Subsidence Peer Review

BYLONG COAL PROJECT
Environmental Impact Statement

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Rory Gordon
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Dear Rory

PEER REVIEW – BYLONG – MSEC SUBSIDENCE PREDICTIONS AND IMPACTS ASSESSMENT

SCT Operations (SCT) have been asked by WorleyParsons to conduct a peer review of the Mine Subsidence Engineering Consultants (MSEC) Subsidence Predictions and Impacts Assessment for the Bylong Coal Project. The MSEC Subsidence Report was prepared to provide information to support the Environmental Impact Study (EIS).

1. SCOPE AND REQUIREMENTS

Specifically the scope details that SCTs peer review should consider, as outlined by WorleyParsons, include:

i. The scope of the report

ii. The requirements indicated in the SEARs issued by the Department of Planning & Environment (attached included in the Conditional Gateway Certificate and correspondence for statutory agencies that are referred to in the SEARs)

The scope of the MSEC report, SEARs, Gateway Report and correspondence were reviewed in preparation for the peer review of the MSEC report.

The MSEC scope relevant to the impacts assessment includes:

a. Review the proposed longwall layouts in the Coggan Seam based on the Feasibility Study mine plan.

b. Update subsidence predictions for the natural and built features based on the Feasibility Study (FS) mine plan.

c. *Update subsidence predictions along selected prediction lines (cross-sections), plus key linear features such as roads or streams.*

d. *Update and complete the draft report including subsidence predictions and impact assessments on surface features. The report will include the provision of figures and drawings.*

The Secretary's Environmental Assessment Requirements (SEARs) outlines key issues that must be specifically assessed in the environmental assessment. The specific issues that the EIS must include, relevant to the subsidence assessment, are detailed as follows:

- ***Subsidence*** *– including an assessment of the likely conventional and non-conventional subsidence effects and impacts of the development, and the potential environmental consequences of these effects and impacts on both the natural and built environment, paying particular attention to those features that are considered to have significant economic, social or environmental values.*

- ***Land*** *– including:*

  - *An assessment of the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any biophysical strategic agricultural land (BSAL), having regards to the Mining & Petroleum Gateway Panel's and Department of Primary Industries' requirements;*

  - *An assessment of the likely agricultural impacts of the development, paying particular attention to the mapped equine critical industry cluster in the area*

  - *An assessment of the likely impacts of the development on landforms (topography), including:*

    - *The potential subsidence impacts on cliffs, rock formations and steep slopes; and*

    - *The long term geotechnical stability of any new landforms (such as mine waste emplacements);*

  - *An assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*

- ***Water*** *– including:*

  - *An assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the Mining & Petroleum Gateway Panel's, EPA's, Department of Primary Industries' and (Commonwealth) Department of the Environment's requirements*

  - *An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users; and*

  - *An assessment of the likely flooding impacts of the development;*

- ***Heritage*** *- Including an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development having regard to OEH's and the Heritage Council of NSW's requirements;*

- ***Transport*** *- Including an assessment of the likely transport impacts of the development on the capacity, condition, safety and efficiency of the local and State road and rail network;*

- ***Public Safety*** *- Including an assessment of the likely risks to public safety, paying particular attention to potential subsidence risks, bushfire risks, and the transport, handling and use of any dangerous goods;*

Additional issues, relevant to the subsidence impacts assessment, outlined in the report accompanying the Conditional Gateway Certificate for the Bylong Coal Project include:

> *"**4.1.2 Disturbance due to longwall mining subsidence***
> *The Project will cause direct impacts to 185.6 ha of verified BSAL due to subsidence from longwall mining. The Gateway Panel concludes that the subsidence study (MSEC, 2014) is generally adequate with respect to potential impacts on verified BSAL, but could be significantly improved by considering the following.*
>
> - *Differences in the engineering properties of the Permian and Triassic stratigraphic sequences, which comprise the strata that longwall mining will impact;*

- *The propagation of fracture and faulting patterns in the sequences overlying the coal-bearing strata will vary notably from the general pattern modeled in the Application, and these variations will produce deviation from the general results which the modelling in the Application outlines; and,*

- *Clarification of the vertical versus horizontal occurrence (or not) of Mesozoic Teschenite or Phonolite in the underground mining area, i.e.depicted in Figure 7.19 of AGE (2013). MSEC (2014) (refer to Figure 1.2) show the Mesozoic Teschenite ("Mt" on map) underlies some 30 to 40% of the subsurface area proposed for longwall mining. An alternative is that the symbol "Mt" is an incorrect label, and the rock is actually Tertiary Basalt ("Tb")."*

2. PEER REVIEW

This peer review consists of a review of the approach taken by MSEC to determine the impacts on surface features above the proposed Bylong underground project, in addition to ensuring that MSECs assessment addresses the scope and outlined requirements set out by WorleyParsons and in the SEARs.

Typographic errors have not been included in this review. Only the aspects of the report that affect the outcomes of the assessment or addressing of the scope have been reviewed.

2.1 Scope Review

We agree that MSECs report addresses the scope items outlined by WorleyParsons.

Generally we have found the MSEC report addressed the SEARs with exception to the following where further detail, explanation or comments may be required:

- **Subsidence** - More detail of subsidence effects and impacts may be required for selected surface features.

- **Land** – Further detail on equine critical industry cluster may be required.

- **Transport** – More detail on far field effects outlining the potential for impact to the rail line may be beneficial.

These items are discussed with further detail later in this review.

In relation to the report accompanying the Gateway certificate, the following points are discussed:

Differences in the engineering properties of the Permian and Triassic stratigraphic sequences, which comprise the strata that longwall mining will impact;

It is recommended that MSEC provide geotechnical properties of the Permian and Triassic units for comparison and provide comment on whether this will impact caving and the associated subsidence.

The propagation of fracture and faulting patterns in the sequences overlying the coal-bearing strata will vary notably from the general pattern modeled in the Application, and these variations will produce deviation from the general results which the modelling in the Application outlines; and,

Mining induced fracturing is discussed in a separate SCT report currently being finalised.

Clarification of the vertical versus horizontal occurrence (or not) of Mesozoic Teschenite or Phonolite in the underground mining area, i.e. depicted in Figure 7.19 of AGE (2013). MSEC (2014) (refer to Figure 1.2) show the Mesozoic Teschenite ("Mt" on map) underlies some 30 to 40% of the subsurface area proposed for longwall mining. An alternative is that the symbol "Mt" is an incorrect label, and the rock is actually Tertiary Basalt ("Tb"). "

MSEC have identified that the Teschenite basalt is "10-40m" thick and is "blocky (highly fractured sub 10cm scale)". We would expect that this basalt would subside readily and not provide significant variation in subsidence to MSECs predictions.

2.2 Specific Review of Chapters in MSECs Subsidence Report

2.2.1 Chapter 1

"Chapter 1 of this report provides an overview of the mining geometry, seam information and the overburden geology for the project." (MSEC)

MSEC have identified the scope of work outlined by WorleyParsons.

MSEC have identified the key matters for consideration from the Director General in the SEARs.

The seam thickness has been noted in the report however comment detailing if the extraction height is the full seam thickness would be useful to clarify the extraction height.

Further comment on the geotechnical properties of the Permian and Triassic strata would demonstrate why the two stratigraphic units are expected to cave consistently or differently.

2.2.2 Chapter 2

"Chapter 2 provides a summary of the natural and built features that will be affected by the proposed mining." (MSEC)

Table 2 requires updating.

2.2.3 Chapter 3

"Chapter 3 provides an overview of conventional and non-conventional subsidence movements and the methods which have been used to predict the mine subsidence movements for the project." (MSEC)

The Incremental Profile Method (IPM) that MSEC use is an empirical approach for the prediction of subsidence which has undergone validation with surveyed subsidence data from a large number of mines and has been periodically updated with new data. Taking into account that the characterisation that MSEC have used to validate that the geology is consistent with the geology of the empirical database, we agree with the approach that MSEC have taken to predict subsidence.

We generally agree with the upper limit approach of 65% maximum subsidence given the greenfields nature of the Bylong Coal Project. However given the presence of Triassic Sandstones and the evidence at Ulan of less subsidence, caused by bridging Triassic sandstones, MSEC may be overestimating the subsidence for Bylong. It may be useful to clarify the thickness of the Triassic unit at Ulan to show the difference in Bylong and Ulan Triassic thickness to validate the approach of using 65%. It may also be useful to indicate areas of increased Triassic thickness similar to that of Ulan that may produce reduced subsidence effects. Outlining the differences between Ulan and Bylong would support the decision to use 65% extraction height for the maximum subsidence, in addition to MSECs comment of the large distance between the two sites.

2.2.4 Chapter 4

"Chapter 4 provides a summary of the maximum predicted subsidence parameters resulting from the extraction of the proposed longwalls in the Coggan Seam." (MSEC)

MSEC have noted that for conventional strains they adopt a "factor of 10" on curvature, based on statistical analysis of the MSEC database. Section 4.3 also outlines the potential for increased strains from surveyed data outlining non-conventional subsidence effects. A factor of 10 is considered reasonable for conventional strains however it is understood that locally strains can increase due to localised non-conventional effects.

Section 4.5 details cracking experience for two case studies in the Hunter Valley indicating <0.1% surface area affected by cracking. MSEC estimate that for Bylong, cracking is to affect 1% of mine area to be "conservative" and with remediation the area affected by cracking is estimated to be 5-10% of the mine area. It may be beneficial to also discuss crack spacing and the spatial extent of fracturing and rehabilitation, as the entire length of the panel can be affected by cracking produced from transient strains.

2.2.5 Chapters 5-11

"Chapters 5-11 provides the predictions and impact assessments for the natural and built features within the proposed mining area, based on the predicted mine subsidence movements. Recommendations of management strategies for the potential mine subsidence impacts have also been provided in this chapter." (MSEC)

Some general comments on the impacts assessments have been included in this section in additional to specific comments on the assessed features in the coming sections.

For the discussion of strains in the impacts chapters 5-11, the conventional strains are noted together with a referral to Section 4.3 for the non-conventional strains, which are often noted as being more relevant. It may be beneficial to note the range of possible non-conventional strains in the discussions of key features as well as the conventional strains noted.

There may be benefit to further detail the importance of subsidence monitoring as a mitigation measure to both monitor the impacts and validate the predicted subsidence.

2.2.6 Chapter 5

Section 5.2 on streams provides adequate discussion on subsidence effects, impacts, increased impacts and mitigation. Section 5.2.2 outlines the predicted tilts and change in grades however it would be beneficial to also outline the change in surface RLs to support the ponding. The figures were not available in the reviewed draft report and it is assumed that Figure D.04, in the MSEC report, showing the subsidence effects along Dry Creek, would outline the ponding locations.

Connectivity of surface cracks to the mine is important and has not been discussed in this report, however MSEC have referred to an external report for this assessment.

A detailed review of subsidence impacts on cliffs and steep slopes has been conducted concurrently and is presented in SCT report BYL4307. MSECs report adequately provides subsidence effects, impacts, increased impacts and mitigation measures, however the detail of cliff and slope impacts is discussed in the above mentioned SCT report.

Section 5.4 on steep slopes concludes that the slopes are considered stable from experience and in comparison with local topography. It may be beneficial to comment on what magnitude is considered unstable and how this is determined. Again, steep slopes are discussed in detail in SCT Report BYL4307.

MSEC have outlined that flood prone land, swamps, threatened species and natural vegetation are features of importance that have been assessed by other third party consultants and are not assessed in this report.

Section 5.10 identifies that the Bylong State Forest is significantly within the study area. We would suggest that further comment and discussion of subsidence effects, impacts and mitigation be included in this section.

2.2.7 Chapter 6

Section 6.1 on the Sandy Hollow – Gulgong Railway provides comment on far field effects but does not detail the potential effects, impacts, or mitigation measures other than a management plan. The lesser detail is likely to be due to the railway being outside of the study area and outside the vertical subsidence limit, however due to the importance of the transport system as outlined in the SEARs as a key issue, it may be useful to identify the magnitude of potential far field horizontal effects and associated impacts to delineate the magnitude of the low impacts.

Section 6.2 on roads provides adequate discussion of effects, impacts and mitigation measures for Bylong Valley Way. Increased impacts, however, have not been discussed for roads.

There appears to be an unsealed road in Figure 2.1 that crosses the mine area and has not been discussed in this section. It may be beneficial to include the unsealed roads in the discussion as these are compacted surfaces that are susceptible to cracking and erosion due to change in RLs and grades.

Section 6.8 on electricity transmission lines and Section 6.9 on telecommunication infrastructure includes adequate discussion on subsidence effects, impacts, increased impacts and mitigation.

Section 6.11 on survey control marks includes adequate discussion on subsidence impacts and mitigation measures. The brief discussion of these features is considered adequate due to the magnitude of effects not playing particular significance.

2.2.8 Chapter 7

No public amenities were noted in this chapter.

2.2.9 Chapter 8

Section 8.1 on agricultural utilisation provides a summary of expected impacts and mitigation measures. Given the high importance of the Equine area outlined in the Gateway Conditions, a summary of effects in the Agricultural utilisation may be useful for understanding the magnitude of the subsidence effects. A more detailed summary of effects, impacts and mitigation for the Equine area would provide further detail to more definitively assess the magnitude of the impacts for this key agricultural use.

MSEC have provided adequate discussion on subsidence effects, impacts, increased impacts and mitigation measures for rural structures, tanks, farm dams and silos. The brief discussion on irrigation systems and farm fences is adequate for the nature of the impacts.

Section 8.11 on groundwater bores provides a brief discussion of effects, impacts and a management plan. The mitigation measures state that management plans are to be adopted, however, it may be appropriate to note that the bores within the longwall panels are likely to become unserviceable due to the horizontal shearing. It may also be appropriate to comment that the bore at 500m from Longwall 109 may be affected by small magnitudes of far field horizontal shearing.

2.2.10 Chapter 9

Section 9.1 on industrial, commercial and business establish namely Bylong Quarries shows a brief description of effects and a detailed summary of mitigation measures. It may be beneficial to summarise maximum subsidence effects in this section in a table, as provided for other features.

2.2.11 Chapter 10

The subsidence effects, impacts, increased impacts and mitigation at archaeological sites has been adequately discussed in this chapter.

Review of archaeological features related to cliffs including rock shelters, the ochre quarry, sandstone cavities and sandstone formations have been discussed in more detail in a separate review relating to cliffs in SCT Report BYL4307.

Section 10.1.5 on rock shelters however, describes the potential for rock falls at rock shelters to be “very low”. The “very low’ potential for rock falls at rock shelters may be underestimating the impacts as MSEC have referenced that rock falls have occurred in 20% of the cliffs at Ulan. We would interpret 20% of cliff falls as being a higher potential than very low and that cracking and rock falls at rock shelters is possible.

2.2.12 Chapter 11

No residential buildings were noted in this chapter.

2.3 Summary

In our view, the report by MSEC provides adequate discussion on effects, impacts, increased impacts and mitigation measures as detailed in the scope. For some features that have been outlined by the Gateway Conditions and SEARs, such as equine land use and transport, it may be beneficial to expand the discussion on effects and mitigation measures as described in this review.

Impacts on cliffs and steep slopes and archaeological sites related to cliffs have been discussed in a separate SCT Report BYL4307.

Yours sincerely

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5 June 2015

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Dear Rory

PEER REVIEW OF CLIFF ASSESSMENT SECTION OF FINALISED MSEC SUBSIDENCE REPORT MSEC708

Kepco Bylong Australia (KEPCO) is planning to develop a longwall mine as part of the Bylong Coal Project in the Bylong Valley approximately 55km east-northeast of Mudgee and 75km west-southwest of Muswellbrook in the Central West of NSW. KEPCO has engaged WorleyParsons Services Pty Ltd (WorleyParsons) to provide Project Management Services for the project including the preparation of an Environmental Impact Statement (EIS). WorleyParsons commissioned SCT Operations Pty Ltd (SCT) under Contract 201015-00276-PS-CNT-0015 to peer review the cliff assessment component of the subsidence assessment report prepared by Mine Subsidence Engineering Consultants Pty Ltd (MSEC) for the EIS. This report presents the results of our peer review of the finalised MSEC subsidence assessment report.

Our peer review indicates that the conclusions reached in the MSEC report with respect to cliff impacts are reasonable and broadly consistent with the current state of knowledge of the likely impacts of mining subsidence on cliff formations in the Western Coalfield. In the authors view, the key conclusions in relation to cliff formations are somewhat fragmented within the MSEC report and may not be clearly apparent. These conclusions are paraphrased here for clarity.

- The three large cliffs located outside the longwall panels in the southwest are likely to be fully protected against mining induced subsidence effects by the proposed longwall geometry. However, it should be recognised that protection against subsidence impacts does not provide protection against natural weathering processes and naturally occurring rock falls are still possible independent of any mining activity.

- Cliff lines located within the project area are expected to experience rock falls along a length that is likely to be greater than 20% of the

mined under length reported for similar cliffs at Ulan Coal Mine because of the greater levels of vertical subsidence expected. Similarly, perceptible impacts are expected along an average length greater than the 50-70% of the mined under length reported at Ulan Coal Mine.

- Two large cliffs (approximately 33m and 40m high) above Longwalls 106 and 107 are likely to experience rock falls and perceptible impacts over a large proportion of their length because of their increased height, length, and general characteristics. A separate study indicates that these cliffs are not part of the landscape vista as seen from adjacent public roads.

- Cliff lines located outside the longwall mining area are expected to be substantially protected from the effects of mining subsidence with some tensile cracking possible near the edges of the panels (within a distance of less than half depth) and some extension of rock falls from over the longwall panels is possible.

1. INTRODUCTION

Mine Subsidence Engineering Consultants Pty Limited (MSEC) was commissioned by WorleyParsons to provide a subsidence assessment report in support of an Environmental Impact Statement for the Bylong Coal Project.

MSEC prepared a draft report MSEC708-Rev 2 titled "Subsidence Ground Movement Predictions and Subsidence Impact Assessments for all Natural Features and Surface Infrastructure in support of the Environmental Impact Statement" and dated 12 December 2014. The MSEC report addresses all aspects of the subsidence impacts for the project.

SCT peer reviewed the sections of 2014 draft MSEC subsidence assessment relating to cliffs and steep slopes in December 2014 and found that while the report was consistent with general industry experience there were some minor issues where further work was recommended. Following this initial peer review, MSEC subsequently addressed the various issues that were raised. A face to face meeting in May 2015 provided an opportunity for further discussion before the final subsidence assessment report was issued.

The peer review of the cliff impacts presented herein is based on the finalised report MSEC708-Rev A and specifically on those sections that relate to cliff formations and steep slopes, Sections 5.4 and 5.5 respectively, Section 9.1 relating to cliff formations associated with archaeological sites, and the equivalent sections in the summary and conclusions.

In preparation for peer review of the MSEC reports and in order to better understand the context of the site relative to other similar sites in the Western Coalfield, SCT undertook a one day site inspection that included visiting most of the large cliffs above and adjacent to the southern part of the

longwall mining area and an independent review of the LiDAR data available for this southern area supplied by WorleyParsons.

This peer review is structured as a commentary on each of the relevant sections of the MSEC report in the order in which they occur in the report.

2. PEER REVIEW

In this section, the specific sections of the report that relate to cliff formations, steep slopes, and cliff formations associated with archaeological sites are peer reviewed.

2.1 Executive Summary

The section on cliff formations in the executive summary identifies the cliffs outside the subsidence study area as being fully protected and this view is endorsed. A point that is not clearly made in the summary, but is important to recognise, is that protection against subsidence impacts does not provide any protection against natural weathering processes and naturally occurring rock falls are still possible independent of any mining activity. There are examples of recent rock fall debris presented in figures within the body of the report.

This section uses the experience at Ulan Coal Mine that indicates rock falls have been experienced along about 20% of the length of the cliff formations directly mined under and impacts are perceptible along up to 50-70% of the mined under length. The effects of potentially higher subsidence at the Bylong Project are not specifically acknowledged in the summary, but are recognised within the main body of the report.

The findings of the impacts on the steep slopes and archaeological sites are also endorsed.

2.2 Cliff Formations

Section 5.4 of the MSEC report presents a description and characterisation of the cliff formations in the study area, predictions of subsidence movements, and an assessment of the impacts. Histograms of the height and length of cliffs in the general area of the project are provided as context and in the study area specifically.

Three cliffs with heights of 30 m and above are identified to the southwest of the longwall panels and two cliffs with heights in the range 30-40 m are identified directly over the longwall panels.

The assessment for the cliffs outside the mining area is based on predicted low levels of vertical subsidence, tilt, curvature, and horizontal strain. The assessment does not recognise horizontal compression movements along the line of the cliffs as a primary cause of mining induced rock falls, but the

conclusions reached are consistent with the author's experience of observing and monitoring cliff formations at other sites in the Western Coalfield. The three large cliffs outside the mining area are considered likely to be fully protected from mining induced subsidence impacts for the longwall geometry proposed. As noted above though, protection against subsidence impacts does not provide any protection against natural weathering processes and naturally occurring rock falls are still possible independent of any mining activity. There are examples of recent rock fall debris presented in figures within the body of the report.

Within the area of the longwall panels, the experience at Ulan Coal Mine is used as a guide to the length of cliffs likely to be impacted. MSEC note that the actual percentage of cliffs affected may be greater than 20% given the greater magnitude of subsidence predicted at Bylong. MSEC also note that cliffs that have greater height and continuous length are considered to be more susceptible to impacts and the two cliffs in the 30-40 m high range are considered to be at greater risk of rock falls resulting from extraction of the proposed longwalls. In the author's view, these points are important to recognise in the context of overall impacts to cliff formations at the site.

The difficulty of predicting stability of individual cliff formations is recognised in the MSEC report and the approach of estimating general impacts on the basis of percentage of length mined under is considered a reasonable approach. There are considered to be a number of contributing factors that influence a particular cliffs propensity to be impacted that are not specifically mentioned in the MSEC report.

For instance, the MSEC report does not recognise the differences in the geomorphological expression of the different stratigraphic units that form cliff formations at the site and the variation in impacts expected for these different units. However, this omission is not significant in that all the larger cliff formations over the longwall panels are formed within the upper two cliff forming units. The lower cliff forming units are likely to be less susceptible to mining impacts based on experience at Ulan Coal Mine because of their more fragmented geomorphology, but these cliffs are also generally less than 10 m high and have not been specifically considered in the MSEC assessment.

It should be recognised that there are currently few practical methods of protecting cliff formations except to avoid mining near or directly under them. The issues of safety during surveying and visual inspection of cliffs also need to be recognised in management plans as well as the longer term issues around the stability of heavily fractured rock features. These issues are mentioned in the MSEC report but are repeated again here because it is relatively common to see a greater level of exposure of personnel to risk during the period of monitoring than at other times.

2.3 Steep Slopes

Section 5.5 discusses steep slopes and the impacts of mining on these slopes. Although the mechanics of the process that causes slope instability are not recognised, the conclusions reached are nevertheless consistent with the author's experience and are endorsed as providing an appropriate assessment of the likely impacts of mining subsidence on steep slopes.

2.4 Archaeological Sites

In Sections 9.1.4 and 9.1.5 of the MSEC report assesses potential subsidence impacts on an archaeological site identified as an ochre quarry and on rock shelters generally.

The potential impacts to these sites are expected to be consistent with impacts to cliff formations more generally as outlined earlier in the MSEC report. It is possible that some sites may be rendered inaccessible for scientific or other purposes because of their increased potential for instability.

In addition to the comments made in the MSEC report in regard to management of impacts, the issues of personal safety of inspections during mining and subsequently should be recognised.

3. Conclusions

The sections of MSEC report MSEC708-RevA relating to cliff formations, steep slopes, and cliff related archaeological heritage sites have been peer reviewed. The MSEC report is considered to be a comprehensive assessment of the likely impacts on cliffs and steep slopes. The findings are consistent with the author's experience of observing and monitoring mining impacts on cliff formations in the Western Coalfield of NSW.

If you have any queries or require further clarification of any of these issues, please don't hesitate to contact me directly.

Regards

Ken Mills
Principal Geotechnical Engineer