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Appendix 7

Glennies Creek Geomorphology

South East Open Cut Project

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Modification to the

Existing ACP Consent

ASHTON COAL OPERATIONS LIMITED

ASHTON COAL PROJECT - SOUTH EAST OPEN CUT

Geomorphic Assessment of Glennies Creek

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ASHTON COAL OPERATIONS LIMITED

ASHTON COAL PROJECT – SOUTH EAST OPEN CUT
Geomorphic Assessment of the Lower Reaches of Glennies Creek

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Project: 301017–00136 ASHTON SOUTH-EAST OPEN-CUT GEORMORPHIC ASSESSMENT

REV	DESCRIPTION	AUTHOR	REVIEWER	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Review	WJH Warick Honour	CRT Chris Thomas			N/A	
B	Final Report	WJH Warick Honour	CRT Chris Thomas	[signature] C R Thomas		N/A	15-7-09

CONTENTS

1. INTRODUCTION

Ashton Coal Operations Limited plans to undertake open cut mining in an area adjacent to the eastern floodplain of Glennies Creek, downstream from the New England Highway crossing. The location of the open cut is highlighted in **Figure 1**. The open cut mine is referred to as the Ashton South-east Open Cut (*Ashton SEOC*).

The westerly limit of the pit for the Ashton SEOC is potentially constrained by Glennies Creek. This constraint is due to one or a combination of the following:

(i) the potential for flooding of Glennies Creek to lead to flooding of the open-cut pit;

(ii) the potential for impacts on alluvial aquifers located along the western floodplain of Glennes Creek and any associated interconnectivity between these aquifers and the pit; and / or,

(iii) the potential for the pit to encroach into the active geomorphic zone of the lower reaches of Glennies Creek and present as an impediment to geomorphic processes that could occur over the life of the mine or post mining.

Various local and state government departments have identified investigations that need to be conducted to support any approval of the South-east Open Cut. These investigations are identified in the requirements specified by the Director General of the NSW Department of Planning (*"the DGRs"*). Those requirements and issues that relate the potential impacts described above are summarised as follows:

- Singleton Council requires an assessment of the impact of the proposed mine on the riverine environment, and in particular, on the integrity of Glennies Creek.
- The Department of Environment & Climate Change (*DECC*) requires investigation of the potential impact of the mining operations on existing surface water and groundwater systems associated with Glennies Creek, including the connectivity between those systems.
- The Department of Primary Industries (*DPI*) raised concerns regarding the proximity of the proposed high-wall for the mine to the Glennies Creek alluvial aquifer.
- The Department of Water and Energy (*DWE*) also requires it to be demonstrated that there is no hydraulic connection between the mine and the surface water system, including via the alluvial aquifer to the Glennies Creek regulated river zone (*as part of Zone 3 of the Hunter River water source*).
- The DWE also requires that the risks of mining in proximity to Glennies Creek be assessed in detail to demonstrate that there will be no associated long term risk of river degradation, such as the capture of flow or creek migration into the backfilled mine spoil.

FIGURE 1

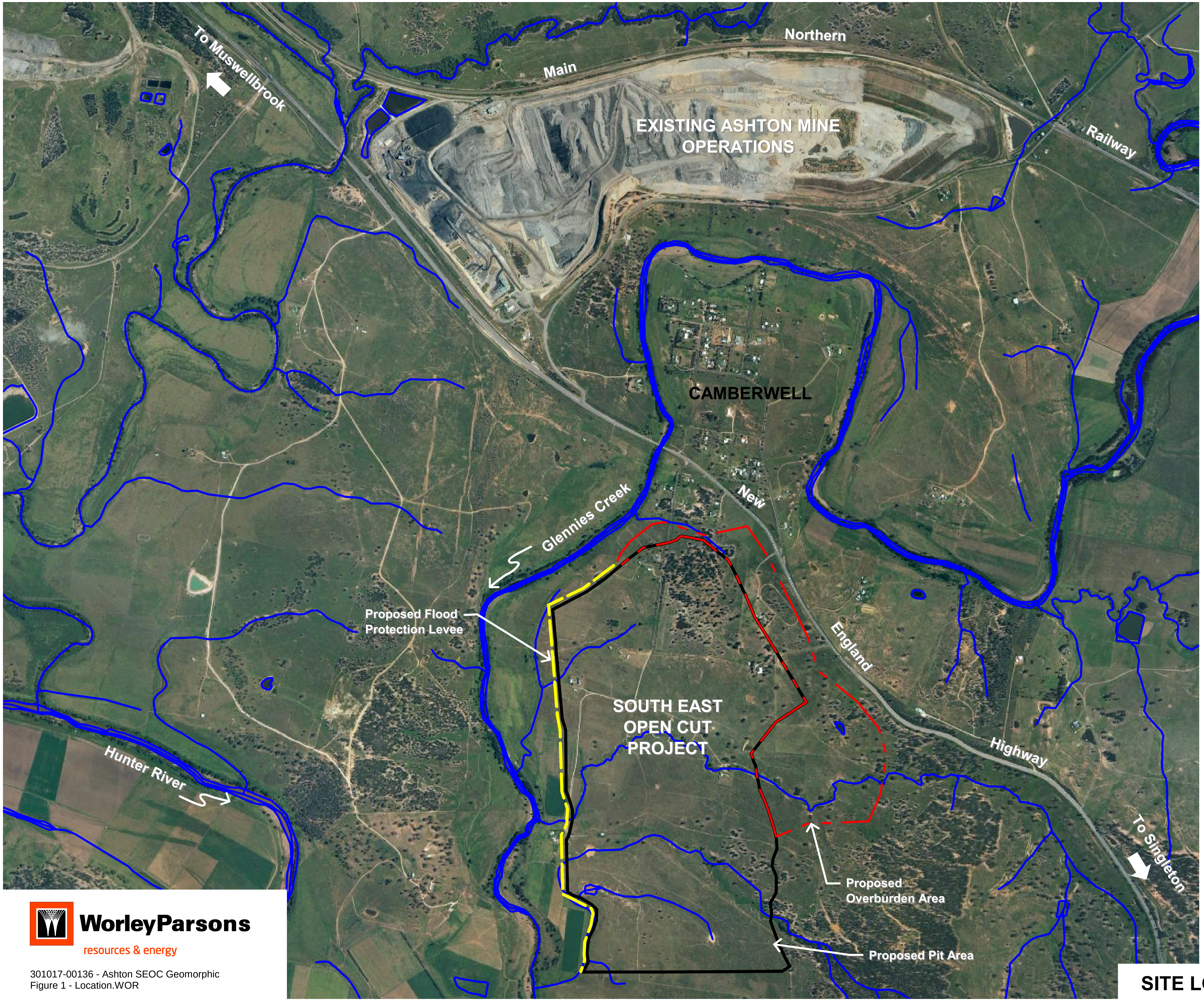

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Figure 1 - Location.WOR

SITE LOCATION AND LAYOUT

Ashton Coal Operations engaged groundwater consultants Aquaterra, to investigate the potential connectivity between the existing surface water and the groundwater systems. Findings from these investigations are documented in a report titled, *'Ashton South East Open Cut Project; Hydrogeological Impact Assessment'* (*2009*).

WorleyParsons was engaged to investigate the potential impact of the mine on surface water and flooding along Glennies Creek. The findings from these investigations are documented in a report titled, *'Ashton Coal South East Open Cut Project; Surface Water Assessment'* (*June 2009*).

WorleyParsons was also engaged to investigate the potential impact of the open cut mine on the geomorphology of Glennies Creek, including the potential for the creek to migrate towards the mine footprint in the longer term. The purpose of the investigation was to consider the extent to which the upper terraces of the eastern overbank of Glennies Creek are geomorphically active. This issue and the extent of any connected alluvial aquifer are important to determining the westerly extent of the pit for the South East Open Cut proposal. This report documents the findings of these investigations.

2. BACKGROUND

2.1 PREVIOUS INVESTIGATIONS

2.1.1 Groundwater Investigations

Aquaterra has prepared a report documenting the potential impacts of the proposed mining operation on existing groundwater conditions within the floodplain of Glennies Creek (*Aquaterra, 2009*).

The associated investigations identified a boundary between alluvium that is connected hydraulically to Glennies Creek and to poorly connected colluvium located further to the east. Aquaterra undertook detailed groundwater modelling and established that the hydraulic connectivity between the Glennies Creek alluvium and the colluvium on the western side of the proposed open cut area is limited. Some groundwater is expected to flow through to the pit. However, any flows from Glennies Creek will only constitute about 10% of the total groundwater flow that is predicted to enter the pit (*Aquaterra, 2009*).

Groundwater flows are only expected to be towards the proposed pit. Therefore, impacts to aquifers outside of the pit shell are not anticipated.

Following completion of the mine, water levels within the alluvium are expected to return to pre-mining levels within 100 years. As a result, there is not expected to be any long term risk of significant losses from Glennies Creek due to the mining operations (*Aquaterra, 2009*).

2.1.2 Surface Water Assessment

WorleyParsons completed investigations to prepare a Surface Water Assessment Report for the proposed South East Open Cut expansion (*WorleyParsons, 2009*).

The assessment concluded that backwater flooding from the Hunter River is the dominant flooding mechanism for the section of Glennies Creek that adjoins the SEOC pit shell. Backwater flooding from the Hunter River will define peak flood levels adjacent to the pit shell during events ranging from the 5 year to 100 year recurrence floods.

The design 100 year recurrence flood level at the site is predicted to be 62.7 mAHD. A conservative flood planning level of 64.0 mAHD is to be adopted for the mine, which provides 1.3 metres of freeboard above the peak 100 year recurrence flood level.

This relatively large freeboard was considered to provide an additional factor of safety that would minimise the risk of floodwaters entering the pit during the mine life.

As a result, the Surface Water Assessment Report recommends that a flood protection levee be constructed along the western boundary of the proposed open cut area to prevent the ingress of floodwaters into the pit. This levee is to have a minimum crest elevation of 64.0 mAHD.

The investigations also involved detailed hydrologic and hydraulic modelling of flooding of Glennies Creek due to local catchment events. The results of HEC-RAS hydraulic modelling indicate that the proposed flood protection levee (*and ultimately the final landform*) could increase peak 100 year recurrence flood levels by up to 30 mm along Glennies Creek.

However, this relatively minor impact is not expected to translate to a measurable impact on the flood conveyance of the creek. Accordingly, the proposed mining operation and associated earthworks are not expected to increase design flood levels in the upstream township of Camberwell.

2.2 AVAILABLE DATA

2.2.1 Topographic Data

Airborne Laser Scanning (*ALS*) data has been collected across the area of the proposed mining operation. This data was used to develop the 1 metre contours of the existing ground surface that are shown in **Figure 2**.

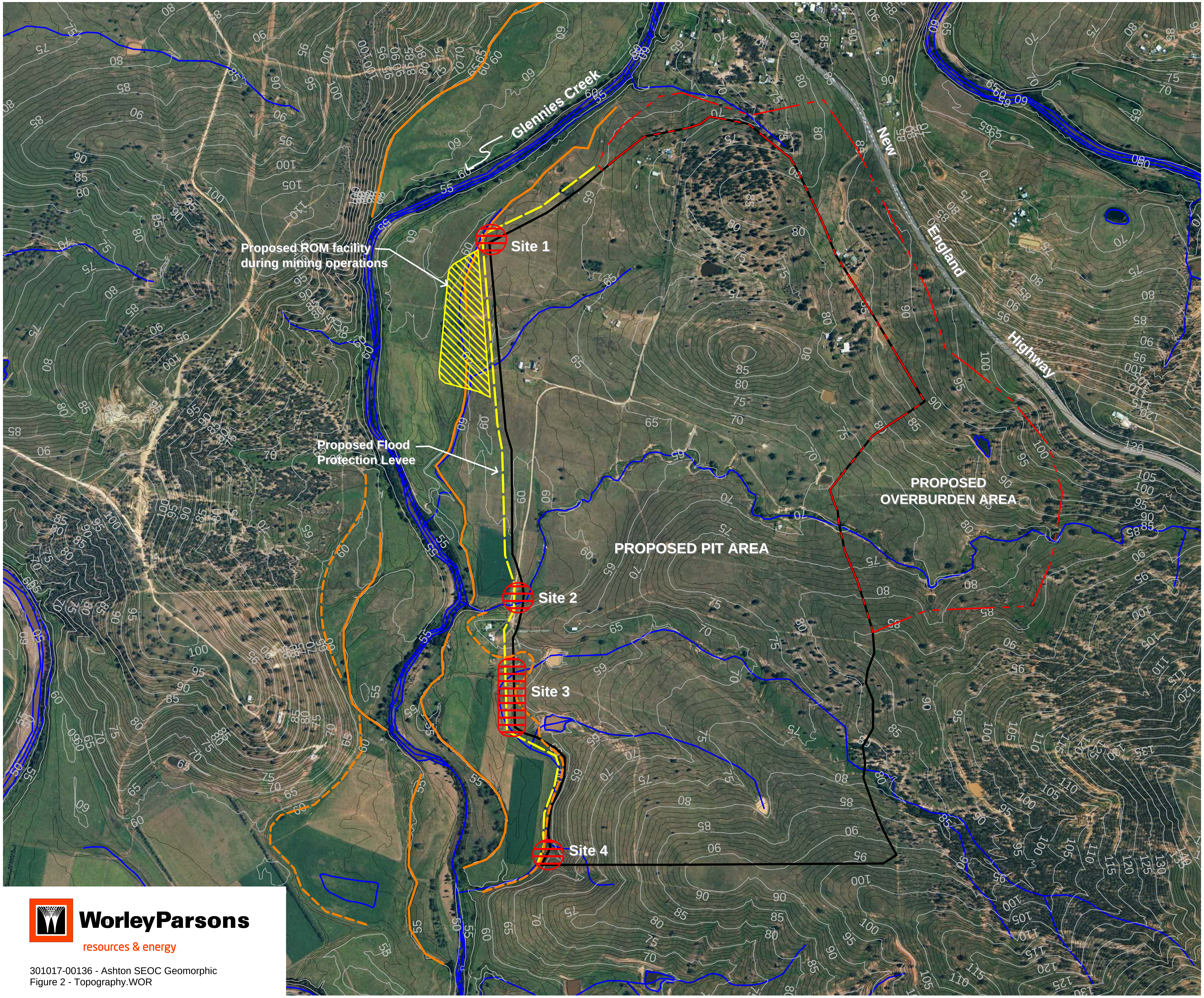
2.2.2 Aerial Photography

Vertical aerial photography for the site and surrounding area was obtained for the investigation. The recent photos were used to identify the location of floodplain features such as flood runners and terraces.

Historic aerial photographs dating back to the 1950s were used to assess any changes in the alignment of Glennies Creek since that time. Details of this assessment are documented in the following sections. Specifically, aerial photographs were obtained for:

- 1958;
- 1974;
- 1996;
- 2005; and,
- 2007.

FIGURE 2



LEGEND

- Target areas for site investigations and geomorphic assessment
- Upper flood terrace
- Secondary flood terrace

N

0 300 600

metres

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Figure 2 - Topography.WOR

SITE TOPOGRAPHY

3. PROPOSED MINING OPERATION

3.1 MINE LAYOUT

The proposed South East Open Cut mine is located south of the village of Camberwell and downstream of the New England Highway bridge crossing of Glennies Creek.

The extent of the proposed mining operation is shown in **Figures 1** and **2**. The proposed open cut pit has an area of almost 200 hectares. Overburden will initially be placed within an adjacent area along the northern and eastern boundaries of the open cut pit.

A flood protection levee is to be constructed between Glennies Creek and the western boundary of the proposed pit area (*refer* **Figure 2**).

It is understood that a ROM facility will be constructed to the south of Site 1 between the pit area and Glennies Creek (*refer* **Figure 2**). The ROM facility and the associated platform will be removed following the completion of mining activities and therefore, is not expected to impact on the long-term geomorphic processes of Glennies Creek.

3.2 EXISTING CONDITIONS AT THE SITE

The predominant land use across the site of the proposed mining operations consists of agricultural activities, including pasture land for cattle grazing and some small areas where cropping is undertaken.

Areas of native vegetation exist in the northern and eastern portions of the proposed open cut area (*refer* **Figure 2**).

3.2.1 Topography

The topography of the mining site generally grades in an east-to-west direction, from a maximum elevation of 100 mAHD down to about 50 mAHD near Glennies Creek (*refer* **Figure 2**). Grades can be up to 10% at steeper sections within the site. However, towards Glennies Creek, grades across the active floodplain are typically less than 2%.

Two main tributaries (*along with smaller gullies*) traverse the proposed pit area and discharge to Glennies Creek (*refer* **Figure 2**).

3.2.2 Geology

Glennies Creek and the proposed open cut mine are located within the Hunter Coalfield of the Sydney Basin and include coal resources and reserves that occur within the Foybrook Formation. This formation is part of the Vane Subgroup of the Whittingham Coal Measures and is the basal coal bearing sequence of the Singleton Supergroup (*Camberwell Geological Series Sheet No. 9133, 1991*).

The major coal seams within the South East Open Cut project area include (*in descending stratigraphic order*) the Upper Liddell, Upper Lower Liddell, Lower Barrett, Upper Hebden and Lower Hebden seams.

Sub-cropping to the west of the proposed open cut area are the Pikes Gully Seam, the Lemington Seams and the Bayswater Seam (*Aquaterra, 2009*).

The strata within the Foybrook Formation comprises fine to coarse grained sandstone, siltstone, conglomerate, mudstone, shale and coal. The top of the formation corresponds with the base of the overlying Bulga Formation which in turn is overlain by the Archerfield Sandstone and Jerry's Plains Sub group, respectively.

These predominant geological units are overlain by Quaternary alluvium deposits comprising silt, clay, sand and gravel, which occur as depositional features across the floodplain and tributaries of the lower reaches of Glennies Creek. These deposits occur within two main terraces:

- a lower terrace that is confined to a relatively narrow strip of land adjacent to the eastern bank of Glennies Creek; and,
- an upper terrace which extends from the lower terrace to the east and includes the remainder of the eastern floodplain.

The upper alluvial terrace is considered to merge with adjacent colluvium and regolith associated with the rising Permian subcrop to the east (*Aquaterra, 2009*).

These terraces of deposited material are naturally related to the extent of flooding that can occur during large storm events and therefore, they typically define the extent of the floodplain.

The upper flood terrace is identified in **Figure 2**. Based on the available topographic information, there is potential for a secondary flood terrace to exist further to the east of the creek, particularly near the southern extent of the proposed mining operation (*refer* **Figure 2**).

4. GEOMORPHIC ASSESSMENT

Streams are dynamic and undergo changes in physical geometry and footprint in response to the extent and velocity of flows and the composition of the sediment load carried by the stream. There is potential for the geomorphic processes of Glennies Creek to cause long term migration of the creek and/or floodplain towards the proposed open cut area. Due to its proximity, there is also potential for geomorphic changes to the Hunter River to impact on the SEOC pit.

A geomorphic assessment of the stability of the lower reaches of Glennies Creek was undertaken based on the following:

- site investigations to confirm flood terracing and assess surface features;
- assessment of stream movement over the past 50 years using historic airphotos;
- consideration of flooding behaviour, including flow velocities and flood extents; and,
- assessment of bed, bank and floodplain stability during flooding.

The findings from these investigations were used to determine the potential for geomorphic processes to impact on the proposed South East Open Cut mining operation. Consideration was also given to the potential for the mining operation to adversely impact on any geomorphic evolution of the stream that could occur during the life of the mine. Further details are outlined in the following.

4.1 SITE INVESTIGATIONS

The available topographic data and GIS watercourse mapping was compared with the proposed layout of mining operations to determine specific target areas for further assessment as part of site investigations (*refer* **Figure 2**). Consideration was also given to the alignment of the upper flood terrace and a potential secondary terrace, which can be considered to define the extent of the Glennies Creek floodplain. Sections of overlap between these terraces and the footprint of the proposed mine and flood protection levee were highlighted as target areas.

Site investigations involved visual inspection of the eastern floodplain of Glennies Creek between the New England Highway and the southern extent of the proposed open cut area, with particular focus on the target sites identified in **Figure 2**.

The primary aim of the site inspections was to confirm the existence of the flood terraces and to conceptualise where "flood runners" would be expected to form during large events (*i.e., where flow breaks-off from the main channel and re-enters further downstream*). Discussion of the findings from site investigations is included below.

Inspection of the site also allowed for the visual assessment of surface sediments and soils, which can provide an indication of geomorphic activity and the extent of alluvial processes.

The digging of test pits to inspect sediments beneath the surface was not undertaken.

4.2 HISTORY OF STREAM MOVEMENT

The aerial photographs taken between 1958 and 2007 were rectified and incorporated into GIS basemapping. The centreline of Glennies Creek was traced and mapped for each airphoto. The centreline maps were overlaid upon each other to allow visual comparison of the centreline alignment at different times during the past 50 years (*refer* **Figure 3**).

It is accepted that the mapping shown in **Figure 3** represents only a relatively recent history of creek movement compared with geological time scales. However, the comparison is considered useful in providing an indication of recent creek movement, and the range of movement that could reasonably be expected over the next 50 years.

Generally, the alignment of the creek centreline has "straightened" over time since 1958.

The greatest movement appears to have occurred between 1958 and 1974. The major Hunter River flood of 1955 could be linked to the creek alignment that was observed in 1958. It is likely that significant rainfall also occurred across the Glennies Creek catchment during this event, causing high flows with high velocity that led to scour of the channel banks and displacement of the creek centreline (*refer to creek alignment near Sites 1, 3 and 4 in* **Figure 3**).

The gradual "straightening" of the creek between 1958 and 1996 is considered to reflect a natural reversion of the creek to a more stable alignment.

Movement of the creek centreline has been relatively minor since 1996, which is considered to be a direct consequence of the lack of major flooding over recent times prior to 2007. It is therefore reasonable to assume that the creek alignment is relatively stable during average dry weather conditions and that major flooding is required to cause any significant movement of the creek centreline.

It should be noted that the analysis presented in **Figure 3** does not consider overbank processes and changes, such as the movement or creation of "flood runners" during major floods. Reliable identification of these types of features was not possible using the available aerial photography.

However, the analysis of the available airphotos does indicate that the main channel of Glennies Creek does not appear to be experiencing any migration in the direction of the proposed open cut mine.

FIGURE 3

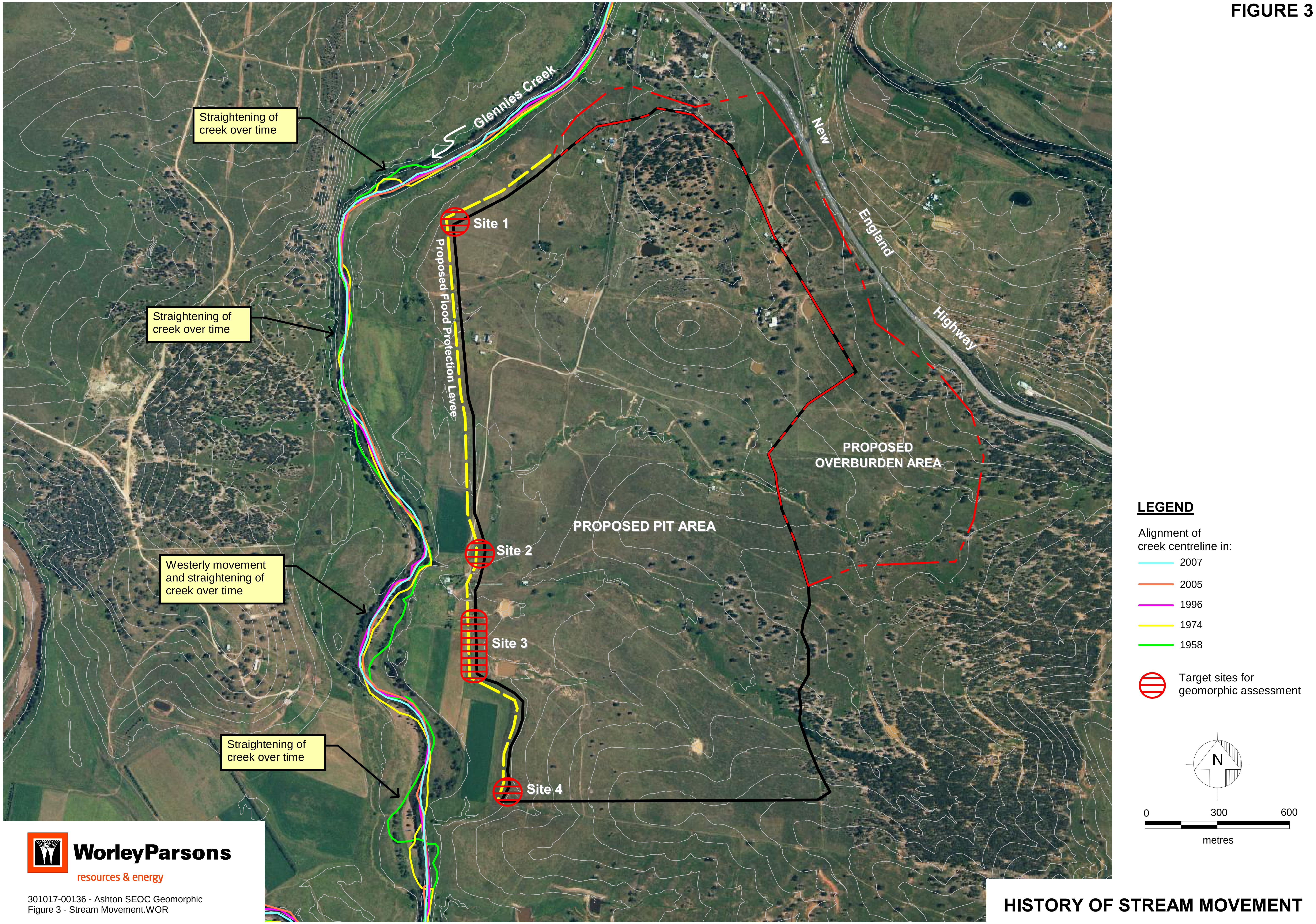

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Figure 3 - Stream Movement.WOR

HISTORY OF STREAM MOVEMENT

4.3 FLOOD BEHAVIOUR AND GEOMORPHIC PROCESSES

As discussed, the behaviour of flooding along Glennies Creek has recently been investigated and is documented in a separate report prepared by WorleyParsons (*2009*).

It is accepted that the peak level of flooding at the South East Open Cut site will be governed by flooding in the Hunter River. Inundation of Glennies Creek during such an event will be via floodwaters "backing up" from the Hunter River. Accordingly, the velocity of flow is expected to be low and therefore, this mechanism for flooding would not have a significant impact on the geomorphic processes of the Glennies Creek floodplain.

The behaviour of *local catchment* flooding of Glennies Creek is considered to be more closely linked to the active geomorphic processes.

The 100 year recurrence flood extent for local catchment flooding is presented in **Figure 4** (*refer blue hatched area*). The 500 year recurrence flood extent is also shown (*refer blue dashed line*).

As outlined above, the alignment and extent of floodplain terraces within the Glennies Creek floodplain have been established through interpretation of topographic data and with reference to the findings from groundwater investigations undertaken by Aquaterra (*2009*). Conceptualisation of flood behaviour during field investigations has also confirmed the likely alignment of these flood terraces.

A conceptual model of flooding along Glennies Creek and the associated geomorphic processes is presented in **Figure 4**.

The results of HEC-RAS hydraulic modelling that has been undertaken for Glennies Creek (*WorleyParsons, 2009*) have been interrogated with respect to the potential implications on geomorphic processes.

Overbank flow velocities during events up to the 500 year recurrence flood are considered to be most relevant and are listed in **Table 1** for each site identified in **Figure 4**.

As shown in the table, peak overbank velocities in the vicinity of the target sites are expected to be less than 1 m/s during events up to the 500 year recurrence flood. Peak velocities will be typically around 0.5 m/s.

Each site is characterised by grassed pastureland and therefore, velocities of this magnitude are not expected to cause any significant erosion of the floodplain surface. The threshold velocity to cause erosion of grassed areas is typically accepted as 1.7 m/s.

Accordingly, the predicted overbank velocities are not expected to lead to any geomorphic changes to the floodplain at these locations.

FIGURE 4

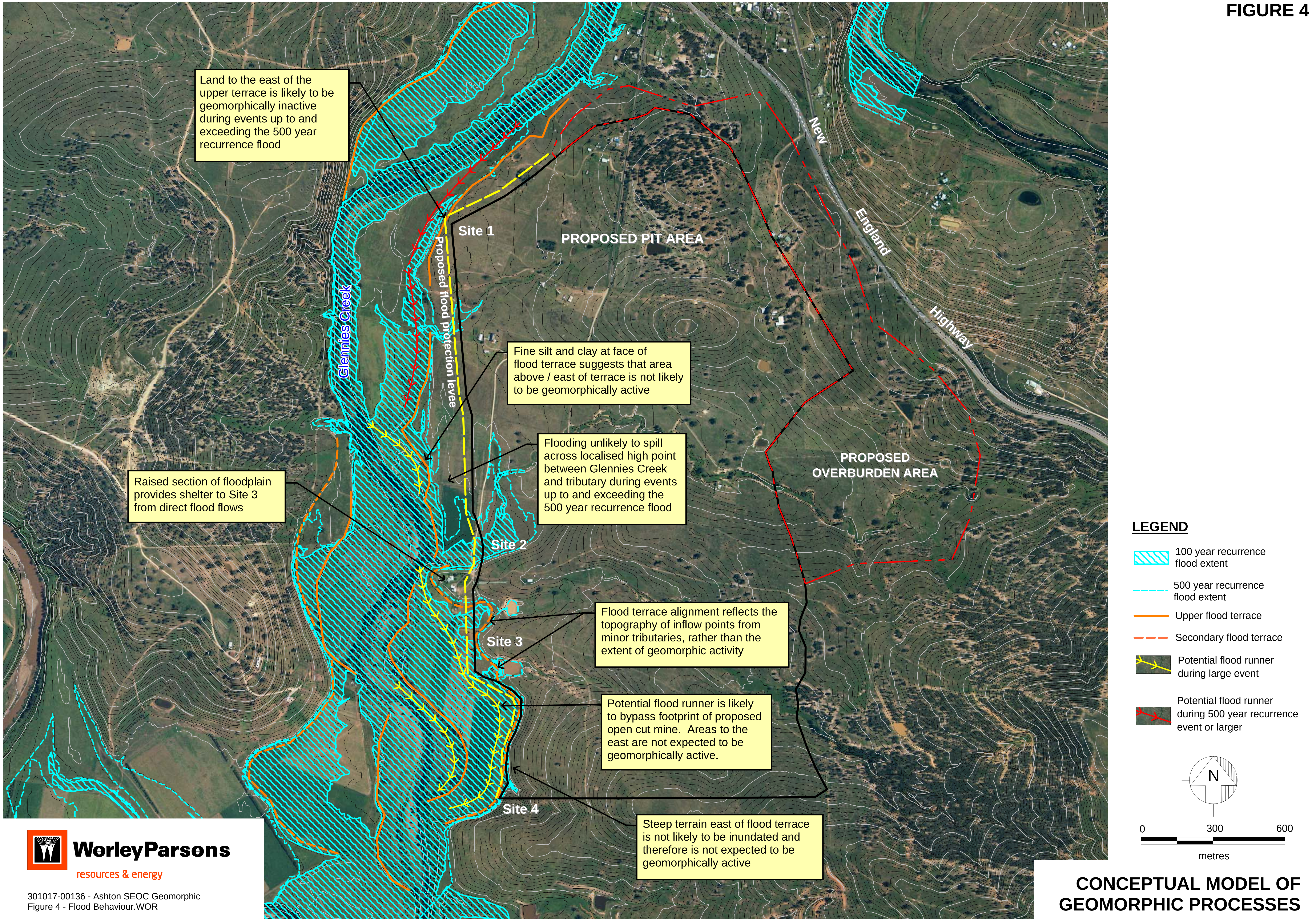

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Figure 4 - Flood Behaviour.WOR

CONCEPTUAL MODEL OF GEOMORPHIC PROCESSES

Further discussion of the geomorphic processes at each site is provided in the following.

Table 1 FLOW VELOCITIES ACROSS EASTERN OVERBANK OF GLENNIES CREEK

LOCATION (*refer* Figure 4)	HEC-RAS MODEL CROSS-SECTION	PEAK OVERBANK FLOW VELOCITY (*m/s*)	
		100 YEAR RECURRENCE FLOOD	500 YEAR RECURRENCE FLOOD
200 metres upstream from Site 1	CH 4389	NA	0.5
Site 1	CH 3958	0.5	0.9
400 metres upstream from Site 2	CH 3221	1.2	1.5
150 metres upstream from Site 2	CH 2965	0.3	0.5
Site 2	CH 2780	0.2	0.4
Upstream limit of Site 3	CH 2651	0.2	0.3
Downstream limit of Site 3	CH 2371	0.7	0.9
Site 4	CH 1838	0.4	0.5

Site 1

In the vicinity of Site 1, the edge of the upper flood terrace can be identified by an abrupt change in topography where the relatively flat open floodplain rises about 2 or 3 metres over a distance of about 20 metres.

Flow from Glennies Creek is not expected to travel along the terrace during events up to and exceeding the 200 year recurrence flood. However, as shown by the extent mapping contained in **Figure 4**, a flood runner could develop within the flood terrace during the 500 year recurrence flood. In other words, during an event of this magnitude floodwaters are expected to leave the channel at a point upstream from Site 1, flow along the terrace and then discharge back into Glennies Creek via the small tributary that runs past Site 1 (*refer red arrows in* **Figure 4**).

Accordingly, the area within the flood terrace could be geomorphically active during very large flood events. Notwithstanding, the associated overbank velocity is expected to be less than 0.9 m/s and therefore, the erosive power of the flow would be minimal.

During the life of the mine, the proposed ROM facility will occupy an area within this potential flood runner (*compare* **Figure 2** *and* **Figure 4**). However, the potential for the 500 year recurrence event to occur during this relatively short period, and hence the flood runner to become active, would be minimal. In other words, it is considered very unlikely that a flood will cause any geomorphic changes across this area during the life of the mine.

As discussed above, the ROM facility would be removed following the completion of mining activities and is therefore will not impact on the long-term geomorphic processes of Glennies Creek.

Investigations undertaken for the Surface Water Assessment (*WorleyParsons, 2009*) have also indicated that the Probable Maximum Flood (*PMF*) for Glennies Creek is not expected to cause significant inundation above (*i.e., east of*) the terrace. As a result, the land to the east of the flood terrace is not considered to be geomorphically active.

The proposed open cut pit will be located to the east of the terrace (*refer* **Figure 4**). Accordingly, the geomorphic processes of Glennies Creek are not expected to impact on the pit.

Site 2

As shown in **Figure 4**, a small flood runner could develop across the eastern overbank of Glennies Creek at the point where a minor tributary feeds into the creek, between 300 and 400 metres upstream from Site 2.

At this location, the edge of the upper flood terrace is signified by an erosion escarpment that is 1.5 to 2 metres high. It is envisaged that this erosion may be due to overbank flows from Glennies Creek, which are expected to reach a velocity of up to 1.2 m/s during the 100 year recurrence flood.

Notwithstanding, the material within and above the face of the escarpment was found to consist of well compacted fine silts and clays. The presence of these cohesive soils suggests that considerable flow velocity would be required to cause further erosion. The embankment was largely covered in grasses and other vegetation, which would also limit the potential for further erosion.

The absence of larger grain sediments such as sand and gravel within and above the embankment indicates that the area to the east of the escarpment is unlikely to be geomorphically active (*refer* **Figure 4**). High flow velocities above the terrace would be required to carry and deposit any larger sediment.

Therefore, it is apparent that any inundation above the terrace that might happen during extreme floods would not comprise high velocity flows. As a result, this section of the upper flood terrace is unlikely to undergo any significant geomorphic migration towards the proposed open cut area to the north of Site 2.

As shown in **Figure 4**, flooding within the terrace (*i.e., along the potential flood runner*) is not expected to spill across the localised high point between the terrace and the small tributary at Site 2 during events up to the 500 year recurrence flood. In addition, **Table 1** shows that any overbank flows adjacent to Site 2 are expected to have a peak velocity of less than 0.5 m/s during events up to this magnitude.

Accordingly, the potential for flow from Glennies Creek to directly impact on the footprint of the proposed open cut at Site 2 is expected to be minimal.

Site 3

As shown in **Figures 2** and **4**, the footprint of the proposed open cut area and flood protection levee may overlap with a potential secondary flood terrace at Site 3.

However, upon inspection of the site it was confirmed that the localised deviations in the terrace alignment at Site 3 can be considered to reflect the topography at the inflow points of two tributaries that currently pass through the site.

In other words, the edge of any potential terrace at these locations is not considered to be linked with the flood characteristics of Glennies Creek. Rather, it is envisaged that a Glennies Creek flood runner would develop to the west of the footprint of the proposed open cut area at Site 3 (*refer* **Figure 4**).

This is also considered to be a result of the "shelter" that Site 3 is provided from flood flows by the raised section of the floodplain to the north-west of the site (*refer* **Figure 4**).

Overbank flow within the flood runner is expected to have a peak velocity of less than 0.9 m/s during events up to the 500 year recurrence flood (*refer* **Table 1**). As such, the potential for erosion would be minimal.

Accordingly, areas to the east of the flood runner are not likely to be geomorphically active and the proposed open cut area is not expected to be affected by geomorphic processes.

Site 4

As discussed above, there is potential for a flood runner from Glennies Creek to develop across the floodplain to the west of Site 3 (*refer* **Figure 4**). The same flood runner would be expected to flow past Site 4 and then be directed back towards the Glennies Creek channel.

The terrain immediately east of the secondary flood terrace rises steeply (*approximately 8 metres over 70 metres*). As a result, widespread inundation of this area is not expected, even during an extreme event such as the PMF.

Combined with the fact that peak overbank velocities will be less than 0.5 m/s (*refer* **Table 1**), it is considered that this area is not geomorphically active.

Accordingly, the footprint of the proposed open cut mine at Site 4 is not expected to be affected by geomorphic processes.

5. CONCLUSIONS AND RECOMMENDATIONS

While only limited field investigations have been undertaken for this assessment, and much reliance has been placed on processes interpretation of aerial photography, survey data and hydraulic model results, the understanding of the geomorphic processes of Glennies Creek that has been developed is considered to be sufficient to establish the potential for geomorphic processes to impact on the SEOC proposal.

Historic aerial photography suggests that the main channel of Glennies Creek is stable and is not undergoing any migration towards the proposed South East Open Cut mining operation.

The results of hydraulic flood modelling indicate that flow velocities across the eastern overbank of Glennies Creek are expected to be less than 0.9 m/s during events up to and exceeding the 500 year recurrence flood. As a result, the potential for erosion of the floodplain to occur across the footprint of the proposed mine is minimal.

The magnitude of flooding that would be required to provide large scale geomorphic change of the floodplain would need to be significantly rarer than the 500 year recurrence event.

Four sites along the western extent of the proposed mine have been identified as potentially being affected by geomorphic processes. However, further inspection and assessment has confirmed that the footprint of the proposed open cut mine at Sites 1, 2, 3, and 4 is not within the active geomorphic zone of Glennies Creek.

Similarly, the proposed mining operation is not expected to impact on the geomorphic processes of Glennies Creek.

It is recommended that the flood protection levee that is proposed along the edge of the open cut area be designed to resist scour due to flood flows and that the design be based on the peak overbank flow velocities for the 500 year recurrence flood (*as listed in* **Table 1**). This should include strict compaction criteria, particularly around the riverward toe of the levee. This will ensure that the levee is constructed using suitable materials and will reduce the potential for levee breaching should an event rarer than the 100 year recurrence flood occur.

Notwithstanding, it is recognised that predicted peak (section averaged) flow velocities are typically less than 1.0 m/s, even in the design 500 year recurrence flood. Therefore, a grass covered embankment should provide sufficient protection. It may be appropriate to provide additional protection in the form of rock armour at localised sections where increased overbank velocity is predicted.

6. REFERENCES

- Aquaterra (*2009*), *'Ashton South East Open Cut Project; Hydrogeological Impact Assessment'*; prepared for Ashton Coal Operations.
- Hunter Catchment Management Trust (*October 1995*), *'Lower Hunter Geomorphology Study- Hydrosurvey Analysis Report'*; prepared by Patterson Britton & Partners Pty Ltd.
- Hunter Catchment Management Trust (*January 1996*), *'Lower Hunter Geomorphology Study- Conceptual and Numerical Models of Fluvial and Sediment Transport Processes'*; prepared by Patterson Britton & Partners Pty Ltd.
- Landcom (*2004*), *'Managing Urban Stormwater; Soils and Construction'* (*4th Edition, 2004*), prepared for NSW Government.
- Patterson Britton & Partners (*now a part of WorleyParsons*), *'Ashton Mine Project; Proposed Diversion of Bowmans Creek'* (*Issue No.2, October 2001*), prepared for White Mining Limited.
- WorleyParsons (*2009*), *'Ashton Coal South East Open Cut Project; Surface Water Assessment'* prepared for Ashton Coal Operations.