06 March 2013

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Dear Lyndon

Western Coal Services Upgrade - Environmental Impact Assessment Geomorphological Assessment

1 Introduction

RPS is preparing the Environmental Impact Statement (EIS) for the Western Coal Services Project – Blackmans Flat (the Project) on behalf of Centennial Coal. The Director General Requirements (DGRs) for the EIS indicates a geomorphology impact assessment is required.

GHD has been engaged on behalf of Centennial Coal, to undertake a Geomorphology Impact Assessment for the Project. This letter provides the outcomes of the geomorphological assessment of Wangcol Creek for inclusion into the EIS documentation for the Project.

2 Methodology

This assessment involved the following tasks:

- Desktop assessment of available information.
- Site Investigation.
- A review of the Project Description and an assessment of the potential impacts of the Project on the geomorphology of Wangcol Creek.

2.1 Desktop Assessment

A desktop assessment of existing information (GIS data and aerial imagery) was undertaken to review the characteristics of the catchment upstream of the site. This included estimation of catchment area and determination of the stream order of Wangcol Creek in the Study area.

Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler, 1952). Figure 2-1 indicates the Strahler stream ordering process for a generic catchment. Numbering begins at the top of a catchment with headwater ('new') flow paths being assigned the number one. Where two flow paths of order one join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on.

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Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the area downstream of the junction will retain the higher stream order.

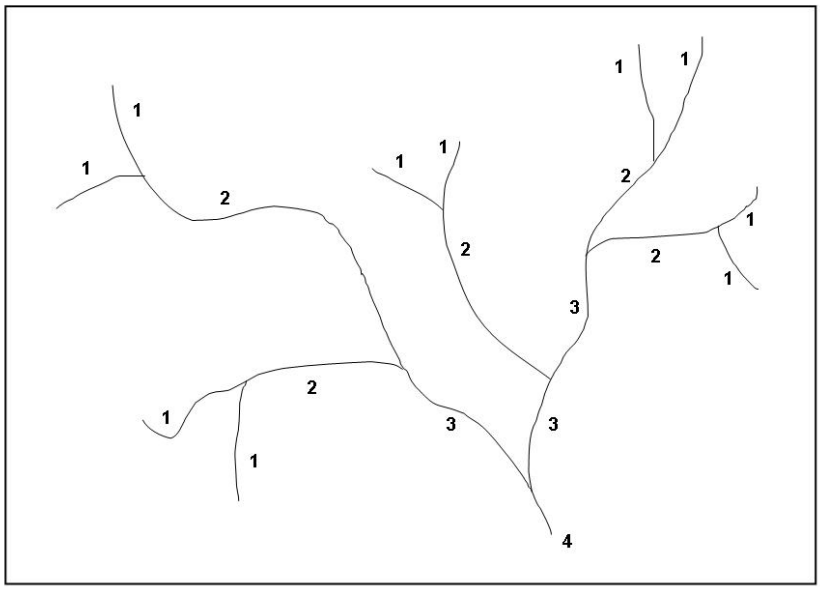


Figure 2-1 Stream Order for a Generic Catchment using Strahler (1952) Method

2.2 Site Investigation

A site investigation was undertaken on the 9th of January 2013 to identify the current physical characteristics of Wangcol Creek through the site. Information recorded during the field investigation included:

- Geomorphic type and condition of Wangcol Creek.
- Nature, location and extent of existing waterway instabilities.
- Nature and location of waterway controls (e.g. bedrock, logs).
- Nature of channel and bedload materials.

General site data was recorded using a hand held GPS with other measurements being undertaken including valley widths and channel widths and depths during the site investigation.

The assessment of stream physical form and function is broadly based on the methods and principles of the River Styles® framework (Brierley and Fryirs, 2005). This is the primary framework used in NSW for the geomorphic assessment of waterways.

Determination of stream types is largely based on the following parameters:

- Degree of valley confinement and bedrock influences.
- Presence and continuity of a channel.
- Channel planform (number of channels, sinuosity).

- Channel and floodplain geomorphic features.
- Nature of channel and floodplain sediments.

The assessment of geomorphic condition was based on Outhet and Cook (2004) who describe a rapid method of condition assessment that frames geomorphic condition in the context of natural and human induced variability. The characteristics of each condition category are described in Table 2-1. These categories provide an indication of the degree of alteration a reach has experienced from its expected natural form.

Table 2-1 Geomorphic Condition Category Descriptions

Indicative condition	Characteristics
Good	Geomorphic structure is largely unchanged from the pre-disturbance state such that only minor cases of localised instability occur. Relatively intact and effective vegetation coverage dominated by native species, giving resistance to natural disturbance and accelerated erosion. There is minimal alteration to catchment controls such as sediment supply and the hydrological regime allowing fast recovery from natural disturbance. There is also a high potential for ecological diversity.
Moderate	Geomorphic structure is moderately altered such that a reduced diversity of river features exist and floodplain connectivity is somewhat limited. Localised degradation of river character and behaviour, typically marked by modified patterns of geomorphic units. Patchy effective vegetation coverage allowing some localised accelerated erosion. The river has not fully adjusted to prevailing conditions and is experiencing ongoing changes.
Poor	Considerable geomorphic alteration to the functioning and structure of the system when compared with the pre-disturbance condition. Type, extent and rate of processes are radically altered. Floodplain connectivity may be significantly altered. Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and/or inappropriate patterns or rates of planform change and/or bank and bed erosion). Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity. Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

3 Baseline Conditions

3.1 Catchment Characteristics

At the site, Wangcol Creek has a catchment area in the order of 20 km^2 and is a 4^{th} order streamline. The headwaters of tributaries largely drain forested catchments, however, middle reaches have been disturbed by mining and agricultural practices. Tributaries are unnamed with the exception of Neubecks Creek which enters Wangcol Creek approximately 1 km upstream of the western boundary of the Project area.

The section of Wangcol Creek within the Study area is approximately 700 m. Downstream of the Project area boundary, Wangcol Creek flows a further 2 km, as a modified 4th order stream, before discharging into the Coxs River.

3.2 Waterway Types

Through the Study area Wangcol Creek exhibits three different stream types as follows:

- Low Sinuosity, Fine Grained System.
- Channelised Fill System.
- Valley Fill System.

The distribution of stream types along Wangcol Creek is displayed in Figure 3-1 (attached) and their characteristics are described below.

Valley Fill Systems

These systems are characterised by a relatively flat, featureless valley floor surface that lacks a continuous, well-defined channel. Features within valley fills can include a poorly defined low flow channel and occasional ponds. Substrates comprised of alluvial fine silts and muds vertically deposited out of suspension as flow velocity and competence is lost. Material eroded from the catchment is not transported through the reach resulting in the long-term deposition and storage of sediment. Hence, these stream types act as long term sediment accumulation zones. Degradation of these systems generally occurs through incisional processes such that a continuous channel forms within the valley floor sediments. Once incised, recovery back to an intact valley system is limited.

The valley fill system identified in the Study Area is largely located along the middle to lower 350 to 400 metres of Wangcol Creek within the Project area. There are number of ponds in this reach and vegetation is dominated by macrophytes (Table 3-1, Photograph 1). The outlet of the Licenced Discharge Point 6 (LDP006) for the Springvale Coal Service Site enters this reach on the southern extent of the waterway (Table 3-1, Photograph 2). Wangcol Creek is also crossed by a bridged road crossing towards the downstream extent of this reach (Table 3-1, Photograph 3).

Additionally, Wangcol Creek exhibits a valley fill system just upstream of the western boundary of the Project area. This reach is marked by the presence of headcuts approximately 1.5 m in height at its downstream extent (Table 3-1, Photograph 4). These headcuts are actively retreating into the upstream unincised valley fill deposits.

Table 3-1 Photographs of Valley Fill Systems

Photograph 1	Photograph 2
	
Downstream view of the Valley Fill system along Wangcol Creek.	Downstream view of LDP006.
Photograph 3	**Photograph 4**
	
View of bridge crossing towards the downstream extent of the Valley Fill system.	Upstream view of headcuts at the western boundary of the Project area.

Channelised Fill Systems

Channelised Fill systems, in relative terms, comprise a laterally stable channel of low sinuosity incised within flat and featureless floodplains. Headcuts, which are usually the cause of the channeling, can progress upstream as a result of disturbances and unprotected banks will erode during times of higher flow. Most channels have incised to a point where all flows are contained within the channel such that the former fill surfaces are rarely inundated.

The channelised fill systems along Wangcol Creek are located at the very upstream and downstream extents of the Project area. The upstream reach has incised to shale bedrock with channel dimensions between 10 and 15 metres wide and up to 1.5 m deep (Table 3-2, Photograph 1). Banks are vertical and largely unvegetated, with a profile composed of weathered clay material with platy sandstone clasts overlain by a 20 to 30 cm veneer of alluvial silts.

This reach contains the NSW Office of Water flow gauge 212055 with an associated concrete weir hydraulic control (Table 3-2, Photograph 2), which was established in 1991. Downstream of the flow gauge weir, an approximate 80 m section of Wangcol Creek has obviously been diverted in the past, with the channel being excavated into bedrock consisting of shales and sandstones (Table 3-2, Photograph 3). This diversion may have initiated the headcuts evident immediately upstream of the western boundary of the Project area.

Wangcol Creek also transitions from a valley fill system to a channelised fill system at the eastern boundary of the Study area. This transition is marked by the presence of a headcut in the order of 0.5 metres high. Downstream of this headcut, the channel has dimensions of between 5 to 10 metres wide and up to 1.5 metres deep. Banks are near vertical and composed of a light brown soil with a sodic appearance (Table 3-2, Photograph 4). Such soils are unlikely to be of recent alluvial origin and hence, it is suspected that this reach is an excavated channel to allow for the diversion of Wangcol Creek away from adjacent mining activities associated with the original Wallerawang Colliery, now Pine Dale mine.

The channelised fill system extends a further 1.9km downstream, and essentially follows an old railway embankment before entering the Coxs River at the site of an old open cut void (known as “Blue Lagoon”).

Table 3-2 Photographs of Channelised Fill Systems

Photograph 1	Photograph 2
	
Downstream view of the upper Channelised Fill system incised to bedrock.	Downstream view with flow gauge weir in middle ground.

Photograph 3	Photograph 4
	
Downstream view of excavated channel in bedrock.	Downstream view of lower Channelised Fill reach displaying near vertical banks.

Low Sinuosity Fine Grained Systems

This waterway type exhibits a low sinuosity channel with continuous floodplains and relatively stable, cohesive banks due to the fine-grained material. The channel generally holds water in isolated pools between flows. The channel itself is of low gradient and low energy such that sediment transported is predominantly limited to fine grained silts and clays in suspension. The low capacity channel allows overbank flows to be readily dissipated across the floodplain surfaces, activating flood channels and depositing fine grained sediments on the floodplain.

The low sinuosity, fine grained section of Wangcol Creek is located between the diverted channelised fill section and the main valley fill section and extends for approximately 100 m. This reach exhibits a channel of low capacity, characterised with pools connected by a narrow and shallow low flow channel (Figure 3-2). Bed and banks are largely composed of alluvial silts, although some gravel is evident which is considered to be sourced from the channel incision that has been occurring upstream. Despite this the channel appears stable with no evidence of bank erosion or bed incision.

Figure 3-1 Upstream view of the Low Sinuosity, Fine Grained system along Wangcol creek

3.3 Geomorphic Condition

Due to the relatively disturbed nature of the Project area as a result of past mining and agricultural practices, Wangcol Creek is considered to be in moderate to poor geomorphic condition. Poor condition reaches are associated with the Channelised Fill sections of Wangcol Creek. All other sections are considered to be in moderate geomorphic condition.

4 Impact Assessment

Based on a review of the proposed layout and description of the Project, the potential impacts on the geomorphology of Wangcol Creek as a result of the Project include:

- Alteration of the discharge regime from LDP006 and potential impacts on downstream sediment transport and scour processes.
- The construction of the haul road link across Wangcol Creek.

4.1 Alteration of LDP006 Discharges

Modelling by RPS Aquaterra (2012) indicates that discharges from LDP006 will reduce due to the increased water usage in the washery process as a result of the upgrade and improved recycling of process water on site. This will result in less discharges associated with the on-site water management system with a greater proportion being natural runoff from undisturbed catchments. Given Wangcol Creek does not actively transport bedload material (i.e. sand or gravel); the impact of any reduction in discharges from LDP006 on the geomorphology of Wangcol Creek is considered to be negligible.

4.2 Haul Road Crossing

As part of the Project, a new haul road link between the Springvale Centennial Coal Services Site to the existing private haul road between Angus Place Colliery and Mount Piper Power Station is proposed. Two options have been suggested, with Option 1 crossing Wangcol Creek towards the downstream eastern boundary of the site and Option 2 crossing towards the upstream western boundary.

Haul Road Option 1 (Eastern Route)

Option 1 involves construction of a new haul road crossing of Wangcol Creek towards the downstream extent of the Valley Fill system. Given there is no well-defined channel at this location, it is expected that some excavation of the creek for a distance both upstream and downstream will be required to provide flow conveyance through the crossing. This will directly alter the local geomorphology of the creek and potentially initiate channel incision upstream. Further, in the event that approaches to the crossing are raised on an embankment, the crossing will concentrate flows in moderate to large flood events over the existing downstream headcut. This will exacerbate this headcut, causing it to retreat upstream at a faster rate and posing a potential risk of undermining the crossing in the future.

Haul Road Option 2 (Western Route)

Option 2 is the most direct of the proposed routes and will cross Wangcol Creek between the western boundary of the Project area and the existing flow gauge. Here the creek exhibits a Channelised Fill system with a shale bedrock floor. The presence of the bedrock will restrict the potential for bed scour associated with flow concentration due to construction of a crossing at this location. Additionally, given the channel is already incised, a crossing at this location is unlikely to result in any significant channel alteration beyond the extents of the actual footprint of the crossing.

Hence, from a geomorphic perspective, the haul road link Option 2 presents the lower impact of the two options. With implementation of the following recommendations, the impact of the haul road link Option 2 on the geomorphology of Wangcol Creek is considered low:

- Wherever possible, waterways should be crossed on a straight portion of the waterway to avoid the risk of erosion. Where this is not possible bank stability works may be implemented.
- Avoid impeding flows through selection of an appropriate crossing type. For any proposed culvert crossings, the hydraulic capacity of the culvert should be equivalent to the channel capacity of the waterway, or at least equal to the hydraulic capacity of the waterway below the level of the road surface.
- Avoid concentrating or redirecting flow on the outlet of crossings. Where this is not possible, appropriate scour protection measures will need to be provided.
- Avoid the need for access of heavy machinery to the bed of the waterways as works should be undertaken from the top of the banks where possible. Scour protection measures should be extended to include minimisation of any further retreat of the existing headcuts.

- Avoid disturbance of surrounding banks by machinery or other construction works.
- Vegetation clearance should be avoided where possible to protect soils from erosion. If clearance cannot be avoided, the area of vegetation cleared at any one time should be minimised.
- Stabilise disturbed areas and reinstate vegetation as quickly as practicable after construction.

5 References

Brierley G and Fryirs K, (2005). Geomorphology and River Management: Applications of the River Styles Framework. Blackwell Publishing, Oxford, UK, 398pp.

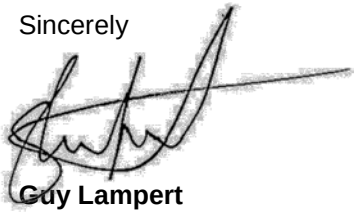
Outhet, D. and Cook, N. (2004). “Definitions of Geomorphic Condition Categories for Streams” Unpublished internal draft paper for use throughout NSW by the Department of Infrastructure, Planning and Natural Resources.

RPS Aquaterra, 2012. Centennial Western Coal Services Project Upgrade, Surface Water Impact and Water Balance Assessment.

Strahler, A. N. 1952, "Hypsometric (area-altitude) analysis of erosional topology", Geological Society of America Bulletin 63 (11): 1117–1142

Should you have any questions in regards to this report please do not hesitate to contact the undersigned.

Sincerely



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Attachment: Figure 3-1

LEGEND

Waterway Type

- Channelised Fill
- Low Sinuosity, Fine Grained
- Valley Fill
- Proposed Haul Road (Option 1)
- Proposed Haul Road (Option 2)
- Site Boundary

50 25 0 50 Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

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Centennial Coal
Western Coal Services Upgrade

Wangcol Creek
Geomorphology

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Figure 3-1

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