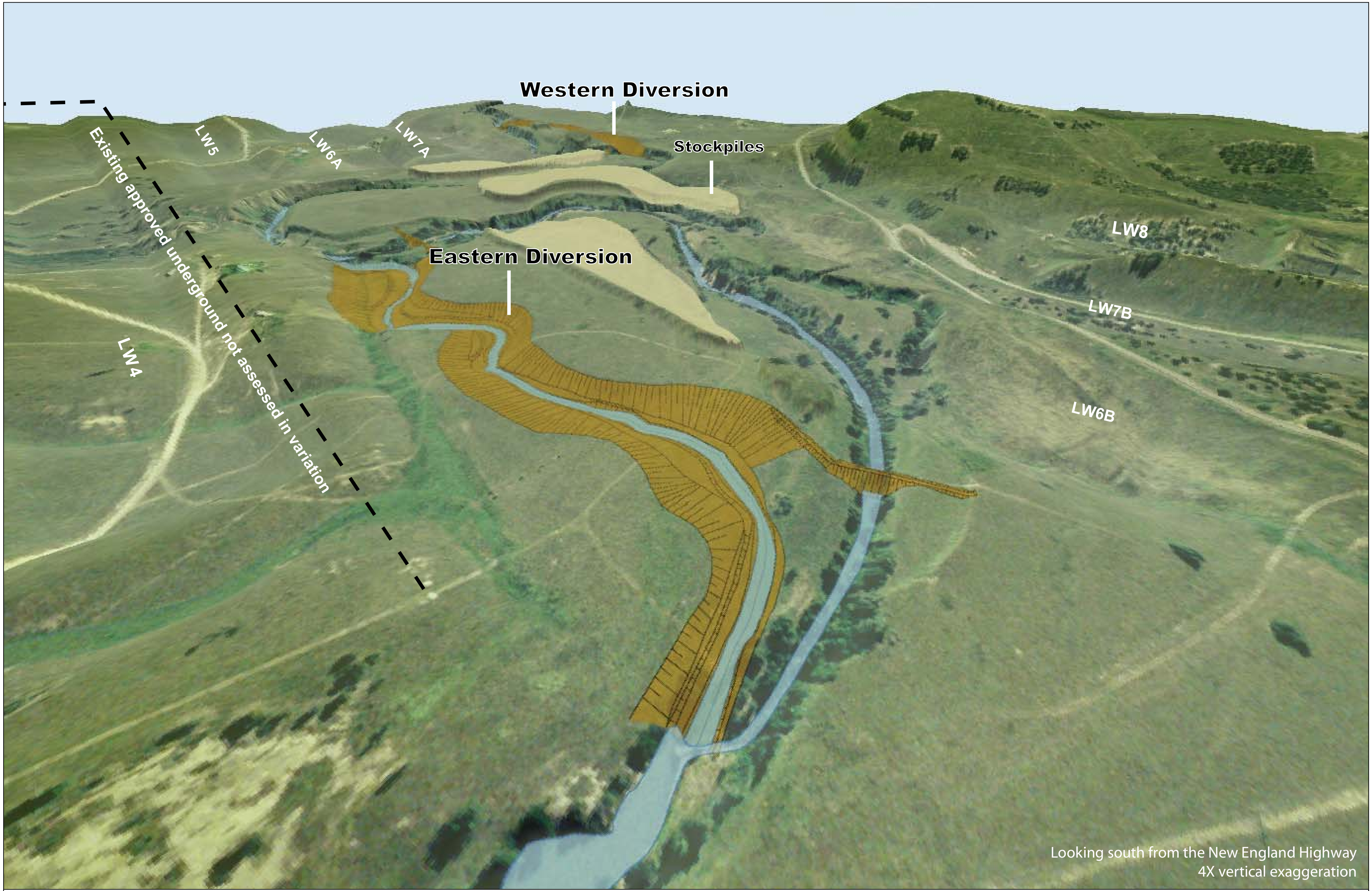
- Location of the diversion channels in areas which will be subject to minimal subsidence, if any (outside the alignment of the longwall panels);
- Use of "miniwalls" under those sections of the existing creek that will remain functional in order to minimise subsidence effects;
- Progressive filling and re-contouring of areas on the floodplain as necessary to maintain a free draining landscape;
- Drainage works on elevated land outside the floodplain as necessary to maintain a free draining landscape.

As part of the studies that support the project application, detailed analysis was undertaken, based on recent monitoring and research, to provide a high degree of certainty in the predictions of subsidence (see *Section 6* and *Appendix 4* of the EA). The subsidence predictions have been based on an assumed 'worst case' mine design in which longwalls in the lower seams are 'stacked' immediately below the one above.

Subsidence at the centre line of the longwalls is predicted to progressively increase from a maximum of 1.6m following mining of the upper seam (Pikes Gully) to a maximum of 8.3m following mining of the lowest seam (Lower Barrett). The predicted subsidence varies significantly from a maximum at the centreline of the longwall to a negligible amount (~20mm) about 50m outside the boundary of the longwall panels. The subsidence assessment included an analysis of the effects of the "miniwalls" that are proposed to run under those sections of the existing creek that will remain functional.

Figure 9 is a perspective view of the Bowmans Creek area following subsidence resulting from mining of all four coal seams. This view has been generated from the most recent data for the existing landform onto which the predicted subsidence, diversion channels, block banks and temporary stockpiles have been superimposed. It should be noted that the image shows the subsidence troughs and temporary stockpiles prior to re-working of the stockpile material to partially fill the subsidence troughs on the floodplain in order to create a free draining landform.

The data used to generate **Figure 9** has also been used to generate a series of cross sections and a longitudinal section through the final landform. These are contained in **Annexure A** to this report.



Looking south from the New England Highway
4X vertical exaggeration

AshtonCoal

Prepared by Wells Environmental Services

Bowmans Creek
Diversion Project

Figure 9
Perspective Landform Following Subsidence from Longwalls in the Immediate Vicinity of Bowmans Creek and its Alluvial Floodplain

4 CONSTRUCTION AND SPOIL MANAGEMENT

Commencing with the Eastern Diversion, construction and rehabilitation of the diversion channels will occur over a total of about six months and will follow the construction sequence outlined below and described in greater detail in *Section 12* of the EA. Construction will commence at the downstream end of each diversion channel and progress upstream so as to ensure that all joins in the geosynthetic clay liner have the exposed edge on the downstream side. Excess spoil from the diversion channels will be stockpiled as shown on **Figure 7** for subsequent re-use for filling subsidence troughs on the floodplain to create a free draining landscape.

4.1 Site Preparation and Clearing

The locations of the diversion channels and the temporary stockpiles have been selected so as to minimise the impact on the existing riparian and floodplain vegetation. Of the 30.3 ha that will be disturbed for channel construction, temporary stockpiles and haul roads, only 1.8 ha requires the removal of existing riparian vegetation. In addition, only three trees containing nesting hollows (out of 31 identified within the project area) will need to be removed for construction purposes.

Competent trees that would be suitable for construction of log jams in the diversion channels will be salvaged and retained for later use. All other vegetation will be retained for use in the rehabilitation of the channel batters.

In accordance with ACOL's existing *Erosion and Sediment Control Management Plan, e*rosion and sedimentation controls and barrier fencing will be installed to demarcate exclusion zones for construction activities (diversion channels, block banks and stockpile areas as shown on *Drawings C045* and *C046* of the *Engineering Design Drawings* in Plans Set 2 of Volume 3 of the EA). In particular, sediment control fencing will be installed in all areas from which runoff could drain into the creek, particularly:

- Along the toe of the stockpile areas closest to the creek. (Note that all stockpiles are to be located a minimum of 40m from the bank of Bowmans Creek and are not to be located within 5m of minor watercourses).
- Around the area of the block banks. (Note that at the time of construction of the block banks, securely anchored straw bales will be placed immediately downstream to provide filtration for any flowing water that inadvertently encroaches into the works area. Minor bunding works within the bed of the creek will be used to divert the majority of flow around the immediate works area as work progresses across the bed of the creek).

In accordance with ACOL's existing *Soil Stripping Management Plan*, topsoil from each channel corridor and from the stockpile areas will be stripped and stockpiled separately and allowed to compost for later reuse on diversion channel batters and spoil stockpiles.

The main earthworks comprise the excavation of the diversion channels which will take place from downstream to upstream (leaving in place a narrow barrier of existing earth to exclude creek flow until the construction works and initial rehabilitation are complete). Because the excavation works will all be below natural ground level, any runoff from the works area or groundwater inflow from the base of the excavation will naturally remain within the excavation. A temporary pump will be set up at the downstream end of the excavation and connected to one of the existing water transfer pipelines that feed into the existing ACP water management system. All sediment laden water collected within the excavation will be treated in this manner.

4.2 Construction Staging

Following site establishment and installation of sediment control fencing, the construction of each of the diversion channels will be undertaken sequentially using the steps set out below (extracted from *Section 12.3* of the EA). Construction will commence at the downstream end of each diversion channel and progress upstream so as to ensure that all joins in the geosynthetic clay liner (GCL) within the channel have the exposed edge on the downstream side.

1. Undertake bulk earthworks using a combination of scrapers and bulldozers together with excavators and trucks. Scrapers and or excavators and trucks will be used to undertake the bulk excavation, while excavators and trucks will be used to selectively extract suitable material for reconstruction of the geomorphic characteristics of the channel, including cobbles and cobble/silt mix as well as fine sandy silt for bedding of the geosynthetic clay liner.
2. Detailed channel shaping that will involve excavation of the low flow channel and trimming of batters using excavators loading onto trucks;
3. In the course of excavation of the base of the channels, it is anticipated that groundwater will be encountered. Sediment laden water resulting from groundwater inflow to the excavation or rainfall runoff will be pumped to the Ashton Mine water storage dam located to the north of the New England Highway by means of an existing pipeline.;
4. Once the excavation is complete, laying of the GCL will be undertaken in accordance with the manufacturers' guidelines. Care will be taken with placement of the bedding material below and above the geosynthetic clay liner to ensure that the liner is not punctured and the imperviousness of the liner is not compromised. The edges of the liner will be firmly anchored in the manner shown on *Drawing C002 of the Engineering Design Drawings*;
5. Once the liner has been laid and a subsequent layer of fine material placed over the top, the stream bed zone will be covered with a geotextile fabric (Bidim A29 or similar);
6. Construction of rock bars upstream and downstream of riffle sections, placement of rock armouring on the outside of bends and construction of engineered log jams will be undertaken following the placement of the geotextile fabric. Details of the locations of these elements of the channel design are shown on the Landscape Masterplans (Drawings SK01 and SK03 in the *Landscape Plans* that form Plan Set 3 in Volume 3 of the EA);
7. The stream bed will be constructed using the stockpiled gravels, cobbles and large sized boulders to form the low flow channel and adjacent cobble terraces in accordance with the details shown on the *Landscape Plans* (Plan Set 3 in Volume 3 of the EA);
8. Detailed landscaping and revegetation work in accordance with the Landscape Plans. This will commence immediately after completion of the detailed shaping of a section of the diversion channel and progressively follow that work along the channel. Extensive use will be made of erosion control matting on the inset benches immediately adjacent to the low flow channel in order to mitigate the risk of erosion to these until they have been stabilised by vegetation;
9. The construction of the block banks and subsequent cut-in of the ends of the diversion channels will be undertaken following completion of revegetation.

An important aspect of the proposed construction of the diversion channels will be the detailed works to be undertaken in the base of the excavation in order to create the geomorphic and habitat features shown on the *Engineering Design Drawings* and *Landscape Plans* (in Volume 3 of the EA), including:

- Variable channel geometry including pools, riffles and cobble beaches in the low active floodplain within the envelope created by the placement of the GCL – primarily created by placement of cobbles;
- Construction of rock bars and a rock ramp (using large imported rock) to provide additional bed control (in addition to the existing rock outcrops in the retained sections of the creek);
- Construction of a total of 23 engineered log jams to provide additional diversity of aquatic habitat.

This work will be undertaken under close supervision of an experienced fluvial geomorphologist.

4.3 Block Banks

Construction of the block banks will be undertaken in the following sequence that is designed to minimise the risk of flood damage to the diversion channels while providing moderate flow fish passage through the diversion channels and retaining (for as long as possible) the existing aquatic habitat in the sections of creek that will eventually be bypassed:

Initially, temporary low level banks (about 1m high) will be constructed in the existing creek near the upstream end of each diversion channel to divert all flows up to about the 6 month ARI. Flows in excess of 6 months ARI will be able to spill over the block banks into the existing creek channel.

The permanent block banks that divert flows up to the 5 year ARI flood level will be constructed just prior to mining of the Upper Liddell seam (approximately 3 years after construction of the temporary banks - see **Figure 6**) unless groundwater monitoring and/or subsidence monitoring indicates that significant alluvial groundwater or surface water has drained as a result of cracking of the underlying Permian rocks, in which case the permanent block banks will be constructed earlier.

Downstream block banks will be constructed in the existing channel just upstream of the point where the diversion channel connects with the existing channel. The primary purpose of these banks is to prevent backwater flooding of the excised section of the creek once subsidence occurs. In order to allow drainage from the excised section of the creek, the downstream block banks will include a culvert with a one-way flap gate that will allow water to drain downstream, but prevent backwater flow into the excised portion of the creek. The downstream block banks will be constructed just prior to mining of the Upper Liddell seam (approximately 3 years after construction of the temporary banks).

Each permanent block bank will have a small concrete levelling inset into the top to provide a fixed level for overflow of flood water (see Engineering design Drawing C016). Apart from the concrete for the levelling wall and large rip-rap for scour protection on the block banks and immediate downstream channel, all materials for the construction of the block banks will be sourced from material excavated from the alluvial floodplain during excavation for the diversion channels.

4.4 Stockpile Management

The management of spoil excavated from the diversion channels has required consideration of different issues from those that typically occur during open-cut mining. In particular, because the excavation will be in alluvial material, in which the existing channels are formed, shortage of topsoil and maintenance of soil health will not require the degree of attention devoted to these issues in relation to the rehabilitation of overburden stockpiles. However, because of the risk that weed seeds might be present in the topsoil used for the channel batters, the vegetation and a shallow soil layer (up to 100 mm) will be pre-stripped and disposed of elsewhere on land owned by ACOL well away from the Bowmans Creek floodplain.

From observations of the existing creek bank, investigation drilling and an understanding of the geomorphic processes that created the alluvial fill material, it is anticipated that the alluvium will be heterogeneous with lenses and bands of finer silty/sand mix interspersed with cobbles. Accordingly, it is expected that all bulk materials required for construction of the diversion channels and block backs will be sourced by selective extraction during the excavation for the diversion channels. **Table 4** below summarises the volume of alluvial material that will be extracted to form the channels and the volumes of selected material required for construction, namely:

- Sandy silt for bedding and a protective layer each side of the GCL;
- Cobbles for lining the low flow channel and the inset benches;
- Topsoil for respreading on the channel batters and the temporary stockpiles.

Separate stockpiles for these materials will be constructed within the designated stockpile areas shown on **Figure 7**. Materials for construction of the block banks will be separately stockpiled close to the location of the block banks as shown on **Figure 7**.

Table 4: Estimated Earthworks Quantities

(Source EA Table 12.1 and Engineering Design Drawings)

Item	Eastern Diversion (m^3)	Western Diversion (m^3)	Stockpile Areas (m^3)	Total (m^3)
Extraction				
Topsoil stripping (assume 150 mm)	9,200	5,500	14,800	29,500
Bulk earthworks	131,000	175,000	-	306,000
Excavation for stream bed zone	20,000	15,000	-	35,000
Construction				
Sandy silt layer below and above GCL	6,000	3,000		9,000
Cobble backfilling to form channel and terraces	14,500	12,500		27,000
Topsoil on channel batters	7,500	4,500		12,000
Block banks – bulk earthworks	3,600	3,600		7,000
Topsoil on temporary stockpiles			14,800	14,800
Available for subsidence troughs (1.2 bulking factor)				360,000
“Spare” topsoil				2,700

All excess alluvial material that is not required for channel or block bank construction purposes will subsequently be extracted for filling of subsidence depressions on the floodplain in order to assist in the creation of a free draining landform. All areas to be filled will have the topsoil layer removed prior to placement of bulk fill and subsequently replaced after filling in order to create a soil profile with similar productivity potential to the existing soil.

Viable topsoil is recognised as one of the most important factors in successful rehabilitation. Topsoil stripping, stockpiling and re-spreading will be planned to make optimal use of the available resource and minimise the time that soil is held in a stockpile. Once an initial stockpile of topsoil has been established, topsoil removed progressively from the bulk earthworks area will be re-used immediately on the completed sections of channel batter. This process will ensure that maximum value is obtained from the existing soil organic matter.

Stockpiles of bulk alluvium that will be retained for re-spreading into subsidence troughs on the floodplain will be managed in the following manner:

- Stabilisation with permanent native vegetation and silt fencing to control erosion and weeds.
- Regular inspection, particularly after storm events, with eroded areas stabilised as required.
- Weed growth on stockpiles will be monitored and subsequently controlled with herbicides if necessary.

4.5 Contingency Management

Contingencies associated with the construction of the diversion channels have been carefully considered in the design process in order to provide a design that is highly conservative and inherently resilient to the effects of flood damage. Various contingencies that have been considered in the design, and the way that these contingencies are addressed, are set out below.

4.5.1 Flood Damage

It is expected that during the period of ongoing underground mining following the construction of the diversion channels (about 14 years), there is likely to be a sufficient number of significant flood events to adequately test the integrity of the channels. The hydrologic analysis includes an assessment of the timing of historic flood events that have exceeded flow corresponding to a 5 year ARI flood (about 150 m^3/s peak flow) (see *Figure 2.4* in *Appendix 7* of the EA). That analysis indicates that in any consecutive 14 year period in the historic record there were a minimum of three flood events that exceeded a peak flow of 150m^3/s, and a maximum of six. The peak 5 year ARI flood of 150 m^3/s is significant in this instance because:

- In floods larger than 150 m^3/s the floodwater will overtop the block banks and flow will be split between the excised section of creek and the new (diversion) section. (This behaviour is illustrated for 20 and 100 year ARI floods in *Drawing G009* and *Drawing G010* in *Appendix 6* of the EA.)
- The detailed flood modelling (see *Appendix 6* of the EA) indicates that under these flow conditions, the flow velocity in the diversion channels in a 5 year ARI flood will be very similar to that in a 100 year ARI flood (see *Drawing G007* and *Drawing G010* in *Appendix 6* of the EA).

Accordingly, the diversion channels will be subjected to severe "stress" conditions comparable to a 100 year ARI flood on several occasions during the period following construction, while the mine is operational. This will provide sufficient opportunities to identify and rectify any defects in the design or construction of the diversion channels.

4.5.2 Failure of the Geosynthetic Clay Liner

A geosynthetic clay liner (GCL) is a manufactured hydraulic barrier system comprising a layer of bentonite clay sandwiched between, and bonded to, layers of geosynthetic fabric. A geosynthetic clay liner has been chosen specifically because of its inherent advantages over other hydraulic barrier materials (compacted clay, HDPE, etc). The key advantages of GCLs are that they:

- Have very low permeability (<5 x 10-11 m/s);
- Provide a hydraulic barrier with uniform properties over a large area. (Compared to compacted clay liners which are subject to variation in the source material and construction quality;
- Have high tensile strength and flexibility and can conform to irregular surfaces;
- Are resistant to puncturing because of the geosynthetic fibre, and are self sealing if punctured.

Because the permeability of a GCL is more than an order of magnitude less than the requirements set out in the NSW "*Environmental Guidelines: Solid Waste Landfills*" (1 x 10-9 m/s), GCLs have been widely used as an alternative to compacted clay for leachate barrier systems in landfill cells and capping.

Although the GCL is inherently resistant to puncturing and is self sealing, the GCL will be isolated from the overlying channel cobble bed by a 200mm layer of fine silty-sand material and a layer of geotextile fabric (see *Figure 2.9* in the EA). The depth of the cobble bed has been determined from analysis of the hydraulic conditions that will occur in the channel and takes account of the impacts of the 2007 flood (about 35 year ARI) on the existing channel. Because of these aspects of the design, the risk of puncturing the GCL is considered remote. Nevertheless, in the course of the channel geometry survey and geomorphic monitoring, any significant change in flow regime will be observed and, further investigations and repairs will be undertaken if necessary.

Once placed, the GCL will be subject to minimal movement as a result of settlement following construction or mine induced subsidence (both channels have been located outside the subsidence zones). The inherent flexibility of the GCL layer combined with its self sealing properties will allow the GCL to accommodate any such movements.

As shown in the design drawings (*Drawing C002* of the *Engineering Design Drawings* in Volume 3 of the EA), the GCL will be securely anchored in a trench on either side of the channel. Similar anchoring will be provided at the start and end points of the GCL. The rock protection, to be provided in the bed of the channels at either end of the riffle zones will provide an additional level of protection against undermining of the liner. In addition, the laying procedure (see **Section 4.2**) will involve placement of successive strips of the GCL starting at the bottom end of each diversion channel with each successive stream strip overlapped over the top of the downstream strip. This method of construction will ensure that, should damage or undermining of one section of liner occur, the damage would not propagate downstream. In the remote event that any such damage occurred, it would be repaired immediately.

As noted in **Section 4.5.1** above, the diversion channels will be subjected to "stress" conditions comparable to a 100 year ARI flood on several occasions during the 14 year period following construction which will provide sufficient opportunities to identify and rectify any defects in placement of the GCL.

4.5.3 Tunnel Erosion

Tunnel erosion is not anticipated to be a problem. Tunnel erosion usually occurs in sodic and dispersive soils. The alluvial soils in which the diversion channels will be constructed are not sodic or dispersive, and therefore have negligible risk of tunnel erosion. This low risk is confirmed by the fact that, notwithstanding some almost sheer banks on the existing creek, there is no evidence of tunnel erosion.

Any erosion of the banks of the channels, whether caused by surface runoff or tunnelling processes, will identified during the routine monitoring and repaired as necessary.

4.5.4 Block Banks

The block banks will be broad based, low structures that have been designed to be overtopped by floodwater. Two features have been included in the design to ensure the long term competence of the structures:

- Rock armouring on the face that could be subject to shallow high velocity flow when the bank is overtopped (downstream face of the upstream block banks and both faces of the downstream block banks – see *Engineering Design Drawings* in Volume 3 of the EA). The specifications for the rock armouring have been determined on the basis of an analysis of the case flow velocity down the face of the bank and on the downstream channel.
- A concrete wall embedded in the crest of the block bank to eliminate the risk of flow through the rock armouring leading to core material being washed out.

Notwithstanding these design features, as noted in **Section 4.5.1** above, it is expected that the block banks will be subjected to at least three floods during the 14 year period following construction. Following any flood, the block banks will be inspected and the nature of the damage assessed. Repairs will be undertaken as necessary.

5 REVEGETATION

5.1 Revegetation Strategy and Techniques

Details of the revegetation and habitat enhancement proposed for Bowmans Creek have been developed taking into consideration significant monitoring of the flora and fauna that has been under taken since 2005 (see HLA-Envirosciences 2001, ERM 2005, 2006a, 2006b, 2006c, 2008a, 2009a, 2009b, 2009c, DnA & Carbon Based Environmental 2009a, 2009b, 2009c)

As described in *Section 12.5* and the *Landscape Restoration Report* (Appendix 10) of the EA, and in line with the hierarchy described in **Figure 2**, the rehabilitation of the Bowmans Creek diversion channels is an integral part of the project and has been developed to complement the physical foundations inherent in the design and construction of the diversion channels which include:

- Mimicking the existing channels so as to provide comparable hydraulic conditions;
- Cobble lining of the low flow channel and low active floodplain to provide bed stability comparable to the existing creek;
- Extensive use of erosion control matting to provide additional stabilisation during the plant establishment phase;
- Staged diversion of flow into the diversion channels so as to reduce the risk of damage during the early phases of rehabilitation. Temporary block banks will initially allow flow in excess of a 6 month ARI flood to spill into the existing channel. Permanent block banks (at a level that would allow flow into the existing channel in flows in excess of 5 years ARI) will be constructed about three years after completion of construction of the diversion channels.

The overall objective of the rehabilitation strategy is to re-establish plant communities that are characteristic of those that were present prior to European colonisation including River Red Gums. Aims of the rehabilitation strategy are to create plant communities that establish rapidly, are species rich and have dense plant cover, so as to achieve:

- Quick ground-holding characteristics sufficient to withstand flooding early within the plant establishment period;
- Resistance to on-going weed colonisation, maximising the potential for natural colonisation / regeneration of the planted species, particularly the native grasses;
- A diverse suite of endemic species that maximise the potential for colonising of new niches as they become available within the developing community; and
- High plant cover rates to ensure the communities will have natural resistance to weed colonisation, good ground-holding characteristics sufficient for a range of periodic flood events, and sufficient species diversity to develop into an appropriate climax community.

A key aim of the rehabilitation strategy is to provide a flexible, cost effective and adaptive approach to the restoration process, which takes advantage of the opportunities offered by the relatively long life of the project, i.e. a period of some 14 years. Advantages of this approach are as follows:

- Facilitates early focus on ground stabilisation and associated simplified maintenance approach, i.e. weed management is less constrained by the number and range of species planted and subsequent very high need in the early stages of the project for skilled, highly labour intensive weed management, which given the area to be covered for this project would be very difficult to adequately resource. The proposed approach of having a limited number of robust native grass species providing the main initial ground holding and weed suppressing function, simplifies maintenance and provides better protection, increased soil moisture holding capability and a more biologically active soil layer for subsequent plantings over that available in a single occurrence conventional mass planting process;

- Facilitates early commencement of the works in keeping with ACOL's program, as seed is only required for a handful of species, and cell-grown seedlings can initially be procured in readily low, achievable quantities;
- Provides appropriate lead time to procure a diverse suite of species in high numbers;
- Facilitates the opportunity for collection of provenance propagation materials by ACOL, e.g. for *Eucalyptus camaldulensis*, and may facilitate the same for other species in the normal course of nurseries providing plant material for the project, given the opportunity for substantial plant order lead times;
- Facilitates a gradual building up of species diversity, by-passing problems often associated with procurement of particular species, e.g. limited viable seed drop in some seasons;
- Early structural planting provides a framework for the later introduction of 'softer' species that are difficult to introduce in the early phases of a project due to their particular requirements, e.g. areas with dappled light, elevated soil moisture, wind and sun protection, locally increased humidity, etc.

The restoration will take a measured approach to flood risk and cost by providing for:

- A 'flood resistant' surface on areas below the level of the 1 year ARI flood, comprising erosion / weed control matting to all areas of exposed soil and relatively dense planting; and
- A staged restoration program above the level of the 1 year ARI flood, commencing with the direct seeding of a dense native grass cover and limited structural planting, which will be augmented over an 8 year period into a fully structured, species rich plant community.

Revegetation will be undertaken in accordance with the relevant Ashton Coal project approved management plans (*Landscape and Revegetation Management Plan*; *Weed Management Plan*) as well as the site specific requirements set out in:

- The *Landscape Restoration Report* (Appendix 10 in Volume 2 of the EA) and the
- *Landscape Design Drawings* (Plan Set 3 in Volume 3 of the EA).

The landscape restoration method presented in detail in the *Landscape Restoration Report* (Appendix 10 of the EA) proposes that the works be undertaken gradually and in a staged and adaptive manner, commencing with site stabilisation using a combination of direct seeding of native grasses and planting, followed by a gradual building up of community structure and species richness, until a robust, and relatively low maintenance, self-perpetuating corridor community is created.

An appropriate level of resources will be committed in the initial plant establishment period, in particular during the first 12 to 18 months after implementation to ensure that, subject to climate conditions, this process succeeds. Weed control will be regularly undertaken during this phase, so as to facilitate the colonising of the great majority of available niches by native species. Once this outcome has been achieved, it can be expected that the required maintenance effort will significantly drop-off, until it reaches a relatively low, long-term maintenance level.

As part of this process, an adaptive management approach will be adopted, with outcomes being monitored and evaluated against restoration goals and objectives, and management actions adjusted as required to best achieve a trajectory towards meeting the ecosystem characteristics on relevant baseline or reference sites.

Impact and reference sites will be established that include the following characteristics:

- Underground mining sites;
- Riparian sites removed from mining;
- Sites adjacent to mining activity;
- Reference control sites removed from mining; and
- Road corridor sites.

The objective of the reference sites is, firstly to use these sites as indicators of no change under normal no mining impact conditions, therefore isolating mining impacts and recording changes in populations that can be clearly associated with activity on the site. Secondly, as benchmarks against which the regeneration success can be measured. The surveys proposed for mining areas will also be replicated outside areas of mine impact. Site selection will focus on comparative site (controls) and benchmark sites with the final location being randomly selected for statistical robustness.

5.2 Proposed Vegetation Communities

A flora and fauna assessment that included the Bowmans Creek Diversion project area was undertaken in 2001. The assessment included a summary of eight previous flora and fauna assessments commencing from 1984, and undertaken either specifically for the site, or within close proximity to the site, in addition to species identified within the NSW National Parks and Wildlife Service Wildlife Atlas. The report provides a species list incorporating findings from six of the previous flora and fauna assessments, the NPWS Wildlife Atlas and the 2001 study (copy provided as Appendix 2 to the *Landscape Restoration Report* in Appendix 10 of the EA). No threatened species (flora or fauna) were observed on the site.

Additionally, seven specimens of River Red Gum (*Eucalyptus camaldulensis*) were identified in the narrow riparian corridor of the southern meander of Bowmans Creek near the confluence with the Hunter River. Within the Hunter Catchment, this population is unique in NSW, being the only one to occur within a coastal catchment, and is restricted to 19 stands, covering approximately 100 hectares. The River Red Gum population within the Hunter Catchment is listed as an endangered population under the *Threatened Species Conservation Act, 1995* (TSCA). The Hunter-Central Rivers Catchment Management Authority (Hunter-Central Rivers CMA, 2007) states that:

- the regional TSCA listed population of River Red Gums is in danger of extinction from the introduction of 'non-natural hybrid River Red Gums for revegetation projects' which could result in the extinction of the local gene pool for this species; and
- the community is under extreme threat, is not reserved, and that urgent protection and management agreements are required with private landholders.

The Hunter-Central Rivers Catchment Management Authority has produced vegetation mapping of the Central Hunter Valley which identifies existing plant communities. The plant communities listed below were identified within the CMA reporting, and selected by the landscape consultants as being likely to be associated with Bowmans Creek and its adjoining flood terrace environs (see *Landscape Design Drawings* - Plan Set 3 in Volume 3 of the EA).

5.2.1 Hunter Valley River Oak Forest

This community is proposed for the low active floodplain and adjoining inset benches. The low active floodplain will comprise a cobble / sand / silt material mix placed over a synthetic clay liner, while the inset benches will comprise in-situ alluvial material.

This community typically forms a mid-high to tall forest with a mid-dense canopy almost exclusively dominated by River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*). Other less frequent canopy species may include Rough-barked Apple (*Angophora floribunda*), Forest Red Gum (*Eucalyptus tereticornis*), Swamp Oak (*Casuarina glauca*). Rainforest-affiliated low trees and shrubs sometimes form an understorey stratum, which may include such species as Native Peach (*Trema tomentosa* var. *viridis*), Ironwood (*Backhousia myrtifolia*) and Muttonwood (*Rapanea variabilis*) (Hunter-Central Rivers CMA, 2007).

5.2.2 Hunter Valley Red Gum Woodland

This community is proposed for the side slopes and adjoining flood terrace. The side slopes are likely to comprise of lenses of various in-situ alluvial materials including cobbles, sand, silt and clay.

The community typically forms a mid-high to very tall or open woodland, and occurs on floodplains and floodplain rises along the Hunter River and several major tributaries. Sites on major floodplains between Singleton and several kilometres south of Scone are dominated by River Red Gum (*Eucalyptus camaldulensis*), often as a sole dominant canopy species. Forest Red Gum (*Eucalyptus tereticornis*), Yellow Box (*Eucalyptus melliodora*) and Rough-barked Apple (*Angophora floribunda*) can co-dominate in places although they usually form a minor part of the canopy. River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) once formed a gallery forest, within the typically surrounding Red Gum Forest, along most creeks and rivers (Hunter-Central Rivers CMA, 2007).

5.3 Proposed Plant Species

A list of the proposed plant species to be used to create the various vegetation communities in different elements of the landscape, and for each if the proposed phases of the rehabilitation program (see **Section 5.9**), are set out in **Table 5**.

5.4 Seed Collection and Management

Seed Availability

Seed sourced within the bio-region level and below would be suitable; with the closer the seed stock to the site, the better the restoration outcomes are predicted to be. There is a large area of source stock within local National Parks. Alternatively seed stock will be sourced from local native seed stock suppliers. ACOL will consult with the Hunter–Central Rivers CMA or local agronomists to determine the most appropriate seed source.

Storage and Preparation

The Australian Tree Seed Centre Operations Manual or the Florabank Guidelines will be followed as the guide for storage and preparation. Seed cleaning can be done using sieves, blowing machines or by hand. Relatively unskilled staff can play an important role in this aspect of the work. The cleaned dried seed is sealed into moisture-proof containers. The conditions for storage are related to the expected duration, for example: Short term – room temperature or 4°C, Medium term – less than 0°C, 3-7% moisture content, and Long term – less than -18°C, 3-7% moisture content.

River Red Gum Seed Resource

Where available, provenance River Red Gum seed will be utilised for this project. Research has shown that in some cases seed release, viability and germination rates in River Red Gum do not appear to limit recruitment (Jensen et al 2008). In water-stressed trees, however, seed release was found to be up to nine-fold less. An estimation of seed resource followed by tests of viability may be required to establish River Red Gum seedling stock. Assessment of the effectiveness of the long term self germination success may also be required. It has been shown that germination requires water from floods or local rainfall (Jensen et al 2008). The importance of local rainfall as a complementary water source was also demonstrated (Jensen et al 2008).

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
Aquatic / Ephemeral Community		
Phragmites australis (Common Reed) *Persicaria decipiens* (Slender Knotweed), *Persicaria lapathifolia* (Pale Knotweed), *Polygonum arenastrum* (Common Wireweed)	*Cyperus polystachyos* (Bunchy Flat-sedge) *Cyperus sesquiflorus* (Mullumbimby Couch) *Carex appressa* (Bunchy Flat-sedge) *Juncus subsecundus* (Clustered Rush) *Juncus usitatus* (Common Rush)	*Fimbristylis dichotoma* (Common Fringe-rush) *Schoenoplectus validus* (River Club-rush) *Schoenus apogon* (River Club-rush))
Hunter Valley River Oak Forest (low active floodplain and adjoining inset benches)		
Long-stem tube planting of *Casuarina cunninghamiana* (River Oak), with lesser occurrences of *Eucalyptus tereticornis* (River Red Gum). Augmented periodically with low-density planting of key structural elements as either long stem or cell-grown seedlings, as available. Inset bench protected with erosion control matting. Cell-grown seedings will be planted regularly, but in relatively low numbers to minimize losses to flood, and will include the following: **Trees:** *Casuarina cunninghamiana* (River Oak) *Eucalyptus tereticornis* (River Red Gum) **Endemic colonising shrubs:** *Acacia amblygona* (Fan Wattle), *Acacia falcata* (Sickle Wattle), *Acacia longifolia* **Forbs:** *Lomandra longifolia* (Spiny-headed Mat-rush) *Pratia purpurascens* (Whiteroot) Cynoglossum australe **Endemic grass species**: *Cynodon dactylon* (Common Couch) *Digitaria brownii* (Cotton Panic Grass) Echinochloa telmatophila *Lachnagrostis filiformis* (Blown Grass) *Oplismenus aemulus* **Endemic hydrophytic species** in low elevation points:	Regular planting in relatively small numbers of a diverse range of endemic grasses, shrubs and trees using both tube stock (grasses) and long stem stock (trees), to increase species diversity while minimising the extent of losses from periodic flooding. Building of the community to between 20 and 30 species. Species to include: **Trees** *Angophora floribunda* (Rough-barked Apple) **Shrubs** *Acacia paradoxa (*Kangaroo thorn) *Ficus coronata* (Sandpaper Fig*)* *Hymenanthera dentata* **Forbs:** *Cotula australis (*Common cotula*)* Plectranthus parviflorus (Cockspur Flower) **Endemic grass species:** *Aristida ramosa* (Three-awned Spear Grass) *Chloris truncata* (Windmill Grass) *Digitaria parviflora* (Small-flower Finger Grass) *Sporobolus creber* (Slender Rats Tail Grass) *Microlaena stipoides var.stipoides* (Weeping grass) **Endemic hydrophytic species** in low elevation points *Cyperus polystachyos* (Bunchy Flat-sedge) *Cyperus sesquiflorus* (Mullumbimby Couch) *Juncus subsecundus* (Clustered Rush) *Juncus usitatus* (Common Rush)	Continue to regularly plant in small numbers species reliant on being planted within an established woodland system, to achieve final diversity of between 40-50 species. This will include: **Trees** *Backhousia myrtifolia* (Ironwood) *Rapanea variabilis* (Muttonwood) *Trema tomentosa* var. *viridis* (Native Peach) **Shrubs:** *Myoporum montanum* (Water Bush) *Notelaea venosa* (Smooth Mock Olive) **Forbs:** Stellaria pungens (Prickley starwart) *Convolvulus erubescens* (Blushing bindweed) **Endemic grass species:** *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Chloris virgata* (Feathertop Rhodes Grass) *Panicum effusum* (Hairy Panic)

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
Persicaria decipiens (Slender Knotweed), *Persicaria lapathifolia* (Pale Knotweed), *Polygonum arenastrum* (Common Wireweed)		
Hunter Valley Red Gum Woodland (channel side slopes and adjoining upper flood terrace)		
Channel slopes below the 5 year ARI flood Mass planting of cell-grown seedlings with key structural community species with a high grassland content using both tube stock (grasses) and long stem stock (trees). Works have surface protection of erosion control matting, and are designed to provide quick cover with high ground-holding characteristics. Typical species will include: **Trees:** *Eucalyptus camaldulensis* (River Red Gum) *Eucalyptus tereticornis* (Forest Red Gum) *Angophora floribunda* (Rough-barked Apple) **Shrubs** *Acacia amblygona* (Fan Wattle), *Acacia falcata* (Sickle Wattle), *Acacia salicina* (Willow Wattle) *Eremophila debilis* (Amulla) and *Daviesia genistifolia* (Broom Bitter-pea) **Grasses:** Echinochloa telmatophila *Oplismenus aemulus* *Aristida ramosa* (Three-awned Spear Grass) *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Cynodon dactylon* (Common Couch) *Dichelachne micrantha* (Short-hair Plume Grass) *Panicum effusum* (Hairy Panic) *Paspalum distichum* (Water Couch) Channel slopes above the 5 year ARI flood and adjoining flood terrace Direct seeding and low density planting of cell-grown seedlings on prepared seed bed. Works are above the 1 in 5 year ARI flood and designed to provide cost-effective, early ground holding with a dense	**Channel slopes below the 5 year ARI flood** Substantial augmentation of species. Regular planting in relatively small number to increase species diversity while minimising extent of losses from periodic flooding. Build to 20-30 species. *Brachychiton populneus* subsp. *populneus* (Kurrajong) *Eucalyptus melliodora* (Yellow Box) *Eucalyptus crebra* (Narrow-leaved Ironbark) *Eucalyptus punctata* (Grey Gum) **Channel slopes above the 5 year ARI flood and adjoining flood terrace** Substantial augmentation of species diversity to approximately 30-40 species. **Shrubs:** *Notelaea neglecta* *Bursaria spinosa* (Boxthorn) **Forbs:** *Pratia purpurascens* (Whiteroot) *Dichondra repens* (Kidney weed) *Einadia hastata* *Calotis Lappulacea* (Yellow Burr Daisy) *Geranium solanderi var. solanderi* (Geranium) *Lepidium pseudohyssopifolium* (Peppercres) Rumex brownii (Swamp Dock) *Solanum americanum* (Glossy nightshade) **Grasses:** *Bromus molliformis* (Soft Brome) *Chloris truncata* (Windmill Grass) *Chloris virgata* (Feathertop Rhodes Grass)	**Channel slopes below the 5 year ARI flood** Add any last required species reliant on being planted within an establishment woodland system, to achieve final diversity of approximately 50 species for this community. *Melia azedarach* (White Cedar) **Channel slopes above the 5 year ARI flood and adjoining flood terrace** Add any last required species reliant on being planted within an establishment woodland system, to achieve final diversity of approximately 50 species for this community. Note: at this stage of the project there may be little requirement to plant the remaining species as they may have already naturally colonised the area. **Shrubs:** *Exocarpus strictus* (Dwarf Cherry) **Forbs**: *Amaranthus macrocarpus var. macrocarpus* (Dwarf Amaranth) **Grasses:** *Austrodanthonia setacea* (Small-flower Wallaby Grass) *Austrostipa scabra* subsp. *scabra* (Speargrass) *Cymbopogon refractus* (Barbed Wire Grass) *Panicum effusum* (Hairy Panic)

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
cover of native grasses, and low density cell-grown seedling planting of key structural species. Groundcover species will be supplemented with sterile ground stabilisation species to improve cover and plant establishment. Typical species will include those above, plus the following: *Austrodanthonia setacea* (Small-flower Wallaby Grass) *Austrostipa scabra* subsp. *scabra* (Speargrass) *Sporobolus creber* (Slender Rats Tail Grass) *Lomandra filiformis* subsp. *filiformis* (Wattle Mat-rush) *Lomandra multiflora* subsp. *multiflora* (Many-flowered Mat-rush) *Cymbopogon refractus* (Barbed Wire Grass) *Sorghum leiocladum* (Wild Sorgham)	*Digitaria brownii* (Cotton Panic Grass) *Eragrostis brownii* (Brown's Lovegrass) *Lachnagrostis filiformis* (Blown Grass)	
Buffer Planting / Weed Management		
Buffer planting edge Direct seeding to achieve dense cover of select native species on prepared seed bed to provide weed management buffer planting. Species to include: Capillipedium spicigerum (Scented-top Grass) *Cynodon dactlyon* (Common Couch) *Sorghum leiocladum* (Wild Sorghum) *Themeda australis* (Kangaroo grass) **Weed management edge** 50m width to the perimeter of the works, subject to regular slashing of weed infested pasture community to minimise weed colonisation to the works.	**Buffer planting edge** Low density augmentation planting with key structural species. Primary purpose of this zone is still to provide dense grassland buffer to adjoining weed infested flood terrace. *Aristida ramosa* (Three-awned Spear Grass) *Oplismenus aemulus* **Weed management edge** Encourage natural colonisation of native grasses out onto the flood terrace. This can be readily achieved by providing judicious weed management to assist early natural colonisation that will take place to this weed management edge.	**Buffer planting edge** Increase species number to approximately 10-15, to create simplified community form with relatively strong grassland buffer edge retained. *Bromus molliformis* (Soft Brome) *Chloris truncata* (Windmill Grass) *Chloris virgata* (Feathertop Rhodes Grass) *Digitaria brownii* (Cotton Panic Grass) *Eragrostis brownii* (Brown's Lovegrass) *Lachnagrostis filiformis* (Blown Grass) Echinochloa telmatophila *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Dichelachne micrantha* (Short-hair Plume Grass) *Panicum effusum* (Hairy Panic) **Weed management edge** Encourage natural colonisation of all native species out from the buffer edge and onto the flood terrace.

5.5 Soil Improvement

As described in Section 3 of the *Landscape Restoration Report* (Appendix 10 of the EA), the following soil preparation measures will be undertaken:

- **Low Active Floodplain** – For those areas of the works that comprise of placed cobble material, i.e. to the low active floodplain, no soil preparation will be required after the material has been placed. However, the placed cobble material will be carefully selected during the creek construction phase of works to ensure it contains a sand / silt / clay content sufficient to support an appropriate level of plant growth for the proposed plant species;
- **Inset Benches** – The inset benches will comprise of various alluvial materials. Soil testing will be undertaken to the benches to determine its suitability for planting into, and ameliorants applied as required sufficient to ensure an appropriate level of plant response;
- **Lower Side Slopes** – The lower side slopes are defined as that area below the 5 year ARI flood. It is proposed that this area be mass planted with cell-grown seedlings to ensure a relatively quick cover. Given that it is anticipated that the side slopes will constitute a series of alluvial lenses comprising of a range of materials, soil testing will be undertaken on a representative sample of each lens type to test chemical and physical soil properties and identify any requirements for amelioration to a level that seeks to provide a greater advantage to native seedlings than colonising weed species, e.g. low pH levels. Additionally, the lens material will be assessed to determine whether it can readily be planted into with cell size plants, e.g. if it comprises of a substantial cobble content, it may not be possible to plant cell size seedlings into it. If the lens cannot be planted into, than provision will be made for the installation of a thin (say, 75mm depth) layer of site topsoil as described below.
- **Upper Side Slopes and Flood Terrace** – The upper side slopes are defined as that area above the 5 year average recurrence interval flood. It is proposed that this area be subject to direct seeding of native grasses in the first place, in conjunction with a limited structural planting of cell-grown seedlings.
- **Site Topsoil** – Site topsoil will be stockpiled as part of the civil works package. Prior to stripping of topsoil, testing will be undertaken to determine the depth to which the majority of the weed seed load is situated. For areas to be stripped for their topsoil, this top layer (potentially in the order of 100mm) will be scalped and removed well away from stockpile sites, in order to remove the majority of the soil weed seed bank. The remaining topsoil will subject to soil testing and amelioration as required prior to stockpiling for later re-use in the restoration works, e.g. for topsoiling to the side slopes as required.

5.6 Weed Control

As set out in Section 3 of the *Landscape Restoration Report* (Appendix 10 of the EA), weed management will be a key factor in determining the success of the project, particularly within the first 12 to 18 months of the Plant Establishment Period (PEP). Very high weed densities are present on the flood terrace within which the diversion channels are constructed, particularly within the areas of improved pasture. In addition to the scalping of areas to remove the soil weed seed bank as described above, the following weed management process will be undertaken:

- Slash or otherwise manage the flood terrace for weeds within 50 metres of the creek diversion channels to minimise the extent of weed seed inputs to the area of the works – slashing will commence prior to commencement of the engineering works, and take place at intervals sufficient to stop substantial setting of weed seed for at least the first 12-18 months of the PEP;
- Undertake restoration treatments quickly upon completion of the civil engineering works to minimise the opportunity for weed colonisation;

- Weed manage prepared areas with glyphosate (e.g. Roundup Biactive) as required prior to undertaking restoration treatments;
- Regularly undertake initial weed management of the works until a dense native plant cover is in place, and that is of sufficient capacity to provide for natural regeneration of native species and minimise habitat / colonisation opportunities for weeds;
- Thereafter, undertake weed management as required.

5.7 Fencing

Stock proof fencing will be installed along all rehabilitated sections of Bowmans Creek as shown on **Figure 3** (*Figure 10.3 in the EA*).

5.8 Planting Methods

5.8.1 Long-stem Tubes

Planting to the low active floodplain and inset benches will include long-stem tubes of River Oak, which have been developed specifically for riparian situations. These tube plantings are essentially tall (about 1m high) plants with a single long stem, most of which in fact comprises of roots. Once established, other species from the Hunter Valley River Oak Forest community will be planted using a mix of long-stem tubes for those species for which they are available. Where proposed species are not able to be procured in a long-stem form, these will be planted as cell-grown seedlings progressively in small numbers throughout the period of the works to minimise losses to flood. The initial planting of long-stem tubes will be undertaken at average of 3-4m centres across the area of the low active floodplain and inset benches. This density allows for open cobble and bench areas as is characteristic of the community, as well proving niches for following-up planting of additional species.

5.8.2 Cell-grown Seedlings

Wherever practicable, Cell-grown seedlings will be planted to the lower side slopes at an indicative average density of about 8 plants per square metre, or based on the outcomes of trials during early phases of rehabilitation. The planting palette will comprise of a mix of robust and quick growing species from all structural layers to maximise early soil holding properties, including a substantial ground layer of native grasses and forbs such as Lomandra longifolia. An initial species diverse structural planting will be undertaken for this area, with an emphasis on the canopy and shrub layers, to assess the relative performance of different species within the Hunter Floodplain Red Gum Woodland community, including at different heights up the bank, and possible responses to periodicity of inundation and soil types. Once this initial planting is established, staged supplementary planting will take place to increase species diversity and plant density where required.

5.8.3 Direct Seeding

Direct seeding of a select suite of native grasses will be undertaken to the upper slopes and flood terrace edge in conjunction with a structural planting initially in limited numbers, to provide a dense, weed resistant cover, into which later staged planting can be undertaken to create a species rich community characteristic of Hunter Floodplain Red Gum Woodland. As with the planting to the lower side slopes, an assessment will be made of the relative performance of different species within the Hunter Floodplain Red Gum Woodland community, to help determine an optimal species composition for later supplementary planting. The outer 5m of the corridor restoration will be seeded initially to a dense cover of native grasses to provide a robust weed barrier between the works and the adjoining weed community on the flood terrace. Select native grass species will include: Kangaroo Grass (*Themeda australis*); Scented Top (*Capillipedium spicigerum*) and Wild Sorghum (*Sorghum lieocladum*), species which have previously performed well in direct seeding applications. Additionally, a sterile cover crop will be judiciously used during the initial period of direct seeding, sufficient to assist in weed suppression without unduly compromising the growth of the young native seedlings.

5.8.4 Watering

Watering, where needed, will be undertaken for a minimum period of 3 months after each planting or direct seeding event.

5.9 Rehabilitation Staging

As described in *Section 12.5 and Appendix 10* of the EA, rehabilitation of the diversion channels will be undertaken in three phases.

5.9.1 Phase 1 – Site Stabilisation

This phase of the works will take place over the first 2 - 3 years of the project. Key objectives of this phase would be to:

- Quickly stabilise the works;
- Provide a quick and robust weed suppressing native plant cover which will improve soil structure and microclimate.

The performance of the initial species (see **Table 5**) will be assessed weekly and additional planting will be undertaken to ensure adequate plant cover is achieved and exotic species cover is minimal for stabilisation against runoff on the batter slopes and scour on the low active floodplain and inset benches (see *Landscape Masterplans SK01* and *SK02* in the *Landscape Restoration Report* – Appendix 10 of the EA); and robust native plant cover to suppress weeds and improve soil structure and microclimate. Currently the banks of the system are dominated by exotic species, so the establishment of a groundcover ecosystem that is dominated by native grasses is the primary objective. Additional floristic and structural diversity will be achieved over a greater time frame.

5.9.2 Phase 2 – Vegetation Community Structure

This phase of the works will take place between years 3 and 6 of the project. Key objectives of this second phase of the project would be to:

- Augment species diversity of the communities sufficient to provide a significant level of species richness, characteristic of the community, e.g. in the order of:
    - 30 to 40 species for the Hunter Floodplain Red Gum Woodland community on the upper side slopes of the diversion channels (see **Table 5**),
    - approximately 40 species for the Hunter Floodplain Red Gum Woodland community on the lower side slopes (see **Table 5**), and
    - 20-30 species for the Hunter Valley River Oak Forest community within the low active floodplain and inset benches (see **Table 5**); and
- Increase numbers and density of particular species where required.
- Establish habitat elements for threatened bird species recorded in the local area.
- Dominance of local flora species established in Phase 1 will be complemented with the emergence of structural diversity.

5.9.3 Phase 3 – Species Diversity

This phase of the works will generally take place between years 6 and 8 of the project. Key objectives of this third phase of the project will be to:

- Further augment species composition of the communities to a comprehensive suite of up to 50 species for the Hunter Floodplain Red Gum Woodland community and between 40 and 50 species for the Hunter Valley River Oak Forest community;
- Provide the 'softer' and 'harder' to establish species in the now substantially ameliorated natural environment, which should by that stage provide many of the niches necessary for their establishment, e.g. areas with dappled light, elevated soil moisture, wind and sun protection, locally increased humidity, etc.;
- Increased fauna diversity will be a sound measure used in this phase for ecosystem restoration success. There will be an initial diversity spike that will stabilise, then as structural and floristic diversity peaks, occupation of habitats by a wider range of species, including significant species will be the goal. This in conjunction with dominance by native flora species and ecosystem comparisons with reference sites will be the final measures of ecosystem success.

5.10 Contingency Management

5.10.1 Weeds

Weeds of concern are those that are listed as Noxious under the provisions of the Act, and weeds that successfully outcompete native species. There are many other weeds that whilst being present in a system have no major effects, but should be minimised nonetheless. The initial earthworks, sculpting, stabilising planting and early ecosystem planting phases are the times of greatest risk in terms of exotic weed outbreaks. Regular monitoring of regeneration sites will identify potential problem areas before weeds take hold. If large areas are identified as being destabilised by weeds, the following weed removal methods will be implemented:

- intensive herbicide application,
- hand or mechanical removal.

Weed competition with tube stock for resources can be a major problem. This will be combated with the use of very long-stem tube stock. Long-stem tube stock of fast growing colonizing species will be farmed especially for contingency planting. These areas will be planted in very high densities to improve competitive advantage against weeds. Once established they will outcompete weeds.

5.10.2 Vegetation Establishment

To date rehabilitation programs undertaken by Ashton within the mine site area and adjoining landscapes have been successful, with established systems having being achieved within prescribed timeframes. Monitoring of a small scale planting area within the proposed rehabilitation area indicates that colonisation should be successful, with much higher success rates predicted where planting can be undertaken to take advantage of autumn rain periods.

If large areas of direct seeding fail to colonise the following actions will be undertaken:

- In areas where there is a risk of erosion and weed infestation, direct seeding will be repeated but with a greater focus on sterile stabilising grasses. Once the area is stabilised, the area will be planted with a combination of seeding and tube stock.
- In more stable areas, direct seeding of native local species will be repeated and followed up with increased maintenance and watering.

5.10.3 Fire

ACOL has an approved bush fire management plan – it will be revised to include the Bowmans Creek Diversion project.

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6 COMPLETION CRITERIA AND MONITORING

6.1 Channel Construction

The proposed completion criteria relating to the construction works are set out in **Table 6.**

Table 6: Proposed Completion Criteria for Channel Construction

Domain	Performance Criteria and Assessment Method	Corrective Action
Channel Geometry and Form (To be undertaken during and immediately following construction)		
Channel geometry conforms to design	"As constructed" survey of channel cross sections and longitudinal profile for validation against: • Engineering drawings • Key indicators set out in	Reconstruction of non-conforming elements
Adequate cobble material available to provide specified depth of bed	Depth of bed material audited by geomorphologist during construction	Import additional hard rock with similar grading to cobbles in creek
Rock bars, rock ramps	Construction as per design drawings established by post-construction review by qualified fluvial geomorphologist.	Repair as necessary
Stockpile Rehabilitation (assessment at the end of channel construction)		
Presence of silt fencing	Required silt fencing in place	Install fencing
Revegetation	Stockpile vegetation achieves 70% ground cover within 2 months of seeding	Re-seed any bare patches
Free Draining Floodplain		
Maintain free draining floodplain	Visual inspection for subsidence induced ponding on the floodplain (Not to be confused with existing natural ponding areas which will be surveyed and documented)	Fill depressions or construct drainage to maintain free drainage

6.2 Geomorphology and Stream Health

The proposed geomorphology and stream health completion criteria are based on a number of reference sites within Bowmans Creek that have been monitored since 2005 (see **Section 3.1**) and will continue to be monitored in the future:

- Creek cross sections at 37 locations in the reaches of the creek that are to be retained. These cross sections and associated longitudinal profiles of the bed, which were previously surveyed in 2005 and 2008, will be surveyed periodically for comparison with 10 cross sections within each diversion channel. Bed samples will be collected at the same time for statistical comparison between the retained sections of the creek and the bed of the diverted sections.
- Stream health has been monitored in spring and autumn at a number of locations along Bowmans Creek including sites upstream, downstream and between the proposed diversion channels (see **Figure 10**). The stream health monitoring includes:
  - Aquatic Macro-invertebrate sampling using AusRivAS protocols for collection and taxonomy. Data are used to establish individual site diversity and individual site

SIGNAL indices per season plus mean site diversity and mean site SIGNAL index over time;

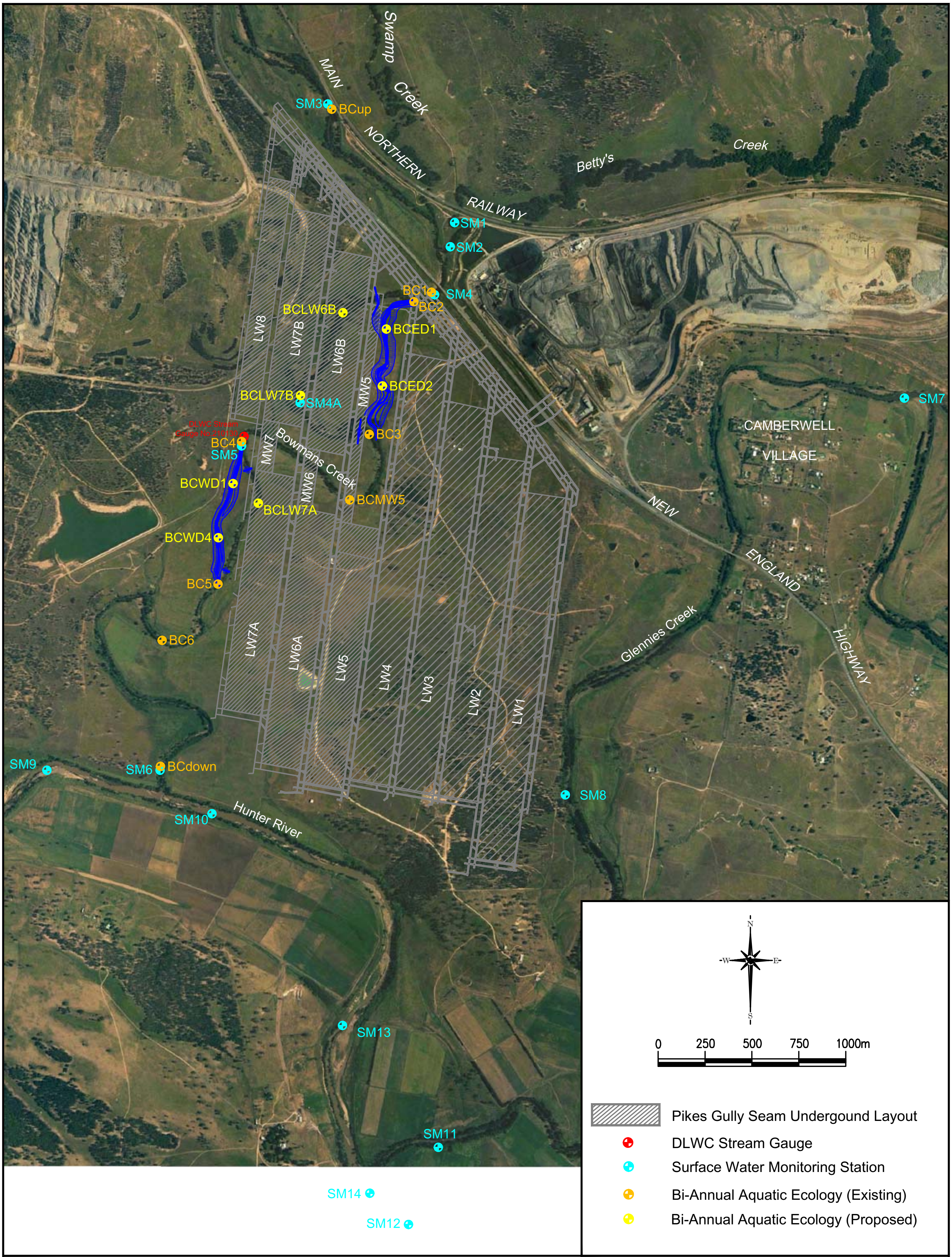
- Combined seasonal site data are used to provide mean and SD of stream site diversity and of stream SIGNAL index for seasonal comparisons over time;
- Fish sampling using bait traps set overnight plus direct observations and incidental captures during macro-invertebrate sampling. Data used to produce fish species lists per site per season;
- Site habitat diversity assessment using existing RCE method and site photo referencing;
- Metered and profiled water quality (EC, Temp, pH, NTU, DO). Data are used to provide specific season between-site comparisons to aid interpretation of site aquatic biota differences for that season.

Table 7: Proposed Completion Criteria for Geomorphology and Stream Health

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
Geomorphology and Channel Stability		
Absence of permanent channel scouring	Visual inspection after minor floods during first three years	Repair any significant scour and revegetate as necessary
Geometry of diversion channels	Establish 10 permanent survey sections in each diversion channel. Survey cross and long sections at the following times after opening of the diversion channels: • 6 months • 1 year • 2 years • 5 years • 10 years • after floods >150 m^3/s Compare channel section against earlier surveys and any changes in reference sites to assess trajectory towards long-term stability	Commission qualified fluvial geomorphologist to assess trend and recommend corrective actions. Undertake necessary corrective actions.
Channel geometry at existing reference sites	Re-survey cross sections in remaining active sections of channel every 5 years and after floods > 150 m^3/s	
Bed load transport	Sample channel bed for particle size analysis at same time as survey. Statistics of data from the diversion channels within 20% of that from the existing channel.	Commission qualified fluvial geomorphologist to assess trend and recommend corrective actions.
Stream Health		
Fish passage and aquatic ecology of diversion sections.	Fish passage and aquatic ecology of diversion sections to be same or better than pre-construction baseline conditions and in line with trends exhibited in the retained sections of the creek Completion for sites within the diversion channels will be established by comparing diversion channel site scores (Macro-invertebrate diversity, Site SIGNAL index, Site fish lists and Site RCE scores against baseline site mean ± SD scores) with: • pre-excision baseline scores for the corresponding sites within the creek	The expectation will be that individual diversion creek site indices will show a more or less steady increase over time against their baseline data. The 'recovery time' deduced from seasonal/site diversity and SIGNAL Index data for Bowmans Creek since the major 2007 mid-year flood was around 5 sampling seasons (around 2.5 years). Thus a period of 2.5 years for growth towards the completion criteria should be expected. Over this period the trigger for possible corrective

Table 7: Proposed Completion Criteria for Geomorphology and Stream Health

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	sections being excised; • trends in scores for reference sites in the retained sections of the creek Completion will be considered to be achieved once new site scores are consistently within or above the range (Baseline Excised Site Mean – SD) score and consistent with trend in reference sites. Establishment of four additional monitoring sites (two in each diverted section – see **Figure 10**) for bi-annual (spring and autumn) monitoring of same suite of indicators as used for monitoring to date: • Aquatic macro-invertebrate sampling using AusRivAS protocols. Calculation of SIGNAL indices; • Fish sampling using bait traps; • Site habitat diversity assessment using existing RCE method and site photo referencing; • Metered and profiled water quality (EC, Temp, pH, NTU, DO).	action for diversion creek sites would be persistently low steady or decreasing site criteria. In this case the aquatic ecologist will first investigate which specific site/criteria contribute to the low or decreasing scores, investigate the causes for particular criterion deterioration, and, once established, report on whether it is a ‘natural’ expected change (e.g., continuing climatic/seasonal variation), a site-specific non-deviation related change (e.g., a local bank slumping) or a possible deviation-related change (e.g., accelerated sedimentation, restricted fish passage). The aquatic ecologist will then make recommendations to ACOL for either further investigations or suggested remediation measures. For the retained “impact” creek sites, the aquatic ecologist will report on individual seasonal within-site low completion criteria results, using a decision tree similar to that devised for the diversion creek sites above.



▨	Pikes Gully Seam Undergound Layout
●	DLWC Stream Gauge
●	Surface Water Monitoring Station
●	Bi-Annual Aquatic Ecology (Existing)
●	Bi-Annual Aquatic Ecology (Proposed)

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Bowmans Creek
Diversion Project

Figure 10
Existing and Proposed Water Quality and
Stream Health Monitoring Sites

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6.3 Rehabilitation

The proposed monitoring regime for assessing the adequacy of the rehabilitation will be based on existing routine monitoring programs undertaken by ACOL (see **Section 5.1**). In particular the monitoring will extend the Landscape Functional Analysis methodology (see DnA & Carbon Based Environmental 2009a) and the program of rehabilitation and farmland monitoring undertaken at sites that will provide reference sites for some aspects of the program for Bowmans Creek (see **Figure 11** and **Figure 12**).

The proposed completion criteria relating to rehabilitation are set out in **Table 8** below. These proposed criteria and the associated monitoring regime and selection of reference sites will be formalised in a Rehabilitation Management Plan which will be prepared in consultation with relevant Agencies.

Table 8: Proposed Completion Criteria for Rehabilitation

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
Site Stabilisation (Phase 1)	The ground cover strategy controls erosion and reduces exotic weed dominance to minimal levels in community structure. During Phase 1: • Quantitative data collection on floristic composition and cover will be undertaken bi-monthly to measure success. • Weekly and stochastic (during rain) quantitative and qualitative measures of soil erosion impacts and ground disturbance will also be undertaken. • Weekly assessments of cover and erosion will be compared with available data and reference sites to assess success. Upon completion of this phase, • Vegetative cover will be dominated by local native species with minimal evidence of weed cover and erosion. • Weeds will be successfully managed so that they are not inhibiting the successful establishment of the future community structure and diversity. This will be determined by direct quantitative comparisons with reference sites, with the aim of achieving comparable mean species diversity and structural complexity scores.	When cover is insufficient to control erosion, additional planting and safeguarding will be implemented in the area of impact. Weed cover will be controlled to minimal levels through appropriate systematic control. However, when surveys identify outbreaks, additional intensive control measures will be implemented. If data shows that future structural and diversity goals will not be met, an adaptive reworking of the planting program will be undertaken to incorporate a wider range of species. The benefits of introducing additional growing material or providing additional soil ameliorants will also be investigated. Measures will be put into place, with the goal of increasing cover and diversity as compared with reference sites.
Community Structure (Phase 2)	Phase 2 will establish structural elements that provide habitat niches. Three structural elements are important to the landscape: • Groundcover is representative of tussock grass clumps, small areas of open ground and fallen timber which	Success of the regeneration in terms of structural elements has to be corrected "along the way". Bi-monthly surveys need to record growth rates, species abundance as well as percentage cover to determine a final structural complexity index. Where elements are

Table 8: Proposed Completion Criteria for Rehabilitation

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	provides both important fauna habitat onsite, and a generally sparse shrubbery; • Mid-stratum is very open to sparse, and should reach beyond 2 metres in height to provide nesting for important species (i.e. Grey-crowned Babbler) and perch sites for others (i.e. Hooded Robin); • Over-storey structure will range from forest (i.e. riparian corridor) to woodland (i.e. floodplain areas), with a diverse yet clumped species composition that is consistent with the community reference sites. Structural complexity scores will be achieved by sampling complexity using a modified vegetation complexity assessment method as first developed by Newsome and Catling (1979). This quantitative data will be compared with data sets from reference sites to assess success of this phase.	lacking this needs to be fed back into the planting program.
Species Diversity (Phase 3)	Community diversity is reliant on many factors. As a measure of present diversity onsite, quantitative data collected (18 sample sites) has identified 91 native flora species as being endemic. These species will form the lowest benchmark for rehabilitation of floristic diversity. Many more species have been identified in the region as occurring within the types of vegetation communities recorded onsite (CMA data – *refer Appendices 3 and 4 of Landscape Restoration Report*). It is, however, impossible to predict whether all these species could potentially colonise the site, because there are many unknown factors to the establishment of flora species. Nonetheless, beyond this benchmark, species that can be successfully harvested and germinated will be included in the development of greater diversity in Phases 2 and 3.	If the diversity measures differ from reference sites beyond the performance criteria, additional adaptive measures will be implemented.
Floodplain Red Gum Woodland	There are two components here: 1. Assessing established River Red Gum individuals, and 2. Assessing the success of River Red Gum rehabilitation to the floodplain terrace (as per **Figure 3**). The health of established River Red Gum individuals will be maintained until project completion. Comparative health assessments will be conducted annually, using reference	When changes in tree health such as water stress are evident, adaptive measures will be implemented.

Table 8: Proposed Completion Criteria for Rehabilitation

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	sites as indicators of health in the absence of onsite impacts. Juvenile River Red Gum survivorship and long term recruitment of established communities cannot be compared to reference sites, as lack of recruitment is a key problem to the long term viability of the population. Experimental pilot studies in line with specific management actions will be used to establish a successful protocol for the establishment and long term survival of individuals.	
Hunter Valley River Oak Forest Community	Analysis of the success of establishing the community will be achieved by an analysis of similarity (Such as an ANOSIM test, Cluster Analysis or PermaNova) to test for differences in species assemblages across the rehabilitation and reference sites. The goal being to assess whether rank similarities within groups are greater than between groups. Therefore, allowing an assessment of the rehabilitation communities "fit": within broader community variability. Throughout the rehabilitation phases comparison between rehabilitation sites and reference sites will be undertaken to establish the progressive success of works. Initial planting phases will establish the great majority of species diversity onsite, this can be compared within structures, (for example, comparing the grass assemblage of sites only) to remove bias of comparing an established site with a rehabilitating site.	When this analysis identifies a divergence from the reference sites community assemblage adaptive planting and management will be implemented.
Floodplain Pasture Lands	Floodplain pastures will be established as viable grazing pastures for long-term agricultural purposes. The area will be dominated by grassland pasture species with minimal agricultural weed species.	If agricultural weed species colonise the area adaptive management will be put in place to remove.
Terrestrial Fauna	Terrestrial fauna species diversity and abundance changes in a non-linear manner. Reference sites will also have community structures that are different with each other and variable overtime. The suite of terrestrial fauna species recorded at all the reference sites (within one standard deviation) over the monitoring period will be the bench mark for terrestrial fauna diversity. Significant species populations in the area will be monitored and compared to reference sites to assess survivorship.	Measures such as, introducing habitat elements for species, introducing new flora species, creating habitat pockets, improving links and stepping stones, and physical management of the landscape (i.e. grazing some area) will be used to correct a lack of species diversity

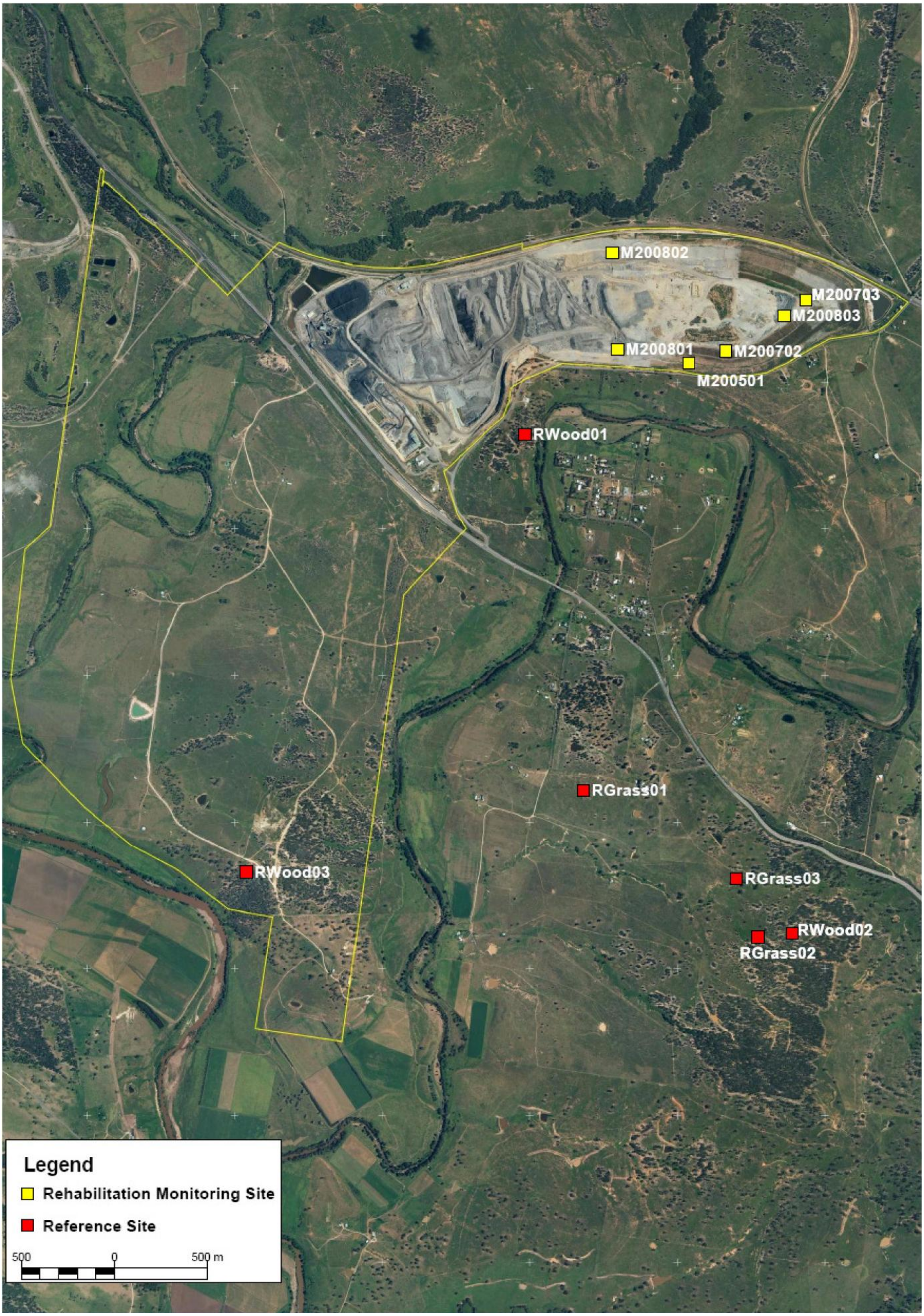

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Figure 11
Map Showing Location of Overburden Rehabilitation Reference Sites and Monitoring Sites

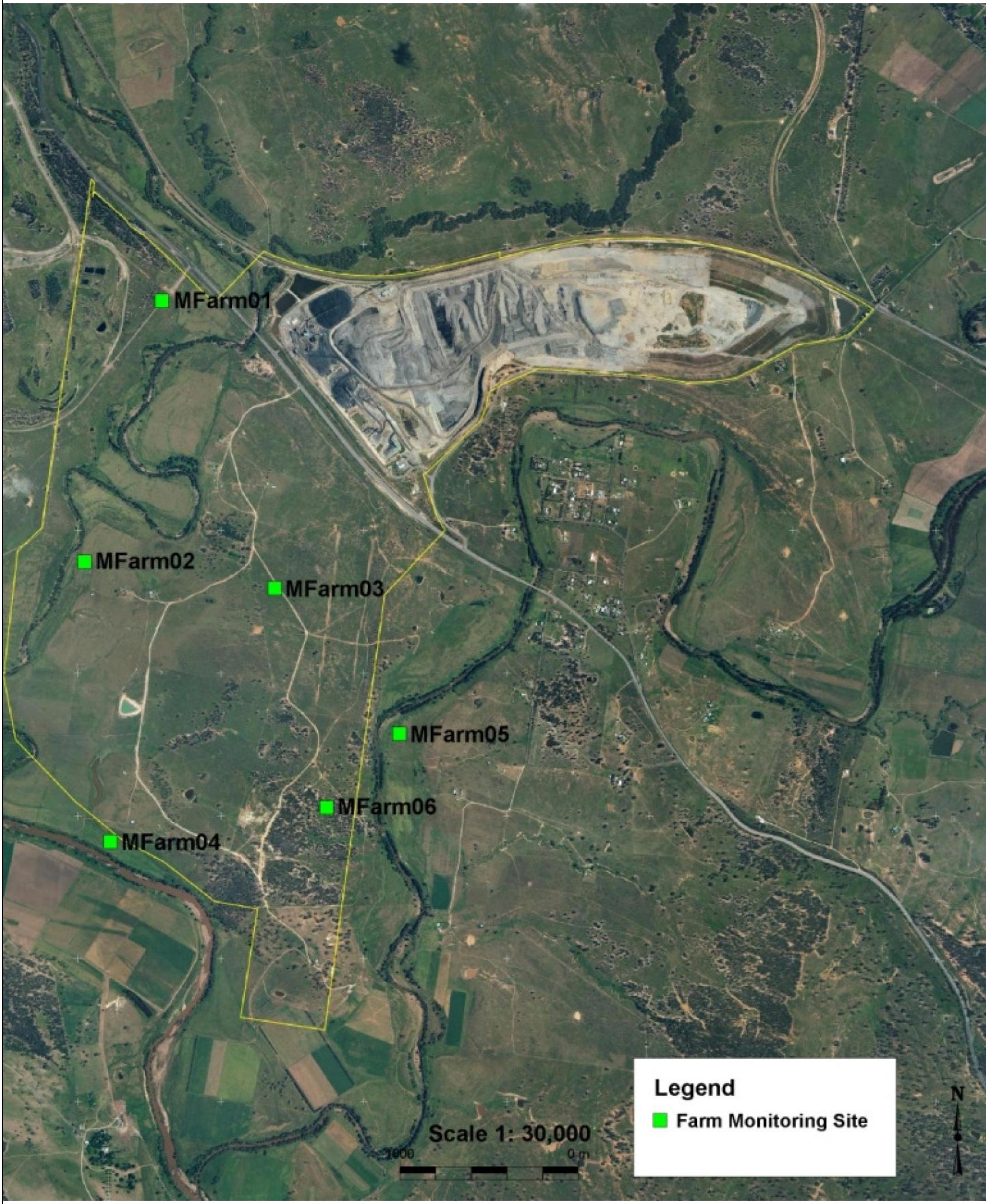

Figure 12
Map Showing Location of Farmland Monitoring Sites

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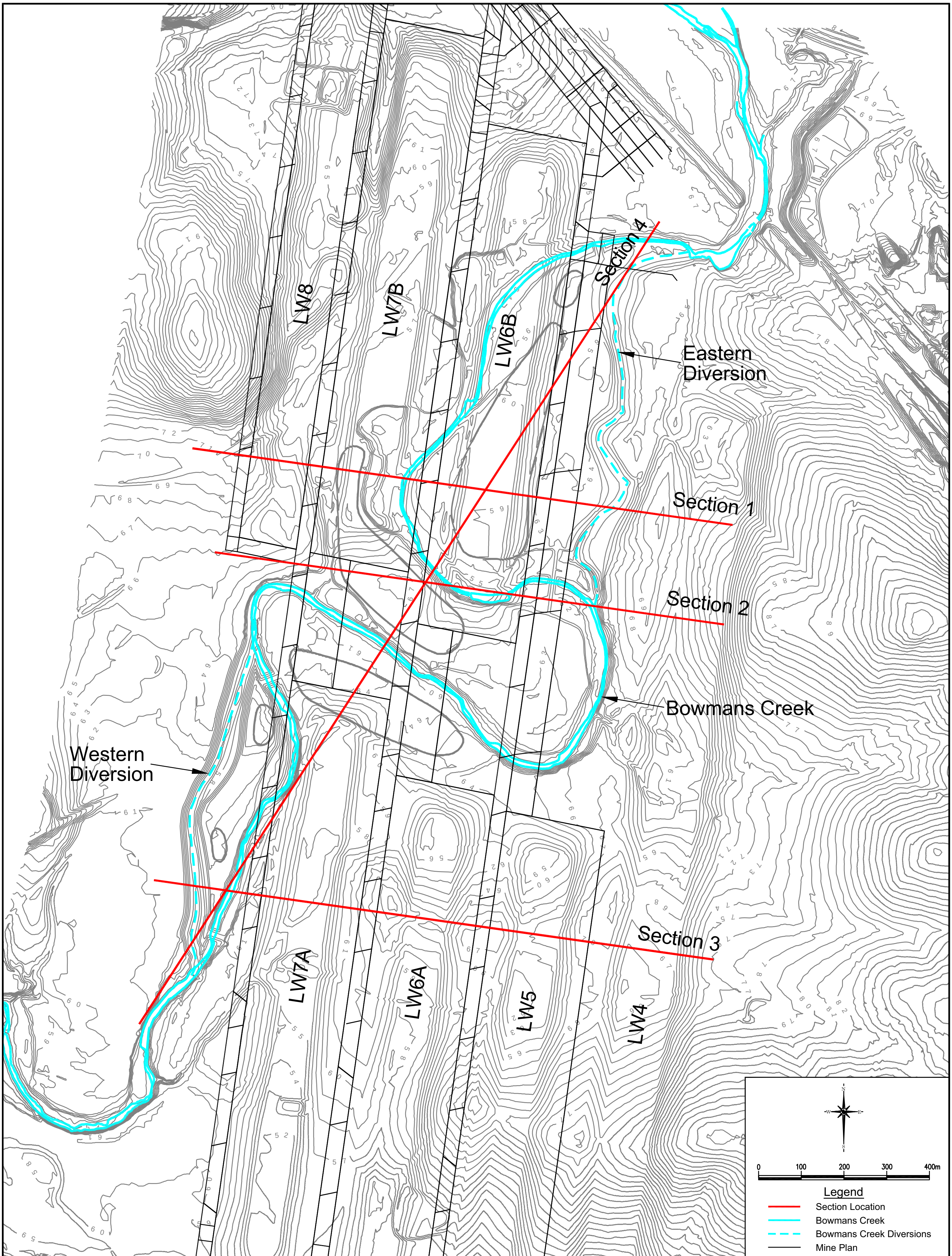
Annexure A: Proposed Final Landform



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Response Figure 1
Indicative Final Landform
Final Landform & Section Location Plan

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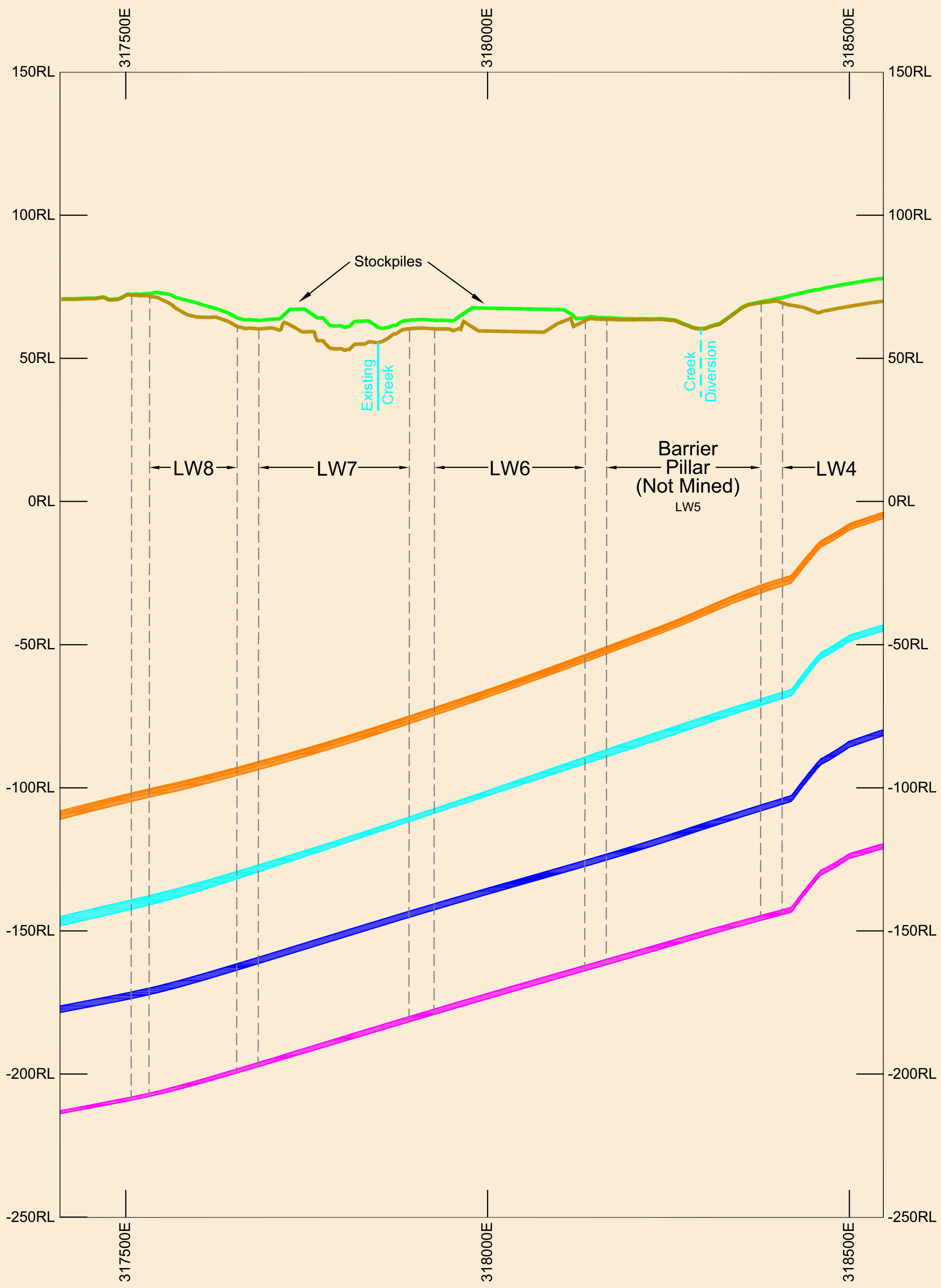

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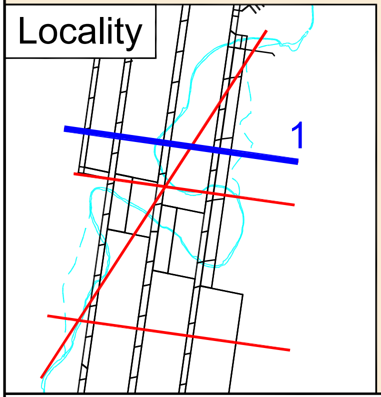

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Response Figure 2
Indicative Final Landform
Section 1

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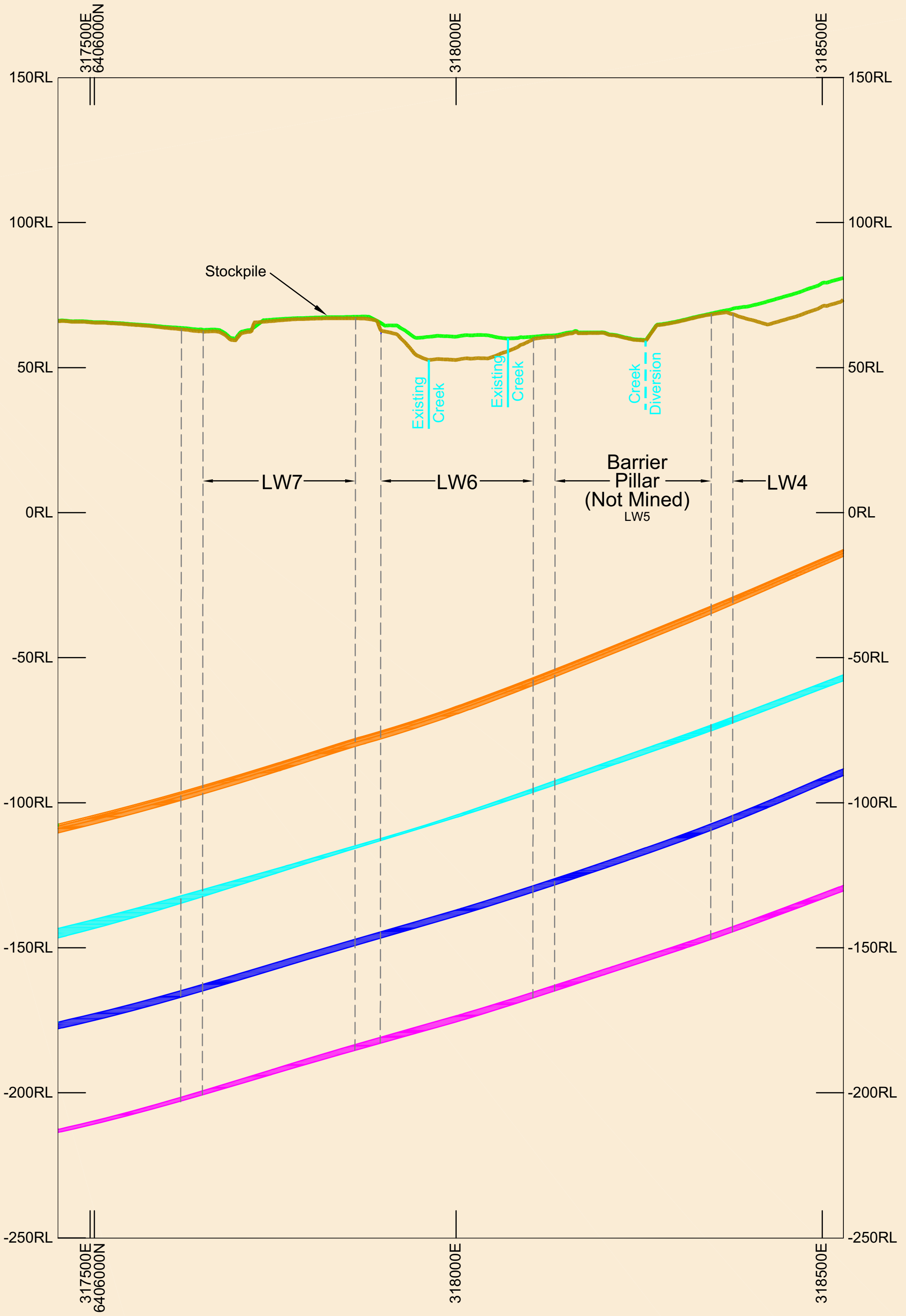

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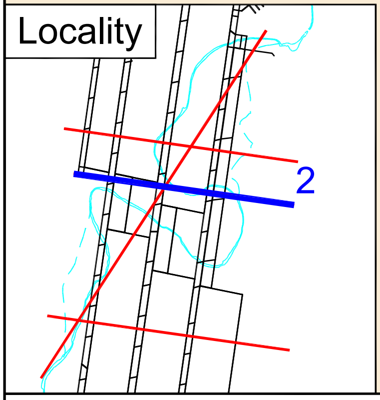

Legend

🟩	Original Topography
🟫	Subsided Topography
— —	Longwall Gate Road
🟧	Seam - Pikes Gully
🟦	Seam - Upper Liddell
🟦	Seam - Upper Lower Liddell
🟪	Seam - Lower Barret

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Bowmans Creek
Diversion Project

Response Figure 3
Indicative Final Landform
Section 2

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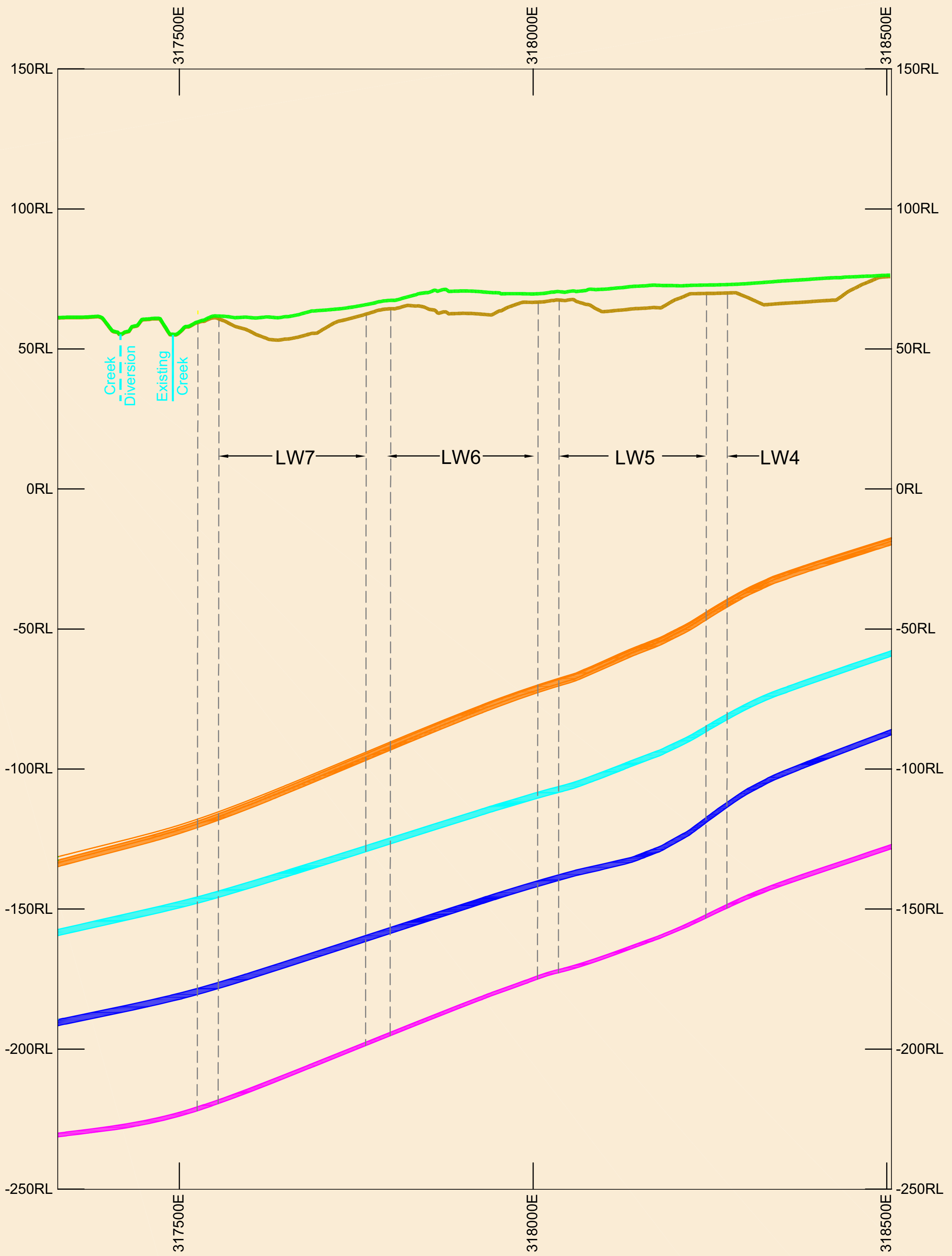

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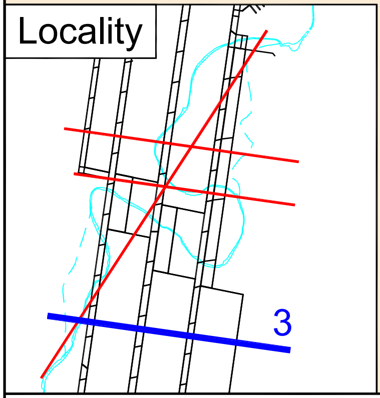
Locality



Legend

🟩	Original Topography
🟧	Subsided Topography
— —	Longwall Gate Road
🟧	Seam - Pikes Gully
🟦	Seam - Upper Liddell
🟦	Seam - Upper Lower Liddell
🟪	Seam - Lower Barret

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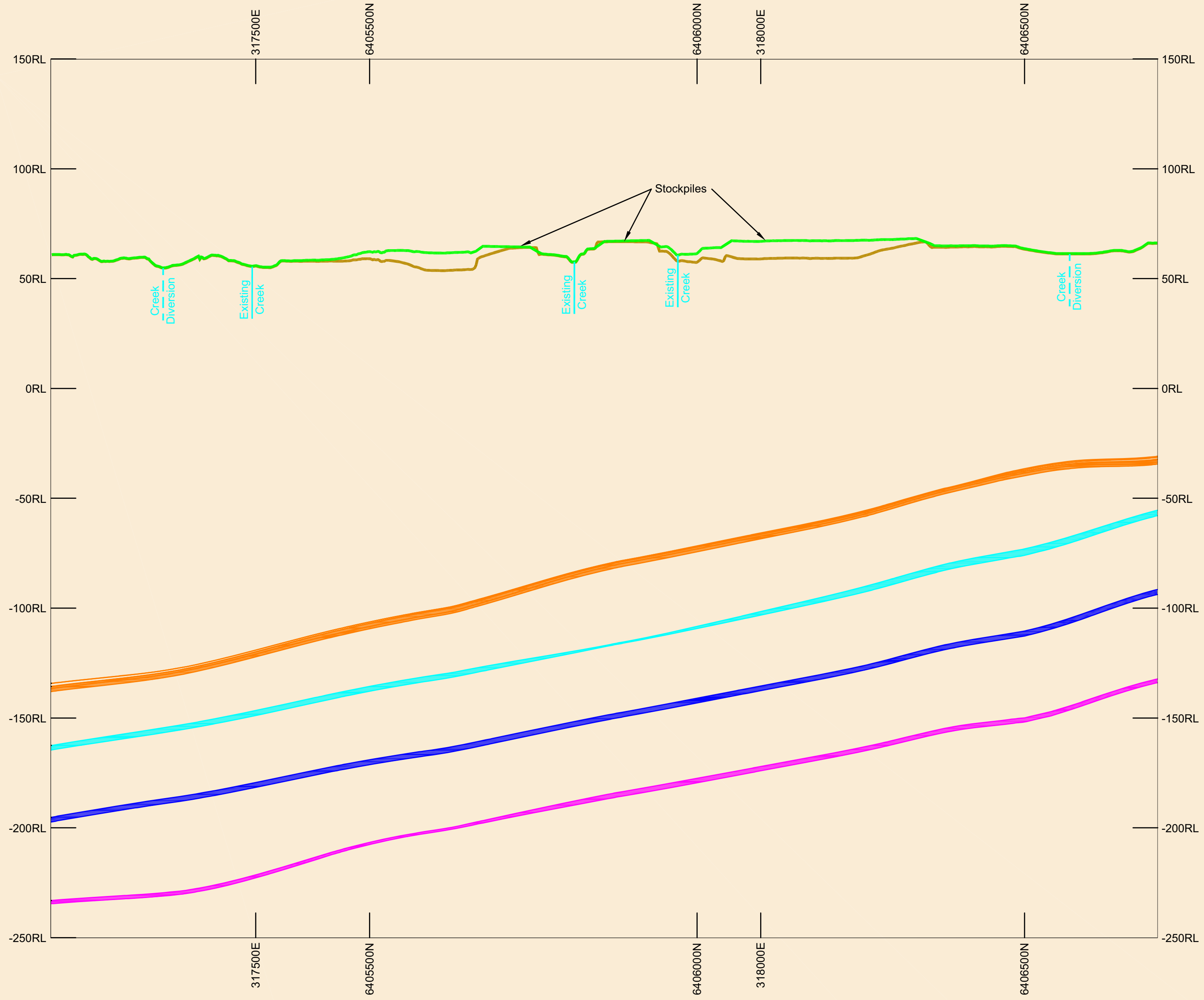
Bowmans Creek
Diversion Project

Response Figure 4
Indicative Final Landform
Section 3

CAD File: 06248B-4.dwg



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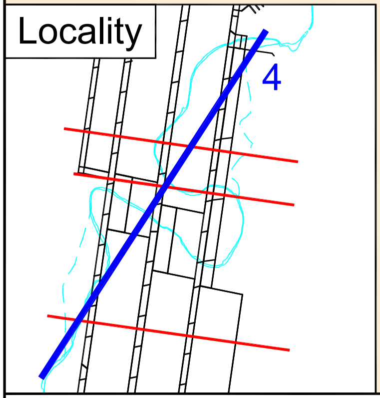

Legend

- Original Topography
- Subsided Topography
- Longwall Gate Road
- Seam - Pikes Gully
- Seam - Upper Liddell
- Seam - Upper Lower Liddell
- Seam - Lower Barret

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Prepared by Pegasus Technical

Bowmans Creek
Diversion Project

Response Figure 5
Indicative Final Landform
Section 4

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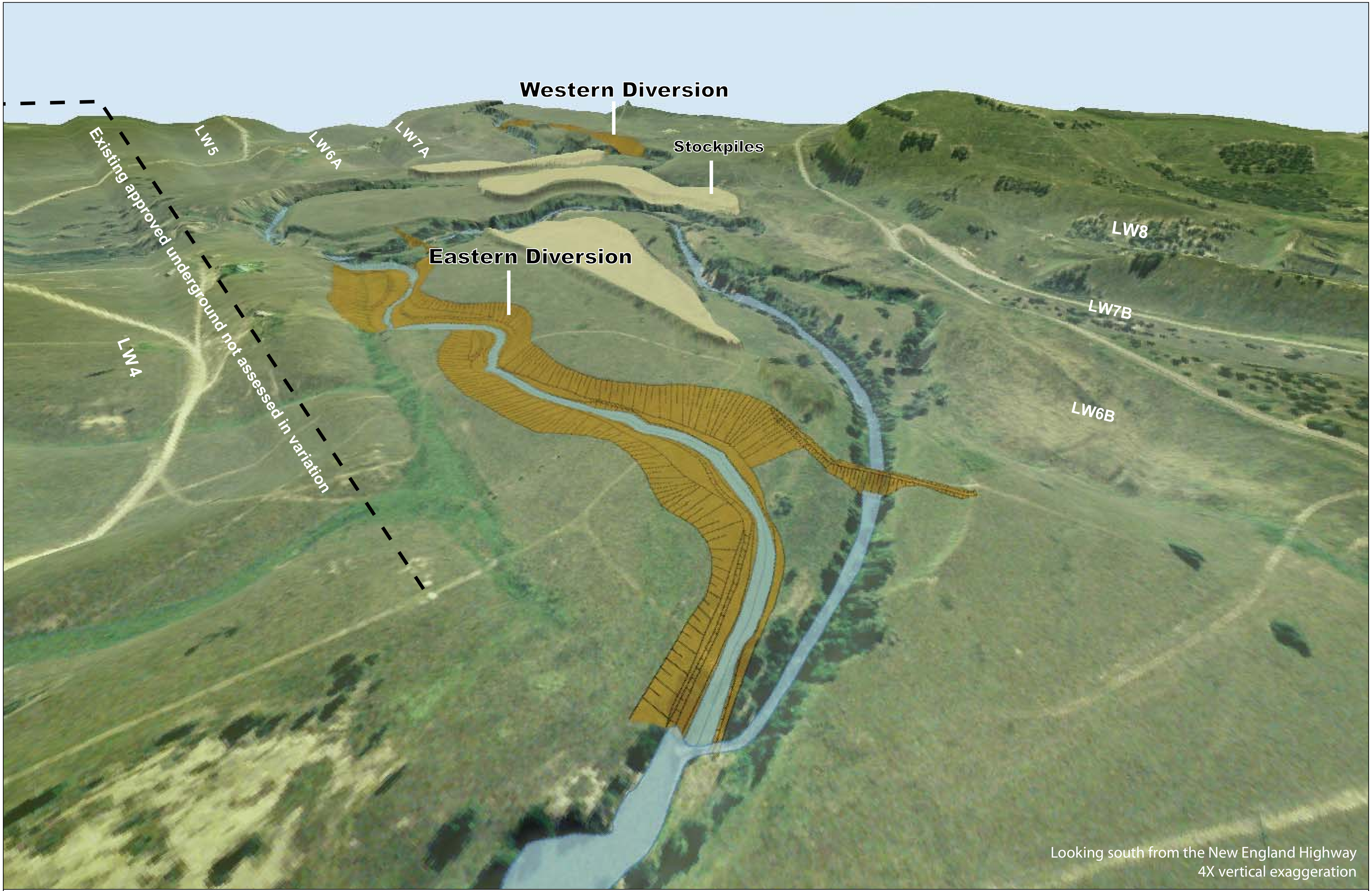

Looking south from the New England Highway
4X vertical exaggeration

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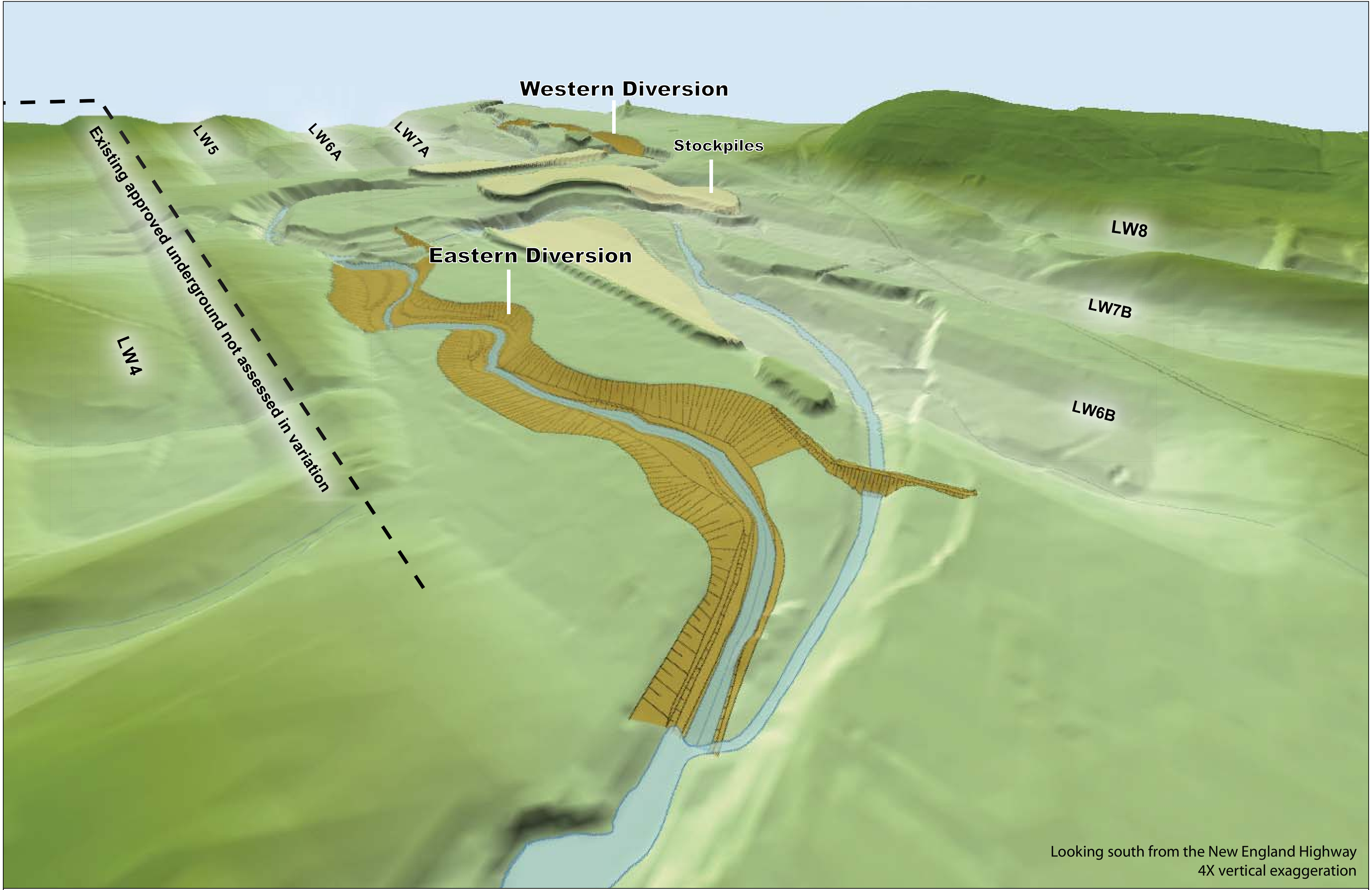
Bowmans Creek Diversion Project

Figure 6
Indicative Final Landform 3-D Perspective with aerial photograph



Looking south from the New England Highway
4X vertical exaggeration

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Diversion Project

Figure 7

Indicative Final Landform 3-D Perspective

Appendix 4: Ecologically Sustainable Development

RESPONSE TO SUBMISSION FOR THE BOWMANS CREEK DIVERSION PROJECT - REGARDING THE PRINCIPLES OF ESD

1 INTRODUCTION

A number of submissions on the Bowmans Creek Diversion Project made the assertion that the proposed modification should be rejected on grounds that the principles of Ecologically Sustainable Development (**ESD**) are not met.

Two of the submissions (the submission of Bruce Russell and submission of the Hunter Environment Lobby Inc.) explicitly made this assertion. A number of other submissions implicitly make this assertion, through assertions to the effect that the New South Wales government does not have the right or ability to allow the proposed modification and that the modification should not be approved on certain listed environmental grounds.

This response attends to those submissions collectively by detailing how the proposed modification adheres to the principles of ESD.

2 THE PRINCIPLES OF ESD

The *Environmental Planning and Assessment Act 1979* (**EPA Act**) at section 5(vii) provides that one of the aims of the act is to promote 'ecologically sustainable development'.

ESD is defined in the EPA Act by reference to section 6(ii) of the *Protection of the Environment Administration Act 1991*, which provides as follows:

> *'ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:*
>
> *(a) the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*
>
> *In the application of the precautionary principle, public and private decisions should be guided by:*
>
> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
>
> *(ii) an assessment of the risk-weighted consequences of various options,*
>
> *(b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,*
>
> *(c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,*
>
> *(d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:*
>
> *(i) polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,*

> (ii) *the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,*
>
> (iii) *environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.'*

The risk assessment strategies and the environmental management and protection and mitigation procedures proposed in the environmental assessment for the Bowmans Creek Diversion Project (**Project**) take into account the principles of ecologically sustainable development such that the objects of section 5(vii) are fulfilled. The manner in which the Project as proposed in the environmental assessment is compliant with the four elements of ESD are detailed as follows.

3 PRECAUTIONARY PRINCIPLE

In preparation and planning for the Project, Ashton Coal Operations Limited (**ACOL**) has carried out thorough scientific and engineering analyses of the existing environment in the Project area and the effect of the modification as proposed in the Project on the environment both locally and regionally. This assessment was an iterative process and fed in to the planning process and the mitigation procedures developed in respect of the Project.
The assessments undertaken include:

(a) Project Risk Assessment
(b) MODFLOW-SURFACT groundwater modelling based on extensive groundwater monitoring;
(c) water balance analysis and modelling;
(d) geomorphic assessment of channel geometry, bed load transport and stability;
(e) hydrologic assessment of Bowmans Creek flow regime;
(f) flooding and hydraulic analysis using TUFLOW and HEC-RAS hydrodynamic modelling;
(g) subsidence assessment;
(h) ecological impact assessment including riparian and aquatic ecology;
(i) Aboriginal heritage assessment in accordance with DECCW guidelines; and
(j) review of previous archaeological assessments carried out over the Project area.

Community consultation was also undertaken as an element of the planning and assessment undertaken for the Project, and consisted of the following:

(a) identification and discussion of the proposed modifications with the existing ACP Community Consultative Committee, established when the approval for the Ashton Coal Project was first granted;
(b) regular community newsletters;
(c) maintenance of the ACOL environmental hotline and website;
(d) Aboriginal community consultation in accordance with DECCW guidelines;
(e) targeted meetings with Singleton Shire Council; and
(f) Consultation with government departments.

This assessment and consultation process has enabled ACOL to identify the negative impacts and potential serious and or irreversible damage of the Project on the local and regional environment and develop measures to avoid, minimise and ameliorate these impacts.

The potential impacts have been identified with adequate scientific certainty to allow planning for the Project to be completed. As a result of the assessments carried out and the new understanding of the environment as detailed in the Environmental Assessment, the proposed modifications allow for greater certainty of impacts as mining progresses in the lower seams as compared to the currently approved mining operations. Particularly, a change in the understanding of the ground water systems in the relevant area of Bowmans Creek have allowed an updated mine plan to be developed which more fully protects the critical environmental factors in the area.

The particular elements of the updated mine plan and proposed modifications to the existing Project Approval which display adherence to the precautionary principle such that environmental damage is minimised and ameliorated are as follows:

(a) the final extraction design of each subsequent seam below the Pikes Gully seam will be subject to results of ongoing subsidence monitoring and further assessment;
(b) creation of a free-draining landform;
(c) recreation of existing creek bed geomorphology in the diversion channels, including pools and riffles, to be enhanced with the addition of engineering log jams, including the use of geosynthetic clay liner to conserve base flow;
(d) implementation of dust suppression measures during construction;
(e) staged landscape restoration and vegetation establishment, in accordance with existing management plans;
(f) improving existing riparian and aquatic habitat by weeding, selective revegetation and selective exclusion of stock,;
(g) various offset measures to counteract predicted environmental damage (further detail below); and
(h) continued implementation of Aboriginal and Cultural Heritage Management Plans.

3.1 SOCIAL EQUITY INCLUDING INTERGENERATIONAL EQUITY

In order to ensure the integrity of the environment for future generations as the Project continues, the following have been proposed:

(a) existing management plans will be adapted and updated to account for the specific requirements of the Project;
(b) the adaptive environmental monitoring program in place will be continued and/or enhanced in respect of the Project;
(c) progressive revegetation of diversion channels will be undertaken to complement and enhance natural vegetation in the area and surrounds;
(d) filling and other works undertaken to maintain a free draining landscape; and
(e) continued maintenance of bonds under the relevant mining tenements to ensure that environmental rehabilitation requirements are carried out.

In recognition of the potential impacts as identified in the Environmental Assessment, a number of offset and mitigation areas and strategies are proposed, including:

(a) an increase from 0.9ha to 1.1ha in the total area of pools available to ensure there is no reduction in actual aquatic habitat,
(b) recreation of geomorphology of existing creek in diversions, with several features to enhance the ecological environment;
(c) construction of riparian and floodplain areas to achieve a net increase particularly in regard to Hunter Valley River Oak and Hunter Valley Red Gum populations;
(d) offset of water losses by surrender of 47.5ML worth of water access licence entitlements annually and a permanent surrender of 20ML worth of entitlements; and

(e) replacement of hollows within riparian corridor at a 3:1 ratio.

ACOL is also aware of the need to preserve existing cultural heritage for future generations, particularly in regard to aboriginal cultural heritage. ACOL is committed to continuing its existing Aboriginal and Cultural Heritage Management Plans and the protection and salvage measures therein.

The Project will also directly and indirectly enhance the economic and social security of future generations as it will provide $80 million dollars of increased revenue at the State and federal level as well as enhancing the security of 195 direct employment positions, along with providing 35 construction positions. The Project will also serve to enhance the New South Wales coal industry by providing access to an additional 5.3Mt of ROM coal, which will assist in ensuring Australia's future through export income and access to competitively priced energy.

3.2 CONSERVATION OF BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY

Significance assessments for the Project have indicated that it will not have a significant adverse affect on species in the area and, in fact, will provide significant additional habitat for a number of species. The two strips of River Red Gum identified (an endangered population in the Hunter Valley) will be managed as part of the existing flora and fauna management plan. The increased riparian and floodplain woodland proposed in the Environmental Assessment will serve to provide additional habitat for the threatened fauna identified in the Project assessment process (being 3 species of bat, 3 species of bird and a species of myotis). Existing riparian and aquatic habitat will be improved by stock exclusion, weed control, selective revegetation measures, and provision of large woody debris..

The geomorphology and rehabilitation of the diversion channels has been designed to be representative of the natural landscape of the area and to enhance the currently poor biological diversity and ecological integrity of the area. The use of geosynthetic clay liner throughout will preserve base flow and the provision of erosion control matting adjacent to the low flow channel will prevent any erosion that may occur in that area prior to completion of revegetation. An increased understanding of the hydrological connection between Bowman's Creek and its alluvium has led to the prediction that the carrying out of the Project will lead to decreased salinity levels in the Hunter River.

ACOL has committed in the Environmental Assessment to a number of ongoing monitoring procedures to ensure that ecological integrity can be re-assessed and maintained and the mine plan reviewed as the Project proceeds, including:

(a) maintenance of existing piezometer network, with additional groundwater monitoring points and bores;
(b) creation of 10 survey cross-channel monitoring locations in the diversion channels to be monitored every 5 years;
(c) monitoring of water extracted from the mine;
(d) operational floodplain monitoring;
(e) ongoing iterative subsidence monitoring and
(f) ongoing surface water and stream health monitoring programs.

In order to minimise the levels of greenhouse gas emitted directly from the Project, haulage routes will be designed as short as is practicable and all machinery and vehicles will be maintained in good condition.

Although the dust generated from the Project is estimated to make a minimal contribution to total cumulative dust levels in the area, the following dust suppression measures will be implemented:

(a) dampening of areas where scraping and hauling occurs by water cart;
(b) minimisation of disturbed areas; and
(c) progressive revegetation measures.

3.3 IMPROVED VALUATION, PRICING AND INCENTIVE MECHANISMS

The costs of identification and consideration of the impacts of the Project as carried out in the Environmental Assessment recognises the value of both the recoverable resource and the environment.

The costs of mitigation and management as described above and further in the Environmental Assessment will be borne in total by ACOL. Therefore the cost of environmental protection and mitigation is borne wholly by ACOL and is included in the total cost of the Project as described in the Environmental Assessment, in accordance with the ‘polluter pays’ principle.