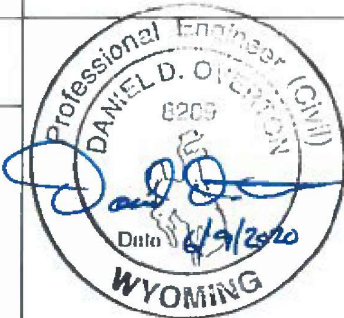


**Technical Memorandum**      **EXHIBIT B**

To:	Mr. Bjarne Kristiansen, P.G.	From:	Daniel D. Overton, P.E.
Company:	Wyoming Department of Environmental Quality – Land Quality Division	Date:	June 9, 2020
EA No.:	110875		
Re:	Review Response to Public Comments and Informal Conference, Issues Specific to Subsidence, Brook Mine Permit to Mine Application (TFN 6 2/025)		

**1.0 INTRODUCTION**

Engineering Analytics, Inc. (EA) was tasked by the Wyoming Department of Environmental Quality (DEQ) Land Quality Division (LQD) to provide an evaluation of subsidence-related public comments to the Brook Mine Permit to Mine Application (Permit Application) (TFN 6 2/025) which were received by the DEQ in April 2020, and subsidence-related oral comments provided during the DEQ Brook Mine Informal Conference conducted on May 13, 2020.

**1.1 Documents Reviewed**

EA has reviewed previous Permit Application submittals as documented in EA memoranda to the DEQ dated June 29, 2018, January 14, 2019, and March 15, 2019 (see References). In addition to the permit documents we have reviewed previously, we reviewed public comments submitted to the DEQ by the following:

1. Shannon Anderson (April 23, 2020). Includes the following as attachments: an Expert Report written by Marino Engineering Associates, Inc. (MEA) regarding mine subsidence, dated April 15, 2020; a Memorandum from Mike Wireman of Granite Ridge Groundwater dated April 16, 2020.
2. James Aksamit (undated).
3. Christine M. Anderson (April 15, 2020).
4. John and Shelley Barbula (April 17, 2020).
5. Bill Bensel regarding Ramaco Brook Mine, dated April 23, 2020.
6. Big Horn Coal Company (April 23, 2020).
7. Anton Bocek (April 5, 2020).
8. John P. Buyok and Vanessa Buyok (April 23, 2020).
9. Wendy Condrat (undated).
10. Louisa Crosby (undated).
11. Mary Brezik-Fisher and David Fisher (April 23, 2020)

12. Gillian Malone (undated).
13. Pam Marks (undated).
14. Author unknown (undated).
15. Joan Tellez (April 8, 2020).

We also reviewed public comments provided to the DEQ during the Informal Conference conducted on May 13, 2020. We reviewed the recorded video oral comments provided by Dr. Gennaro Merino of Merino Engineering Associates, Inc. (MEA) and Tim Ross of Agapito Associates, Inc. (AAI).

## **1.2 Scope of Review**

Our review was limited to issues related to potential mine subsidence in the highwall mining area. Our review was also limited to the portion of the proposed mining area currently under permit review. It's our understanding that the current permit review entails a 5-year period and includes the surface mine and panel TR-1 only, as shown on Figure 1. Public comments pertaining to mining in areas outside of this area, including mining of the split Carney Seam, are not addressed in this technical memorandum.

## **2.0 SUBSIDENCE-RELATED REVIEW COMMENTS**

Based on our review of the written public comments, recorded video oral comments, and documents provided to us previously, we provide the following comments.

### **2.1 Additional Core Holes**

It appears that Agapito (AAI, 2018) relied upon the geotechnical parameters from a single core hole (2017-4) for their geotechnical analysis, modeling and subsidence prediction. The location of core hole 2017-4 is shown on Figure 1. Reference is made in AAI (2018) to additional holes which were used to develop the stratigraphic model, but the specific holes used are not referenced, nor are the associated logs provided.

In an earlier phase of the permitting process, the drilling of additional core holes and geotechnical testing was proposed by Ramaco. We reviewed the proposed Sampling and Analysis Plan (SAP) in a previous Technical Memorandum (EA, 2018). The additional sampling and analysis proposed by Ramaco in their SAP was not performed.

In our opinion, the single core hole (2017-4) does not adequately characterize the stratigraphy or the geotechnical properties of the rock in the immediate area of the proposed TR-1 highwall mining area. From our review of the maps and geologic cross sections in Appendix D5 (Ramaco, 2019a), we note that most of the existing core holes are located well to the west of the TR-1 area. These core hole locations have been overlaid onto the overall mine plan on our Figure 1. We reviewed Cross-Section K-K' on Sheet 14 of Addendum D5-3 Exhibit 2, and it appears that the closest core holes to 2017-4 are 578409 and 578415 which are located well outside the proposed TR-1 mining area at a distance of approximately 3,100 and 3,300 feet from core hole 2017-4, respectively (see Figure 1). In our opinion, this distance between core holes is excessive and does not allow an adequate characterization of the TR-1 area. We recommend that

additional core holes be drilled within the TR-1 boundary, especially since this area will be the first area to be highwall mined.

Dr. Marino expresses a similar concern regarding the use of the single core hole in his written report (MEA, 2020) and in his oral comments during the Informal Conference. In bullet #1 on page 4 of his report (MEA, 2020) he states the following:

*“The one geotechnical boring which was done in the TR-1 area, which is [the] proposed first area to be highwall mined. This boring indicated the roof and floor contains anomalous rock conditions compared to other borings drilled in the application area. Therefore, applying these rock conditions and associated test data to all of the application area or, for the matter, all of TR-1 appears inappropriate.”*

It appears from our review that there is some uncertainty regarding the stratigraphy in the area of TR-1. In the fourth paragraph in Section 2.1 on page MP-6-24 of AAI (2018), Agapito discusses the contours of depth of cover, coal seam thickness, etc. shown on Figures 2 through 7 of their report. The paragraph includes the following:

*“The slope variations seen in the plots seem unusually severe and apparently coincide with the drill holes that were used to construct the contours. It is possible that different series of holes were surveyed and interpreted differently, and the data may contain discrepancies that account for the slope variations. Also, unmapped faults may exist that complicate the seam structure.”*

The additional core holes recommended herein should provide additional information regarding the overall stratigraphy, the thickness and extent of the various lithologic units, and the presence of faults that should supplement the applicant’s current understanding of the conditions in the proposed highwall mining area.

Furthermore, additional core holes will allow the applicant to better evaluate the strength of the stratigraphic units, in particular the carbonaceous mudstone and mudstone layers which will form the immediate floor of the highwall openings. AAI (2018) describes this material as “weak.” AAI (2018) states the following in the first paragraph in Section 2.2.2 on page MP-6-33:

*“The floor is also composed of carbonaceous mudstone underlain by a weak mudstone.”*

In discussing floor stability in the first paragraph in Section 3.4 on page MP-6-38, AAI (2018) states:

*“The proposed highwall panel pillars are underlain by a thin layer (approximately 2 ft thick) of a weak carbonaceous mudstone (CMS). The laboratory tests (Table 1) indicate a moisture content of 18% for the CMS layer, which tends to weaken such shale-related rocks. Weak floor layers can adversely affect pillar and floor stability as well as the efficiency of mining operations through possible mechanisms of floor heave and pillar punching.”*

We reviewed the Rock Mechanics Testing report in Appendix B of AAI (2018). A limited amount of geotechnical testing was performed on the carbonaceous mudstone which will comprise the immediate floor of the highwall openings and pillars. For example, only a single Uniaxial Compressive Strength (UCS) test was conducted for the carbonaceous mudstone (Specimen UCS-16/E). The additional core holes recommended herein should provide additional samples for geotechnical testing which will allow Ramaco and AAI to better evaluate the strength of the stratigraphic units in the proposed highwall mining area, especially the weak units which will comprise the floor.

Determining the sufficient number of core holes to adequately characterize a proposed new underground mining area is somewhat subjective and depends upon many factors. Some researchers have found geostatistical analysis to be useful in determining the maximum spacing between boreholes to adequately characterize coal mine units (Ledvina et al., 1994). We recommend that a geostatistical analysis be performed to determine the adequate number of borings, and that the minimum of two additional core holes be drilled and sampled in the proposed TR-1 highwall mining area. We recommend that the location of the core holes and the associated sampling program be determined by Ramaco in consultation with their geotechnical consultant (AAI) to ensure the data collected meet AAI's needs for modeling and subsidence evaluation.

The data provided from the additional core holes will supplement the currently-available data and allow AAI to refine their analyses and subsidence predictions, and allow Ramaco to revise their Subsidence Control Plan for TR-1 if necessary.

## **2.2 Geotechnical Testing for Subsidence Evaluation**

Samples collected from the additional core holes should include the roof, coal, and floor of the proposed highwall mining area, with special attention paid to the "weak" carbonaceous mudstone and mudstone which will underlie the tunnel openings and pillars. The suite of testing should be similar to that performed by AAI for core hole 2017-4 (including tensile strength, uniaxial compressive strength, axial and diametral point load testing) and any other testing deemed necessary by AAI for a thorough analysis. All testing should be performed in accordance with applicable ASTM standards.

The geotechnical testing should also include testing to evaluate the long-term strength of the roof and floor materials. Dr. Marino expressed concern regarding the long-term strength of the floor layers on pages 7 through 9 and bullet #5 on page 16 of his written report (MEA, 2020), and in his oral comments during the Informal Conference. We recommend that the testing include Atterberg Limit testing to evaluate the plasticity of the roof and floor units, as well as consolidated-drained triaxial testing to better evaluate the long-term strength of the roof and floor.

The geotechnical data collected from the additional core holes will allow AAI to refine their analyses and subsidence predictions, including the long-term stability of the overall highwall mining area, and allow Ramaco to revise their Subsidence Control Plan for TR-1 if necessary.

## **2.3 Abandoned Mine Lands Standards**

In his oral comments during the Informal Conference on May 13, 2020, Dr. Marino of Merino Engineering Associates, Inc. (MEA) states (at approximately 3:53 in the recorded video oral comments) that the Abandoned Mine Lands standards don't appear to be being applied in the Brook Mine permitting process. He does not specify which standard is not being applied. We reviewed his report (MEA, 2020), and we cannot find reference to a specific standard that is not being applied.

We have previously reviewed the applicable standards, as documented in our Technical Memorandum dated January 24, 2019 (EA, 2019a). Our conclusion is repeated below:

A review of the Department of Environmental Quality (020) regulations related to Land Quality – Coal (0006) of the Wyoming Administrative Code (WAC) were reviewed in regards to subsidence for underground coal mining. Pertinent sections with citations relevant to subsidence include:

- Chapter 1: Authorities and Definitions for Surface Coal Mining Operations (020.0006.1.08272014)
- Chapter 2: Permit Application Requirements (020.0006.2.08272014)
- Chapter 4: Environmental Protection Performance Standards (020.0006.4.12172012)
- Chapter 7: Underground Coal Mining (020.0006.7.04112011)

In general, the Subsidence Control Plan and the Agapito Report appear to provide information requested by the code related to evaluating for the potential of subsidence for the planned underground coal mine. The documents provide geotechnical analyses based on local core, with standard approaches to design for stability with the intent to minimize subsidence, as well as provide for monitoring and remediation in the event of subsidence.

## 2.4 Applicability of Subsidence Control Plan

The Subsidence Control Plan in Addendum MP-6 dated March 2019 (Ramaco, 2019b) is written in such a way that Ramaco seems to intend it to apply to all proposed highwall mining areas, even areas outside of TR-1 and areas where multiple seams will be mined. The following is stated in the first paragraph in Section MP-6.1 on page MP-6-3:

*“The majority of highwall mining will be conducted in the two splits of the Carney seam. West of the Carney Seam’s split line shown in Figure MP-6.1-1, the highwall mining activity will be concentrated primarily in the Carney lower split due to its greater thickness. East of the split line the two splits merge allowing full seam thickness extraction within the limits of the highwall mining machine. Figure MP-6.1 also shows the additional highwall mining planned in the lower Master’s seam.”*

The Subsidence Control Plan also first paragraph on page MP-6-8:

*“Highwall miner holes will be oriented in the same azimuth as the holes in the Carney Seam located directly above. Its pillar dimensions will be sized based on the thicker Carney Seam so that ‘pillar stacking’ is achieved.”*

It must be noted that the Agapito report (AAI, 2020), included in the Subsidence Control Plan as Attachment MP-6-A, evaluated highwall mining in the area of TR-1 only, where the single Carney seam is proposed to be mined. It does not include any analyses of highwall mining outside of the TR-1 area, or areas where multiple seams will be mined, or “pillar stacking.” Therefore, it simply does not apply to proposed mining areas other than TR-1. In our opinion, the Subsidence Control Plan should be revised to apply only to the open pit and TR-1 area that is being permitted at this time.

## 2.5 Web Pillar Stability

AAI (2018) states the following in the fourth paragraph in Section 4.2 on page MP-6-42:

*“The design charts shown in Figures 9a through 9c are based on the ARMPS recommended web pillar stability factor of 1.6. An additional set of design curves were prepared using a more*

*conservative value of 1.8, to further reduce the potential for pillar failure. The charts are included in Appendix C if Ramaco wishes to use the more conservative design."*

EA recommends that the applicant indicate which web pillar stability factor (1.6 or 1.8) will be used during highwall mining.

### 3.0 REFERENCES

- Agapito Associates, Inc. (AAI), 2018. *Geotechnical Design and Operational Considerations for Highwall Mining – Brook Mine*. Prepared for Ramaco Carbon. September 13.
- Engineering Analytics, Inc. (EA), 2018. Technical Memorandum regarding Review of Brook Mine Subsidence Sampling and Analysis Plan. Prepared for Wyoming Department of Environmental Quality – Land Quality Division. June 28.
- Engineering Analytics, Inc. (EA), 2019a. Technical Memorandum regarding Review of Brook Mine Permit to Mine Application Specific to Subsidence: Response to EQC Finding of Facts and Conclusions of Law, WDEQ Comments Round 7, and supplemental Materials. Prepared for Wyoming Department of Environmental Quality – Land Quality Division. January 24.
- Engineering Analytics, Inc. (EA), 2019b. Technical Memorandum regarding Review of Round 8 Technical Review response to Comments Specific to Subsidence, Brook Mine Permit to Mine Application (TFN 6 2/025). Prepared for Wyoming Department of Environmental Quality – Land Quality Division. March 15.
- Ledvina, C.T., Dowding, C.H., Fowler, S., Hunt, G. and Nance, R., 1994. *Geostatistical Guidance of Exploration in Roof Control – How many Drill Holes are Enough?* Proceedings of the 5<sup>th</sup> Conference on Ground Control for Midwest U.S. Coal Mines, Collinsville, Illinois, pp. 14-30.
- Merino Engineering Associates, Inc. (MEA), 2020. Letter to Ms. Shannon Anderson, Acting Director, Powder River Basin Resource Council regarding Review of Brook Mine Application. April 15.
- RAMACO, 2019a. Appendix D5, Topography, Geology and Overburden Assessment, Brook Mine Permit Application TFN 6 2/025. In Volume IV. December.
- RAMACO, 2019b. Addendum MP-6, Subsidence Control Plan, Brook Mine Permit Application TFN 6 2/025. In Volume XI, Mine Plan. March.
- RAMACO, 2019c. Volume XI, Mine Plan, Brook Mine Permit Application TFN 6 2/025. December.

**FIGURE**





**FIGURE 1  
OVERALL PROPOSED MINING AREA WITH CURRENTLY-PROPOSED HIGHWALL MINING AREA  
BROOK MINE, SHERIDAN COUNTY, WYOMING**

