pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

January 25, 2017

Mr. James D Warner, Executive Director
Lancaster County Solid Waste Management Authority
1299 Harrisburg Pike
Lancaster, PA 17604-4425

Re: Technical Review
Major Permit Modification
Frey Farm Landfill Vertical Expansion/ Increase in Daily Volumes
Permit No. 101389
Manor Township, Lancaster County

Dear Mr. Warner:

The Department of Environmental Protection (DEP) has completed an initial technical review of the Frey Farm Vertical Expansion application. Please respond to the following comments:

1. Volume 4 of 4 - Form 24:

   LCWMA has completed extensive seismic analysis for siting of the Frey Farm Landfill (FFL) as part of the environmental assessment. As part of the design criteria for Phase II design of the FFL, this information should be summarized following the Subtitle D guidance EPA/600 /R - 1995 – RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities.

   Summarize the seismic analysis evaluations, including stability information requested in this technical review letter, as well as previous evaluations that have been performed as part of the Phase I Environmental Assessment.

   In addition, the summary should also include the historical stability of MSE walls (berms) and landfills under seismic conditions. Include information comparing the stability of the landfill as currently designed versus the landfill with 50 foot of additional fill and the MSE Berms.

2. Questions pertaining to the LCSWMA FFL vertical expansion design relating to the geology/groundwater/seismicity have been previously documented; however, LCSWMA chose to not address them entirely until the Phase II design review as noted in the following ARM responses:

   a. March 7, 2016 LCSWMA Response (Pages 7 – 13) indicates that "*LCSWMA and ARM understand the geologic and hydrogeologic characteristics of the site……LCSWMA's and ARM's opinions are that the geology and hydrogeologic conditions are sufficiently characterized and that additional studies are not needed. We cannot conceive of data that could be collected that would plausibly result in a change to any designed system for environmental protection in connection with the FFVE……an underdrain is proposed below the MSE berm in the vicinity of former Spring SP-01 to ensure that groundwater mounding will be precluded. Future settlement issues are not anticipated.*"

b. June 17, 2016 LCSWMA Response (Page 4, Fourth Paragraph) indicates that, *"LCSWMA believes the two additional second professional opinions of Kanishka Perera Ph.D. of HDR and Gerald Ahnell P.G. of HGS related to geologic and seismic site conditions validate the FFVE Phase I application ARM group has developed and submitted. These reports accurately and comprehensively address the incorrect siting concerns raised by Mr. Leis, Mr. Scharnberger, and Mr. Benson. LCSWMA believes any further seismic and geologic stability review should be conducted as part of the Phase II design evaluation."*

c. October 6, 2016 LCSWMA Response – *"We neither wish to amend nor supplement information provided to PADEP related to the geologic and seismic peak ground acceleration at this time. Our team of highly-respected engineers and geologists are certified by the Commonwealth of Pennsylvania to practice as professionals; and these professionals have certified the site conditions and design meet both PA code Title 25 Chapter 273 related to landfill sighting and design as well as USEPA RCRA Subtitle D (258) criterion related to seismic design.....It should be noted that Attorney Yoder's consultants are not responsible for certifying the design and individual biases exist among all disciplines in professional and academic communities."*

3. Areas that need to be addressed:

a. Possible stability issues - Uncertainties/discrepancies in peak ground acceleration (PGA) calculations and seismic hazard calculations between different expert seismologists/engineers are summarized below:

1) The value used by the USGS as the threshold for earthquake-related shaking that causes damage to buildings not designed to withstand damage from earthquakes is 0.10g. The original 2014 LCSWMA FFL vertical expansion permit application indicated that there was no need for a seismic impact study due to the PGA being 0.091g in the area of the proposed vertical landfill expansion; however, due to the closeness of the proposed vertical landfill expansion to the USGS PGA 0.10g contour, the Department requested that a seismic impact study be conducted. Shortly thereafter, the Department acquired an updated USGS PGA map (2014), which included the August 23, 2011 Mineral Virginia earthquake, indicating that the proposed vertical landfill expansion is located in an area greater than 0.10g, thus requiring a seismic impact study. The Department also requested that information be submitted indicating how a magnitude 5.8 earthquake, similar to the one that occurred in Virginia in 2011, would affect the proposed vertical expansion design due to the FFL being located in close proximity of several earlier magnitude 4.0+ earthquakes as noted below.

- 1889 – magnitude 4.3 – 9 km northwest of the FFL;
- 1984 – magnitude 4.2 – 9 km southeast of the FFL (Marticville PA);
- 1800 – magnitude 4.1 – 17 km southeast of the FFL; and
- 1834 – magnitude 4.0 – 24 km northeast of the FFL.

2) The March 7, 2016 LCSWMA response indicated that *"While it is possible that an earthquake with a magnitude greater than 5.0 can occur in Pennsylvania, based on the information provided by the USGS it is unlikely that this will occur. Using the most current earthquake probability mapping online software provided by the USGS, ...there is a 6 to 8 %*

probability that there will be an earthquake with a magnitude of 5.0 or greater within 50 miles of the site in the next 250 years. ...While ARM understands that this mapping software does not account for the Mineral, Virginia 2011 earthquake, or any earthquake data recorded after 2006, it is the only software currently available that will calculate probability for a certain earthquake magnitude. ...the analyses provided in the FFVE Permit Application are in accordance with the most up-to-date seismic hazard maps and do not require revision." As a result, LCSWMA stands by the proposed FFL vertical expansion 0.1g design.

3) *Expert Reports Leis, Scharnberger, and Benson – April 2016,* provided by Yoder, indicated that the FFVE is located in an area which may require the analysis to be conducted with a PGA of approximately 0.2g, or twice that assumed in the current application.

4) LCSWMA's June 17, 2016 response, which included second opinion expert reports (Perera and Ahnell), indicated that the geotechnical stability analysis for the FFL vertical expansion 0.1g design would be appropriate for the seismic study scenarios noted below.

    - magnitude 5.0 earthquake – 10 km distance from FFL (LCSZ-1)
    - magnitude 6.0 earthquake – 20 km distance from FFL (LCSZ-2)

    The deterministic method used by Perera incorporated site-specific conditions (i.e. soils and geologic borings). Perera concluded, *"...although a 6 Mw seismic source at 20 km from the site is considered, the average peak ground acceleration is approximately 0.101g for a section within the MSE Wall and 0.083g for the waste mass behind the MSE Wall. Accordingly, the use of 0.1g for geotechnical stability analysis for the MSE Wall and waste mass is appropriate* (Attachment #7, Page 31, Last Paragraph)." The report presented by Ahnell discredited/disputed the reports by Scharnberger and Leis and was in agreement with the ARM Group interpretation that the soil/geologic/hydrogeologic data included in the Phase I FFL proposed vertical expansion application was adequate.

    It should be noted that the PGAs documented above are <u>averages</u> and that Perera used 760 m/s as the shear wave velocity to 30 meters in the calculations. In comparison to the 0.101g PGA for a section within the MSE Wall due to a 6 Mw seismic source at 20 km from the site, the highest value documented on the plot was 0.137g. Additionally, for a section within the MSE Wall for a 5 Mw seismic source at 10 km from the site, the highest value documented on the plot was 0.11g compared to the 0.082g average PGA.

5) LCSWMA's August 19, 2016 response included the April 2010 ARM report titled <u>Geotechnical Engineering Report for the Proposed Frey Farm Landfill Wind Energy Project</u> per the Department's request. Average shear wave velocities were collected over the site via a Multichannel Analysis of Surface Waves (MASW) geophysical survey in the vicinity of the wind energy project area and were documented in the report as follows:

Turbine A		
Depth Range (ft)	Average shear wave velocity feet/second (ft/s)	Average shear wave velocity meters/second (m/s) (PADEP converted ft/s to m/s)
0 - 20	1,511	461
20 - 50	2,537	773
Turbine B		
0 - 20	1,199	365
20 - 50	1,662	507

a) For comparison purposes:

- The initial FFL vertical expansion application documents, Form 6, Attachment 6-2 PGA maps, were based on "Site Class A" lithified rocks (i.e. 2000 m/s) and not for "site-specific" lower shear wave velocities.

- The LCSWMA March 7, 2016 response included recalculations using the "Site Class B/C" average shear wave velocities of approximately 760 m/s based on the April 2010 wind energy project. As noted in the table below, ARM indicated that *"The 'hardrock' assumption used by the USGS is based on the site classification as published in the International Building Code (IBC) and is used to relate the subsurface materials in the upper 100 feet (30 meters) at the site to an average shear wave velocity; this parameter is commonly referred to as the V_s^{30}. The Site Class Definition (Table 1613.5.2 page 350) of the IBC is included below:"* ARM also indicated that "*Assigning the proper V_s^{30} is important, since this parameter is used when calculating the seismic hazard for a location. The 'A' site class will return a lower PGA than the value determined for a 'B' site class."*

Site Class	*Soil Profile Name*	*Average Property in top 100 feet Soil Shear Wave Velocity, V_s^{30} (m/s)*
A	*Hard Rock*	$V_s^{30} > 1524$
B	*Rock*	$762 < V_s^{30} \leq 1524$
C	*Very dense soil & soft rock*	$366 < V_s^{30} \leq 762$
D	*Stiff soil profile*	$183 < V_s^{30} \leq 366$
E	*Soft soil profile*	$V_s^{30} < 183$

The March 7, 2016 response also included calculations via the USGS Interactive Deaggregation online software tool used to help determine the design PGA that utilizes representative subsurface conditions at the site. The PGA results calculated by this software using a V_s^{30} of 760 m/s indicate that the peak horizontal ground acceleration for the FFVE is ≥0.09113g.

b) Information from an April 7, 2016 USGS report pertaining to San Francisco Bay area earthquakes and the effect of softer soils is inserted below from the following link: https://earthquake.usgs.gov/regional/nca/soiltype/

"Seismologists have observed that some districts tend to repeatedly experience stronger seismic shaking than others. This is because the ground under these districts is relatively soft. Soft soils ***amplify*** *ground shaking. If you live in an area that in past earthquakes suffered shaking stronger than that felt in other areas at comparable distance from the source, you are likely to experience relatively strong shaking in future earthquakes as well. An example of this effect was observed in San Francisco, where many of the same neighborhoods were heavily damaged in both the 1906 and 1989 earthquakes. The influence of the underlying soil on the local amplification of earthquake shaking is called the* ***site effect***

Other factors influence the strength of earthquake shaking at a site as well, including the earthquake's magnitude and the site's proximity to the fault. These factors vary

from earthquake to earthquake. In contrast, soft soil always amplifies shear waves. If an earthquake is strong enough and close enough to cause damage, the damage will usually be more severe on soft soils."

c) Would "Site Class C" or lower class be more appropriate than the one used in the March 7, 2016 seismic risk calculations (i.e. "Site Class B/C" = V_s^{30} of 760 m/s) as a result of the average shear wave velocities from the actual April 2010 wind energy report being documented at lower values as noted in the table above (i.e. Turbine A = 461 - 773 m/s and Turbine B = 365 – 507 m/s)? The MASW Profiles (i.e. Figure 4 and Figure 5 from the April 2010 wind energy report), included as Figure 1 and Figure 2 of this review, indicate softer areas with shear wave velocities from about 1000 to ≤2500 ft/s (i.e. 300 to ≤762 m/s) from ground surface to 63 feet below ground surface (BGS) in the vicinity of Turbine A and from ground surface to 80 feet BGS for Turbine B. Additionally, the Perera seismic report (Attachment 7 of the June 17, 2016 LCSWMA Response), documented lower shear wave velocities ranging from 700 to 3700 ft/s (i.e. 213 to 1128 m/s) for different materials such as fill/waste, clay, silt, sand, gravel, schist, bedrock as noted in Table 11, Table 12 and Table 13 of the report.

6) The August 31, 2016 report submitted by Yoder (i.e. Scharnberger – August 30, 2016; and Cramer – August 30, 2016 and September 1, 2016) questioned why a magnitude 6.0 earthquake was considered at a 20 km distance from FFL, but only a magnitude 5.0 earthquake at 10 km. The reports submitted by Yoder indicated that an average PGA value for a magnitude 6.0 earthquake at 10 km from the FFL is about 0.4g. It was also noted that a magnitude 6.0 earthquake in the Lancaster Seismic Zone is a reasonable scenario for the Marticville area (10 km distance from the FFL). The Cramer report also indicated three problems with the June 1, 2016 Perera report:

" 1. Improper scaling of input ground motion records at PGA;
2. Incomplete geotechnical model for the site response; and
3. Not allowing for the increased short period (including PGA) energy and ground motion expected in Pennsylvania earthquakes."

During a meeting on May 25, 2016, ahead of the submittal of the June 17, 2016 LCSWMA Response, the Department asked why a PGA was not provided for a magnitude 6.0 earthquake at a distance of 10 km from FFL for a similar comparison, instead of the

magnitude 5.0 earthquake? ARM indicated that an earthquake of the higher magnitude would not be appropriate for this area. As a result of the Perera and Ahnell reports, LCSWMA continues to stand behind their original design/seismic calculations.

7) The September 9, 2016 report was submitted by Yoder (i.e. Leis – September 2, 2016 and Cramer – September 9, 2016). Cramer's report included PGA recalculations for both the MSE wall (Column-1) and the final cover of waste (Column-2), similar to the Perera report; however, included the impact of stress drop and proper scaling/modeling. It is mentioned in Cramer's report that magnitude 6.0 earthquakes can occur near any site in the central and eastern United States (CEUS) and that *"This fact is supported by the USGS national seismic hazard model (Petersen et al., 2014) and by the occurrence of the Mineral, VA earthquake in 2011."* As a result, Cramer also included a scenario of a magnitude 6.0 earthquake at a distance of 10 km from the FFL, which revealed PGAs for MSE wall (Column-1) and the final cover of waste (Column-2) of 0.397g and 0.358g, respectively. The Leis report continued to request further characterization of the site via additional soil/bedrock/hydrogeologic studies and is further discussed below.

b. Northwesternmost end of the MSE berm:

1) The length of the MSE berm in this area runs parallel to the Wissahickon schist strike and close to the edge of Turkey Hill point. As a result of the foliation dip ranging from 50 – 90° NW towards the Susquehanna River, a steep dip slope exists in this area providing a larger surface area for erosion potential. Could the variability of the Wissahickon Formation (i.e. weak interbedded zones in-between more competent zones), jointing/fracturing and the weathered bedrock/saprolite documented onsite affect slope stability in this area and also be enhanced due the annual freeze/thaw cycle?

2) As noted on the inserted enhanced LIDAR map (attached Figure 4), there appears to be earth disturbance (circled area) beneath the proposed MSE berm area closest to the Manor Township Park/Hiking Trail property line in the vicinity of Phase II, Sheet 17, Line of Section 5. Could this be related to erosional weathering of the underlying fractured/jointed bedrock? A major NE-SW trending fracture extends through this area in addition to a smaller possible NW-SE trending fracture as noted on the LIDAR map (attached Figure 4).

3) Only one soil boring has been collected in this area, MSEB-26 located in vicinity of the intersection of Line of Section 5 and the proposed MSE berm, and revealed from about 12 to 31 feet BGS the Schist to be highly to completely weathered, medium dense to very dense, greenish-gray and dry; from 31 – 36 ft BGS the Schist was greenish-gray, hard, slightly to moderately weathered, no apparent bedding, closely fractured and Rock Quality Designation (RQD) of 47%. Water was noted on the well log at 31 feet BGS.

   Soil boring MSEB-25, located about 150 feet east of MSEB-26 and in-between Phase II, Sheet 17, Line of Sections 6 and 7 (attached Figure 3), revealed from about 10 to 15 feet BGS the Schist to be highly to completely weathered, very dense, greenish-gray, and dry. From 15 – 25 feet BGS the Schist was greenish-gray, hard, slightly to moderately weathered, no apparent bedding, closely fractured, and RQD (40 – 73%). Water was noted at 13.6 feet BGS.

Due to minimal investigation of soils/bedrock in the vicinity of the MSE berm proposed in the area adjacent to the Manor Township Park/Hiking Trail property line, a steep dip slope cliff in close proximity of the Susquehanna River, and in areas of complexly deformed/disturbed bedrock, especially in the vicinity of the circled area on Figure 4, and earlier documented nearby seismic activity, the Department does not agree with ARM's statement: "*We cannot conceive of data that could be collected that would plausibly result in a change to any designed system for environmental protection in connection with the FFVE.*" How can LCSWMA base the proposed MSE berm design in this critical area on only one soil/bedrock sample (e.g. MSEB-26) and softer zones being noted at depth on the April 2010 wind energy project report MASW profiles, as noted on the attached Figure 1 and Figure 2?

4) The September 9, 2016 report was submitted by Yoder (i.e. Leis – September 2, 2016 and Cramer – September 9, 2016). Leis continues to request a need for LCSWMA to further study the area beneath and surrounding the proposed vertical expansion because of the lack of data pertaining to soils, geology, hydrogeology, and potential for ongoing/future surface impacts due to soil creep, shallow groundwater, closeness of the proposed MSE berm to a steep sided high hill adjacent to a major river, and "skree" deposited along the river side. The Merriam Webster definition for "skree" is *"an accumulation of loose stones or rocky debris lying on a slope or at the base of a hill or cliff, talus."*

5) The June 17, 2016 LCSWMA Response, Attachment 6, Page 11-12, Item 12, Third Paragraph, noted below, was included to justify the slope stability of the underlying Wissahickon schist geologic formation:

> *"A portion of the western toe slope was removed to install the Norfolk Southern Railroad. By Leis' admission in his review of the FFVE PMA, the cut along the toe-of-slope has been in place since 1913 (i.e., in excess of 100 years). No indication of compromised slope stability has been observed along the cut slope over the past 100 years. If any indicators of compromised slope stability were observed along the western slope, the railroad in this area would no longer be operational. Furthermore, over the past 100-plus years, trains have utilized the railroad tracks immediately adjacent to the cut slope causing vibrations throughout the bedrock in which the cut occurred. Additionally, the foundational materials and cut slope endured flooding from Hurricane Agnes, a 500-year storm event. A shear rock face with no visible deformation and no destabilizing indicators can be observed parallel to the railroad tracks at the base of the FFVE's western slope. Over the past 100-plus years, the slope has proven to be stable, and the addition of the FFVE will not subject this slope to any stress as illustrated in Attachment 6.5.*
>
> *With little to no loading on the western slope, creep is not a likely failure mode. Furthermore, Leis admits that creep 'is not a catastrophic soil/rock failure problem in eastern Pennsylvania.' A second opinion regarding the site geology, addressing this topic, was also prepared by Gerald Ahnell, P.G. of HGS as part of this response document."*

The 1913 cut along the western toe slope was in an area perpendicular to bedrock strike. Could the bedrock be more stable in this area as a result of the bedrock acting more or less like pillars due to the steep 50 – 90° NW foliation dip? Could the confidence level regarding

the 100-year slope stability along the western edge of the landfill be different in the area in-between Phase II, Sheet 17, Line of Sections 3, 4, 5, 6 and 7 (attached Figure 3), as a result of the MSE berm in this area being parallel to bedrock strike and located near the edge of a steep slope dipping 50 – 90° NW towards the Susquehanna River? As noted on the LIDAR map (attached Figure 4), there appears to be a possible fracture striking in the NW direction in close proximity to Phase II, Sheet 17, Line of Section 5 (attached Figure 3). As previously mentioned, only one soil boring (e.g. MSEB-26) has been documented in this area and softer zones were noted at depth on the April 2010 wind energy project report MASW profiles, as noted on the attached Figure 1 and Figure 2. As a result, this area needs to be further studied to verify slope stability due to the closeness of the proposed MSE berm to: the adjacent steep dip slope cliff in close proximity of the Susquehanna River; in areas of complexly deformed bedrock and seismic activity; and being less than 30 feet from the Manor Township Park/Hiking Trail property line and the disturbed area circled on the LIDAR map (attached Figure 4). Additionally, the outside/adjacent haul/maintenance road is even closer, less than 20 feet from the Manor Township Park/Hiking Trail property line and the circled disturbed area on the LIDAR map (attached Figure 4).

6) At the NW end of the proposed MSE berm, the area closest to the property line, LCSWMA is proposing the MSE Berm to be soil-filled and the landfilled waste to be placed no closer than the 100 feet from the property line. The September 21, 2016 Manor Township Ordinance No. 4-2016, revised the setback limit for waste disposal per §458.3 as follows: "*No solid waste shall be deposited or stored within eight*(y)*-five (85) feet of any property line or within one thousand (1,000) feet of any land within any of the Residential Zones.*"

   The soil filled MSE Berm in this area will be as close as 30 feet and the adjacent haul/maintenance road as close as 20 feet from the property line and overlying the disturbed area circled on the LIDAR map (attached Figure 4). As noted on Page 5 of the September 23, 2016 document submitted by Yoder, "*...if there is a problem with the MSE wall, the liner or even storm water runoff, the 15-20' of setback from the base of the MSE berm to the property line would make it virtually impossible to maneuver the type of large equipment necessary to address such problems. Worse yet, should some type of failure occur, waste and ash would cascade over the edge of Turkey Hill point down into the Susquehanna River. Due to limited setback and the existence of steep slopes, cleaning up such an accident would be impossible and lead to an environmental catastrophy.*" Additionally, Recommendation #6 of the September 16, 2016 expert document (Benson) suggests that, "*A deformation analysis should be conducted to evaluate movement of the MSE wall and translation of the waste should a static or seismic failure occur. This analysis should evaluate whether the existing and proposed setbacks are sufficient to contain the waste should a failure occur.*" In the event of a cap slide, membrane slide, or other issue, is there sufficient setback distance on top of Turkey Hill to maneuver heavy equipment for remediation purposes?

7) Would LCSWMA consider moving the northwesternmost end of the proposed MSE berm design further to the east? A greater distance away from the Manor Township Park/Hiking Trail property line and the steep dip slope cliff would create a protective buffer zone for park visitors, reduce the viewshed impact from the Susquehanna River; and also provide a larger area for remediation purposes if needed.

c. The proposed vertical expansion MSE berm design on the east side due to the shallow groundwater.

1) Department correspondence dated November 17, 2015 and May 5, 2016 requested that the former and current springs be included on the groundwater maps. The June 17, 2016 LCSWMA submittal included former Spring SP-01 and SP-02 locations on the Phase II, Sheet 14, Sheet 18 and Sheet 19; however, the SP-01 spring location is incorrectly documented. The original Spring SP-01 was located closer to Wells FFMP013W and FFMP014W, approximately 180 feet further to the northwest than noted on the June 3, 2016 revised maps (i.e. Phase II, Sheet 14, Sheet 18 and Sheet 19). The LCSWMA Groundwater Contour Map, dated July 27, 1989, is attached as Figure 5 documenting the original Spring SP-01 location. The Spring SP-01 location noted on the June 17, 2016 Phase II revised maps erroneously documents the outfall of the underground pipe extending from the original spring area, which was constructed due to earlier landfill encroachment, and not the former spring location.

2) As previously noted under Item 2.a., LCSWMA indicated that "*LCSWMA and ARM understand the geologic and hydrogeologic characteristics of the site……LCSWMA's and ARM's opinions are that the geology and hydrogeologic conditions are sufficiently characterized and that additional studies are not needed. We cannot conceive of data that could be collected that would plausibly result in a change to any designed system for environmental protection in connection with the FFVE……an underdrain is proposed below the MSE berm in the vicinity of former Spring SP-01 to ensure that groundwater mounding will be precluded. Future settlement issues are not anticipated.*" Additionally, LCSWMA's June 17, 2016 Response, Attachment 6 Letter, Item 8.b.(2)(b), Page 5 indicates: "*The location of the water table was accounted for in all stability analyses. The groundwater table is modeled in the slope stability program SLIDE and the MSE berm is designed to provide an adequate factor of safety given the site conditions, including the highest plausible water table conditions.*"

   Does the proposed underdrain (i.e. Phase II, Sheets 7, 18, 19, 30, 33, ES-3, ES-4, ES-5, and ES-9) extend to the appropriate area as a result of the former Spring SP-01 not being properly located on current maps? Will the former Spring SP-01 location and/or underdrain interfere with the Cell 4 Primary/Secondary Leachate system documented on Phase II Sheet 33?

3) In accordance with §273.252(b) of the Department's Municipal Waste Regulations, "*At least 8 feet shall be maintained between the bottom of the subbase of the liner system and the regional groundwater table in an unconfined aquifer. The regional groundwater table may not be artificially lowered.*" Phase II, Sheet A-1 indicates the proposed ash-filled MSE Berm will extend from about Phase II, Sheet 17, Line of Section 8 through Line of Section 24; yet Form 24 includes Slide analysis information for an ash-filled MSE Berm outside this area (e.g. Line of Section 25). Does LCSWMA plan to propose an ash-filled MSE berm in any areas outside the outlined ash-filled MSE Berm area noted on Phase II, Sheet A-1?

4) Several of the proposed MSE berm cross sections were revised and included in the June 3, 2016 submittal (e.g. Phase II, Sheet 14 – Critical Cross Sections and Typical MSE Berm – Line of Sections 5, 25, 33, 38, 40 and 50). The current grade is documented on the revised Sheet 14; however, is not documented on all of the December 19, 2014 Cross Sections (i.e.

Sheet 20, Sheet 21, and Sheet 22). As a result, are there are any other areas as noted below where the proposed MSE berm could be encroaching upon the shallow groundwater?

The Department requests that LCSWMA provide revised drawings for all of the December 19, 2014 Cross Sections (i.e. Sheet 20, Sheet 21, and Sheet 22) that were not included in the June 3, 2016 submittal (e.g. Phase II, Sheet 14 – Critical Cross Sections and Typical MSE Berm – Line of Sections 5, 25, 33, 38, 40 and 50) indicating where the current grade will be excavated during the MSE berm construction project. Shallow groundwater has been documented in the following areas.

a) Line of Section 25 (Phase II, Sheet 14, Sheet 18, and Sheet 21):
   - FFMP027W [Depth to Water (DTW) ranges from 14.8 – 35 feet BGS]; and
   - Base of MSE berm is proposed approximately 7 feet below the present grade (noted on Phase II, Sheet 14) which would create less than 8 feet separation distance.

b) Line of Section 28 (Phase II, Sheet 18 and Sheet 21):
   - MSEB-14 (DTW = 8.4 feet BGS); and
   - Cross Section 28 (Sheet 21) indicates the groundwater within 8 feet of the base of the proposed MSE berm.

c) Line of Section 29 (Phase II, Sheet 18 and Sheet 22):
   - Cross Section 29 (Sheet 22) indicates the groundwater is within 8 feet of the base of the proposed MSE berm.

d) Line of Section 30 (Phase II, Sheet 18 and Sheet 22):
   - MSEB-13 (DTW = 8.2 feet); and
   - Cross section 30 (Sheet 22) indicates the groundwater is within 8 feet of the base of the proposed MSE berm.

e) Line of Section 31 (Phase II, Sheet 18 and Sheet 22):
   - Line of Section (LOS) 31 is located in-between MSEB-13 (DTW = 8.2 feet) and the original Spring SP-01 location; and
   - Cross section 31 (Sheet 22) indicates the groundwater is within 8 feet of the base of the proposed MSE berm.

f) Line of Section 32 (Phase II, Sheet 18 and Sheet 22):
   - LOS 32 is located in-between the original Spring SP-01 location and MSEB-12 (DTW = 8.0 feet); and
   - Cross section 32 (Sheet 22) does not indicate if the existing ground surface will be excavated, as noted on the adjacent Cross Section 33 (Sheet 14 – June 3, 2016 revision).

g) Line of Section 33 (Phase II, Sheet 14, Sheet 18, and Sheet 22)
- MSEB-12 (DTW = 8 feet)
- Cross Section 33 (Sheet 14) indicates the groundwater is within the MSE berm due to the base of the MSE berm being proposed approximately 20 feet below the present grade.
- Note: Cross Section 33 (Sheet 22) does not indicate any excavation of present grade as noted on the revised Cross Section 33 (Sheet 14). As a result, do other cross sections need to be revised similarly?

h) Line of Section 38 (Phase II, Sheet 14 and Sheet 18)
- MSEB-9 (DTW = 12.9 feet)
- Cross Section 38 (Sheet 14) indicates the groundwater is within the MSE berm due to the base of the MSE berm being proposed approximately 18 feet below the present grade.
- Note: Cross Section 38 (Sheet 22) does not indicate any excavation of present grade; whereas Cross Section 38 (Sheet 14) does. As previously noted, do other cross sections need to be revised similarly?

i) Line of Section 40 (Phase II, Sheet 14 and Sheet 18)
- MSEB-8 (DTW = 13.8 feet)
- Cross Section 40 (Sheet 14) indicates the groundwater is within 8 feet of the MSE berm due to the base of the MSE berm being proposed approximately 6 feet below the present grade.
- Note: Cross Section 40 (Sheet 22) does not indicate any excavation of present grade; whereas Cross Section 40 (Sheet 14) does. As previously noted, do other cross sections need to be revised similarly?

j) Line of Section 50 (Phase II, Sheet 18)
- The proposed MSE berm is in close proximity of MSEB-4 (DTW = 10.3 feet) and the former Spring SP-02.
- Cross Section 50 (Sheet 14) indicates the groundwater is within 8 feet of the MSE berm due to the base of the MSE berm being proposed approximately 12 feet below the present grade.

4. The LCSWMA June 17, 2016 Response, Attachment 6, Page 7, Item 8, b. (3), Third Paragraph indicated that ..... *"If, after reviewing the information provided in Attachment 6.5, the PADEP requires any additional slope stability analyses, they will be completed during the Phase II Technical Review."*

a. Dr. Cramer's September 9, 2016 calculations indicate site bedrock PGAs between 0.361g and 0.737g depending on the magnitude of the earthquake and its distance from the site. As a result, in order to ensure that an adequate seismic slope stability design is being proposed, the Department requests LCSWMA to indicate:

1) In 1984 a magnitude 4.2 earthquake occurred about 9 km from FFL in Marticville, PA. Would the currently proposed FFL vertical expansion withstand a magnitude 5.8 earthquake,

similar to the seismic event that occurred in Mineral Virginia in 2011, if it were to occur about 9 km away in the vicinity of Marticville, PA?

2) The stability of the currently proposed 0.10g vertical expansion landfill design using "Site Class C" or lower "Site Class," instead of "Site Class B/C" average shear wave velocity values (e.g. V_s^{30} of 760 m/s) used in the seismic impact study calculations, due to softer zones noted on the MASW Profiles (i.e. Figure 4 and Figure 5 in the April 2010 wind energy report) included as Figure 1 and Figure 2 of this review. As previously mentioned, this report documented softer areas with shear wave velocities from about 1000 to ≤2500 ft/s (i.e. 300 to ≤762 m/s) from ground surface to 63 feet BGS in the vicinity of Turbine A and from ground surface to 80 feet BGS for Turbine B.

b. The Department requests LCSWMA to conduct additional geotechnical studies and slope stability analyses in order to further evaluate the stability of the underlying soils/bedrock and groundwater in the following areas:

1) In the vicinity of the northwestern most end of the proposed MSE berm and the adjacent steep dip slope (i.e. underlying disturbed area that is circled on the attached Figure 4 LIDAR map) to help determine if weaker weathered/fractured zones could enhance slip potential in the area due to natural occurrences such as erosion, freeze/thaw cycle, increased seismicity, or other factor(s). Only one soil boring (e.g. MSEB-26) has been documented in this area. As previously noted, softer zones were noted at depth in the April 2010 wind energy project report via the MASW profiles, attached to this review as Figure 1 and Figure 2.

2) On the east and south sides of the proposed vertical landfill expansion where shallow groundwater is within or in close proximity of the proposed MSE berm.

3) On the northeast side of the proposed vertical landfill expansion where the shallow groundwater is in close proximity of the proposed ash-filled MSE berm (i.e. in between Phase II, Sheet 17, Line of Sections 24 and 25).

4) On the north and northeast sides of the proposed vertical landfill expansion where the proposed ash-filled MSE Berm overlies the major NE-SW trending fracture due to minimal soil boring data in this area and softer zones being documented at depth in the April 2010 wind energy project report via the MASW profiles, attached to this review as Figure 1 and Figure 2.

5. Volume 4 of 4 - Form 18:
   a. Discrepancies were noted when comparing Phase I - Form 7 to Phase II - Form 18 data (i.e. Form 7 - Attachment 7-1 - Tables - Table 7-2, Form 7 - Attachment 7-2 - Well Logs, and Form 18 - Attachment 18-1), see attached Table 1.

1) Some elevations documented in the tables were based on Top Inner Casing (TIC) and not Top of Protective Casing (TPC) as indicated. Please revise Attachment 18-1 to include the Measuring Point Elevation (TPC or TIC) that is used to calculate quarterly groundwater elevations.

2) Other discrepancies are crossed out and revisions noted.

6. Volume 4 of 4 - Form 24:
One of the concerns with stability under seismic conditions is liquefaction of soils under saturated conditions. In accordance with the RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities, please evaluate the ash material of the FFL under saturated conditions if there is any consideration of liquefaction to reduce stability in the event of a seismic event with the resultant calculated intensity of shaking resulting from the peak acceleration.

7. Volume 4 of 4 - Form 24:
Is there any liquefaction potential of the subgrade soils beneath the landfill or the MSE berms under seismic conditions?

8. Volume 4 of 4 - Form 24:
Calculate the maximum deformation of the liner system and capping system under seismic conditions.

9. Volume 4 of 4 - Form 24:
Evaluate all layers of the FFL for veneer stability under the calculated peak acceleration of the landfill. Please address comments from Mr. Chris Cramer dated September 9, 2016 (received under cover letter from Mr. Dwight Yoder, September 9, 2016) regarding the values of Peak Ground Acceleration that in his opinion should be used as input values for the veneer stability as well as global stability calculations under seismic conditions.

10. Volume 4 of 4 - Form 24:
The FFL has recently modified the Landfill cap materials to include a capping system that increases the friction angle and therefore more veneer stability. If this capping material is proposed to be used on the Vertical Expansion, please include this updated information as part of this application and accompanied veneer stability analysis indicating the increased veneer stability of the capping system.

11. Volume 4 of 4 - Form 24:
The Ash MSE berm will be placed above a liner system. Will the ash berm have any less veneer stability than the soil MSE berm under seismic conditions or similar veneer stability?

12. Volume 4 of 4 - Form 24 - 5.3.6 Waste:
The shear strength parameters used in all the stability calculations were based on typical municipal solid waste values. The FFL is primarily ash. Would the stability analysis indicate increased stability with the shear strength values of incinerator ash?

13. Volume 1 of 4 - Form J - 2.9 Structural Fill:
The narrative lists the type of soil however there is no gradation listed. The narrative also states the final Project Specifications may refine these requirements. Who can determine the final specifications for the soil to be used in the berm that will meet the requirements of the design engineer?

14. Volume 1 of 4 - Form I:
Channel C2-3 is improperly labeled on Sheet 1.

15. Volume 1 of 4 - Form J - Attachment J-2:
Please revise Section 4.5.2, *Repairs and Retesting*, to specifically address procedures for off-spec protective cover.

16. Volume 1 of 4 - Form J - Table J-2(2):
Please revise the sampling frequency of the subbase material to 1/5,000 yd^3 for hydraulic conductivity.

Please revise the sampling frequency of the protective cover material to 1/5,000 yd^3 for carbonate content.

17. Volume 1 of 4 - Form H - H-1 2.2:
The soil test plan for determining plant nutrients and soil amendments should be added or referenced in Form J - Table J-2 (2) *MINIMUM SOILS TESTING FREQUENCIES FOR MATERIALS EVALUATION.* (This will allow QA to have one table for soil testing rather than a reference in a narrative of the application.)

18. Volume 1 of 4 - Attachment J-1 - 2.0 Narrative Responses:
The narrative states, *"Contingent upon adoption of the proposed regulatory changes that make provisions for 'overfilling' to anticipate the estimated settlement of the landfill, Frey Farm Landfill will utilize the guidelines set forth in the new regulations to 'overfill' waste in a manner that results in achieving the permitted final grades at the frame of final closure certification."* Will LCSWMA propose any settlement accommodation?

19. Volume of 1 of 4 - Form J - 2.4 Protective Cover Material:
The narrative states, *"The protective cover will have no particles smaller than the U.S. Standard No.200 (0.075mm) sieve."* How will this be specified in Quality assurance testing? There will always be some fine particles passing the 200 sieve.

20. Volume 1 of 4 - Attachment Q-7.1:
Can the base liner slope under the Ash MSE berm be at 2% versus 1%? This allows for any settlement and slight grading anomalies.

21. Volume 1 of 4 - Attachment I-4:
Indicate if the FFLVE complies with the Manor Township Storm Water Management Ordinance, and post construction stormwater requirements. Please include documentation.

22. Volume 1 of 4 - Form Q-5.1:
The applicant proposes a lined containment berm at a height of 18 inches versus a 4 foot lined berm as required by Section 273.252(f) *A lined perimeter berm at least 4 feet high shall be constructed and maintained along the edge of the lined disposal area to prevent the lateral escape of leachate.* Section 273.252 does not allow for equivalency review.

23. Volume 1 of 4 - Form Q:
The Department has required 34 ounce/yd^2 nonwoven geotextile for both angular and sub-angular AASHTO #57 stone. Will the proposed #57 stone be exclusively sub-rounded?

24. Volume 4 of 4 - Form 24 - 5.6.1 Method of Analysis:
The narrative states "*MSE berm soil backfill material will likely contain a significant fines portion and therefore, potentially a low permeability. As such, aggregate drains or other drainage measures will* ***potentially*** *be incorporated where soil backfill is utilized to allow excess pore water pressures to dissipate and maintain effective stress conditions.*"

Drains are incorporated into the MSE Berms in the cross sections. The term "potentially" is used. Does the design engineer see the need for additional drains based on soil obtained, or will the specifications of the soil type in the application provide for adequate drainage in the MSE Berms Please provide clarification?

25. Volume 4 of 4 - Form 25 - Inspection Frequency:
Reference is made as to how long the MSE Berm will be inspected after closure of the landfill and "*the Owner and PADEP will evaluate the need (i.e. frequency) for on –going future inspections.*" The owner will be required to conduct annual inspections as a minimum, unless PADEP and the owner determine more frequent inspections of the MSE Berm are necessary.

26. Volume 4 of 4 - Form 28 - Attachment 28-2:
Should the Post Closure Inspection Form include specific inspection items for the MSE Berm?

27. Removal of waste from the sump area of Cell 1 will remove an area of toe buttress temporarily. The design engineer may consider doing this work during dry period of the year so that leachate is not flowing. Provisions should be made to complete the work in a scheduled manner. The placement of specified material back in the sump and compaction of this material should be in a work plan developed by the engineer before construction.

28. Volume 2 of 4 - Sheet 5:
It appears that Channel A-2 (defined on Sheet 1 of Form I) will not be formed until filling from the final expansion grades creates it (draining to Culvert 5 on Sheet 1 of Form I). Until then, that area will either drain onto new liner or pond runoff for an indefinite period of time until final grades are achieved. Please propose additional design or operational measures to address this matter.

29. Volume 2 of 4 - Sheet 15:
Please provide a detail drawing for overlapping uniaxial geogrids, such as on inside curves and around post insertions, depicting the 3-inch minimum fill separation for proper anchorage of the overlapping geogrid.

30. Please provide specifications for gradation (i.e., sieve size distribution), liquid limit, and plasticity index for the reinforced structural fill material to be used in the MSE berm.

31. Volume 2 of 4 - Sheet 24:
It appears that none of the 14 remaining gas wells on Sheet 24 will be included in the proposed vertical gas management plan of Sheet 36. Is this correct? If not, then please note the well number redesignations of the 14 remaining gas wells that will be consistent with Sheet 36.

32. Volume 2 of 4 - Sheet 25A:
Please provide a detail drawing for a gas lateral road crossing.

33. Volume 2 of 4 - Sheet 28:
The tie-in details for Cells 3, 5, and 6 are depicted on the horizontal. Are not these tie-ins all at the toe of the inside slope of the proposed MSE berm, similar to Cell 1?

34. Volume 3 of 4 - Sheet 37 - Detail 43:
AASHTO #3 aggregate is specified for gas well backfill. Is this correct?

35. Volume 3 of 4 - Sheet 36:
Please propose additional gas wells in the non-expansion areas of Cells 1, 2, and 6.

36. Volume 3 of 4 - Sheet 38:
Gas monitoring probe FFGMP002 is misplaced on the drawing.

37. Volume 3 of 4 - Sheets ES-2 and ES-3 appear to be duplicates. Is there anything different on Sheet ES-3 from Sheet ES-2?

38. Volume 3 of 4 - Sheets A-4 and A-5:
Please provide detailed notes on how the 16 ounce/yd^2 geotextile will be installed during MSE berm construction so as to be intersected by uniaxial geogrid.

39. Please provide detailed notes on how the vertical aggregate drainage column will be constructed with each lift of the MSE berm.

40. Volume 4 of 4 - Form 24 - Attachment 24-2.1A:
The soil that is proposed for construction of the MSE berm appears to be less coarse than optimal, as presented in the analyses of samples MSEB-2 through MSEB-18, and MSEB-20 through MSEB-26. Please provide additional data or literature to demonstrate that this finer soil material would adequately drain in order to be suitable as a structural fill in the MSE berm.

41. Volume 4 of 4 - Form 28 - Bonding Worksheet A:
Please revise Line 4 to $75 per ton.

42. Volume 4 of 4 - Form 28 - Bonding Worksheet B:
Please revise Line 2 to 80 acres.

43. Miscellaneous:
    a. The topographic contours are inaccurate south and southeast of the proposed Sediment Basin D as noted on Phase II Sheets 1, 6, 10, ES-1, ES-2, ES-3, ES-4, and ES-5.

    b. Phase I, Form 4, Section 4.2 indicates that *"The sampling methods currently implemented under the existing FFLF Groundwater Monitoring Plan will continue to be implemented with the approval of the proposed FFVE."* The Department requests that LCSWMA submit an updated Groundwater Sampling and Analysis Plan as required by §273.152(b) and include a map indicating all the surface water and groundwater sampling points including the Act 101 drinking water well locations, the corrected well construction information as discussed under Form 18 above, the well logs for each sampling point, description of Act 101 filtration/treatment systems, and sampling procedures/techniques/parameters for the quarterly sampling events.

c. Phase I, Form 7 – Attachment 7-5 - ARM recommended in the report titled Benthic Macroinvertebrate Assessment – Manns Run and Its Tributaries – Spring 2014 for the FFL vertical expansion project, the following future actions:

- *"If construction of the FFVE project is to occur more than two years from the 2014 benthic macroinvertebrate assessment, an additional baseline assessment should occur to account for any changes that may have occurred in the watershed.*

- *Future assessments should continue to use the IBI Guidance in the evaluation of the macroinvertebrate community and habitat conditions at the 13 stream stations. Additionally, collection of 'in-situ' water quality parameters and stream flow and collection of nitrate-N, phosphorus, alkalinity, total dissolved solids and fecal coliform for laboratory analysis should continue for future assessments.*

- *As previously recommended in past reports, unstable stream banks and channel entrenchment observed at several survey stations in the upper reaches of the Manns Run watershed (main channel and tributaries) may warrant voluntary stream restoration and/or stabilization improvements by LCSWMA.*

- *During the next scheduled water quality sampling event in October 2014, monitor the fecal coliform results at Station SA1E002S. If the results again exceed the PA Chapter 93 water contact recreation (WC) criteria, perform a visual inspection of the area to attempt to determine the source of the fecal coliform and continue to monitor fecal coliform results during regularly scheduled sampling events."*

The Department requests that an additional baseline benthic macroinvertebrate assessment be conducted, as recommended by ARM, to account for any changes that may have occurred in the watershed since the Spring 2014 assessment. Several examples of surficial changes in the area that may have possibly impacted the benthic macroinvertebrate community since the Spring 2014 assessment include the breached pond in 2015 on the adjacent property in addition to preparation of this property for the proposed ash processing plant. If changes to the benthic macroinvertebrate community did occur since the Spring 2014 assessment, it is important to determine if it is related to upstream source(s) and not the proposed FFVE area. The Department requests that future surveys be conducted on an annual basis in accordance with PADEP's Benthic Macroinvertebrate protocol so that any possible impacts to the community can be monitored; and as a result, the community be properly protected. It is recommended that LCSWMA coordinate the surveys with a Department aquatic biologist.

If you believe that any of the stated deficiencies are not significant, instead of submitting a response to that deficiency, you have the option of asking DEP to make a decision based on the information with regard to the subject matter of that deficiency that you have already made available. If you choose this option with regard to any deficiency, you should explain and justify how your current submission satisfies that deficiency. Please keep in mind that if you fail to respond, your application may be denied. If you have any questions, you may contact this office at 717.705.4706.

Sincerely,

John L. Oren

John Oren, P.E.
Permitting Section Chief
Waste Management Program

cc: Manor Township
Lancaster County Planning Commission

PADEP Phase II Review Figures

Figure 1

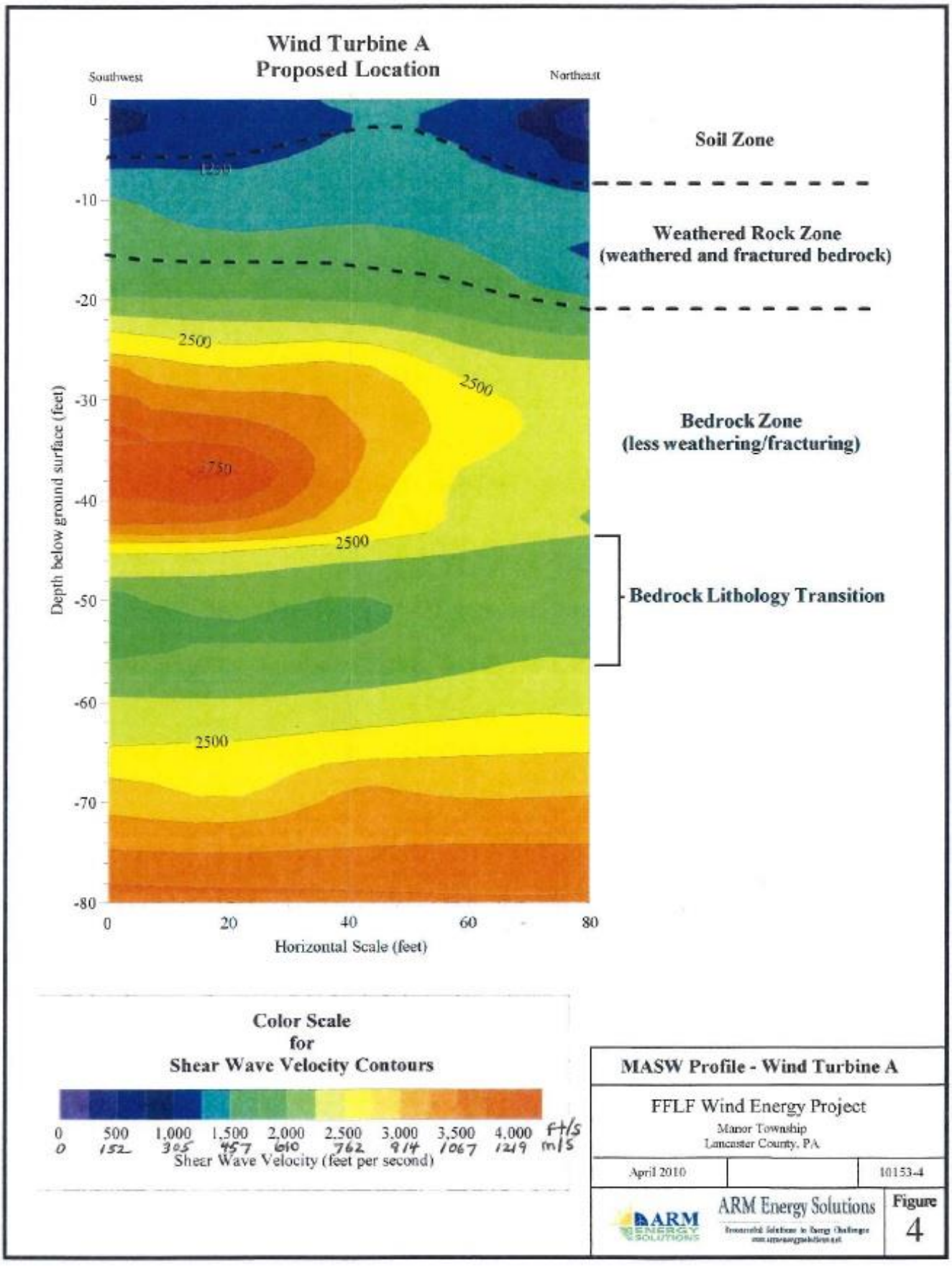


Figure 2

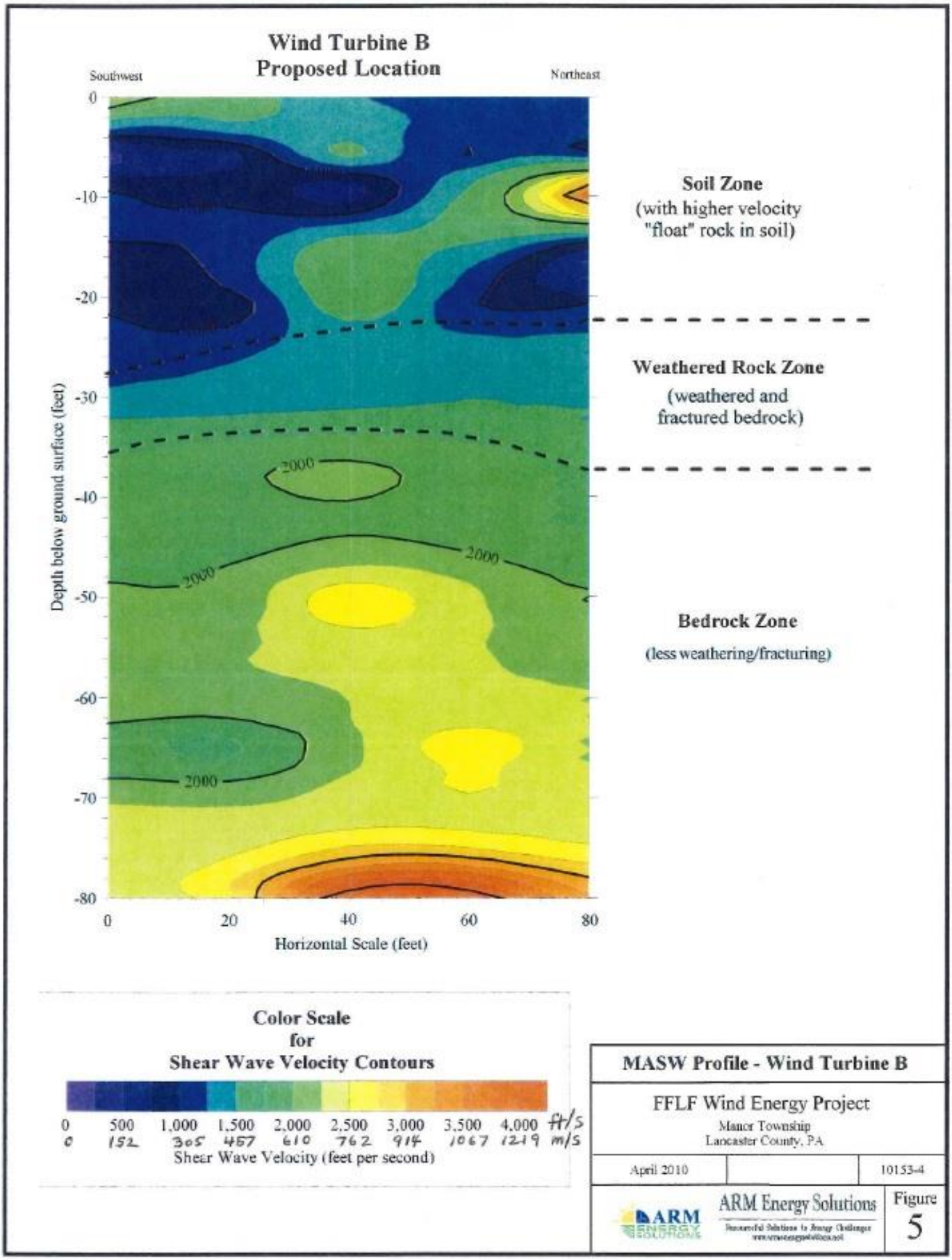
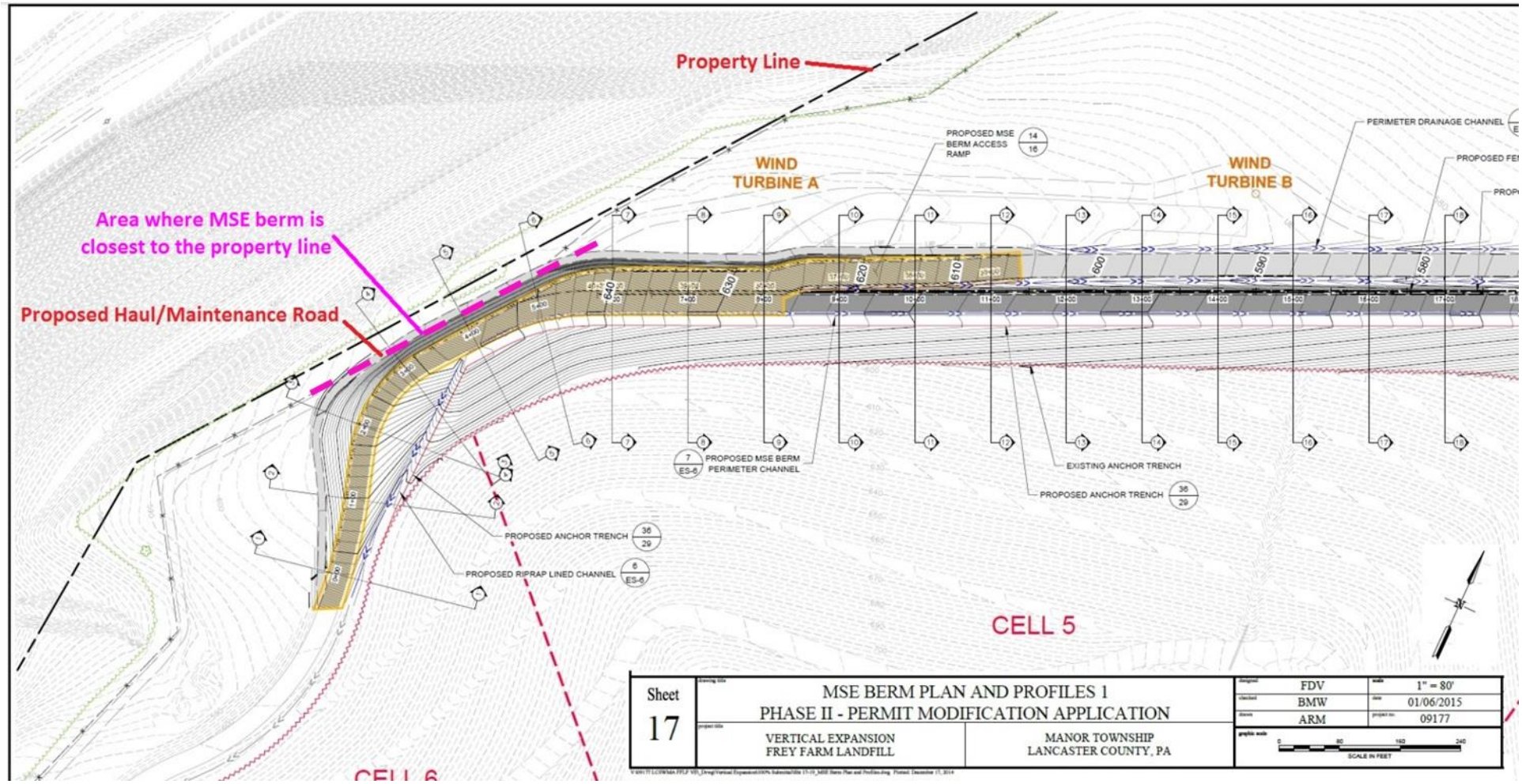
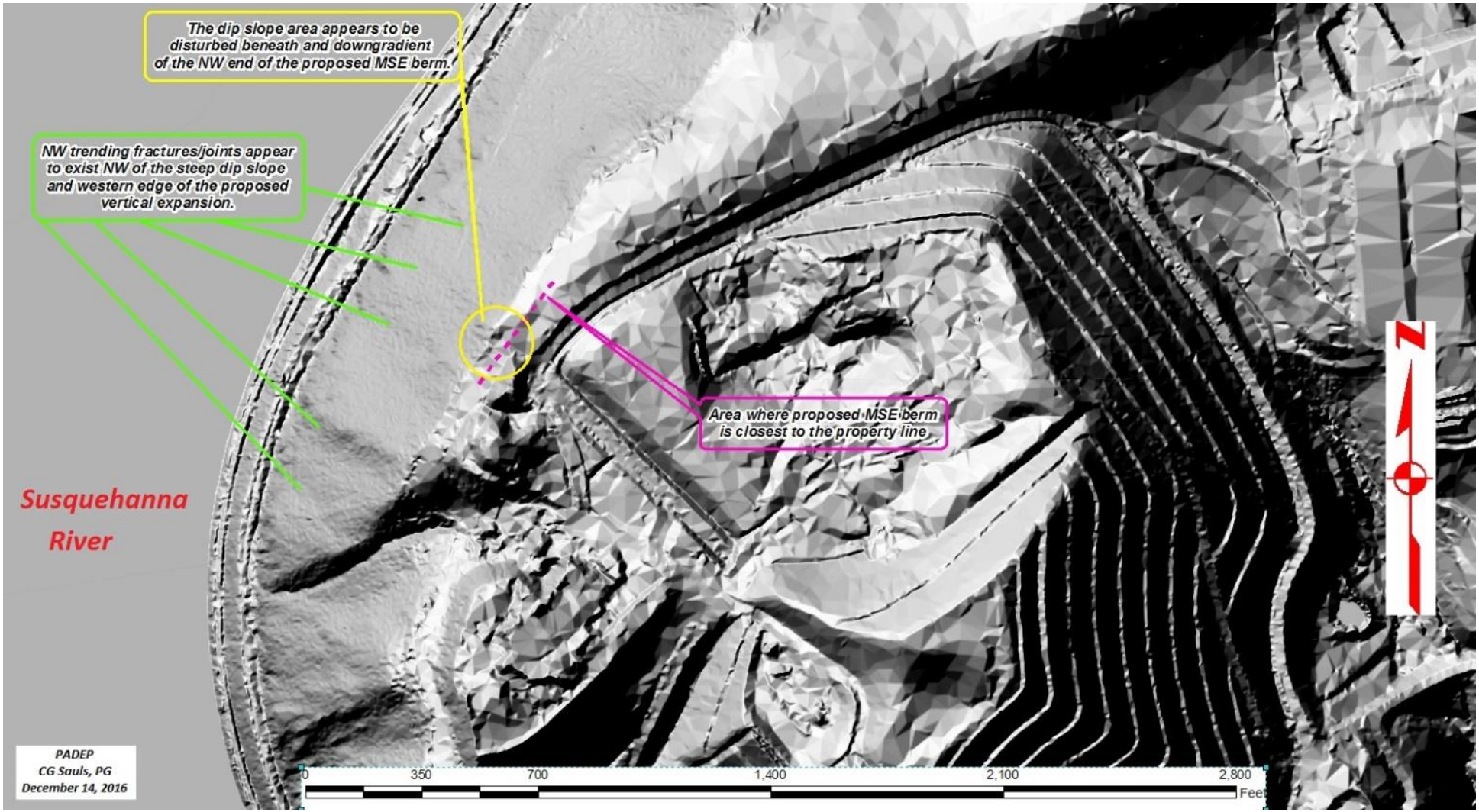

Wind Turbine B
Proposed Location
Southwest
Northeast
Depth below ground surface (feet)
0
-10
-20
-30
-40
-50
-60
-70
-80
2000
2000
2000
0
20
40
60
80
Horizontal Scale (feet)
Soil Zone
(with higher velocity
"float" rock in soil)
Weathered Rock Zone
(weathered and
fractured bedrock)
Bedrock Zone
(less weathering/fracturing)
Color Scale
for
Shear Wave Velocity Contours
0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 ft/s
0 152 305 457 610 762 914 1067 1219 m/s
Shear Wave Velocity (feet per second)
MASW Profile - Wind Turbine B
FFLF Wind Energy Project
Manor Township
Lancaster County, PA
April 2010
10153-4
ARM Energy Solutions
Figure
5

Figure 3



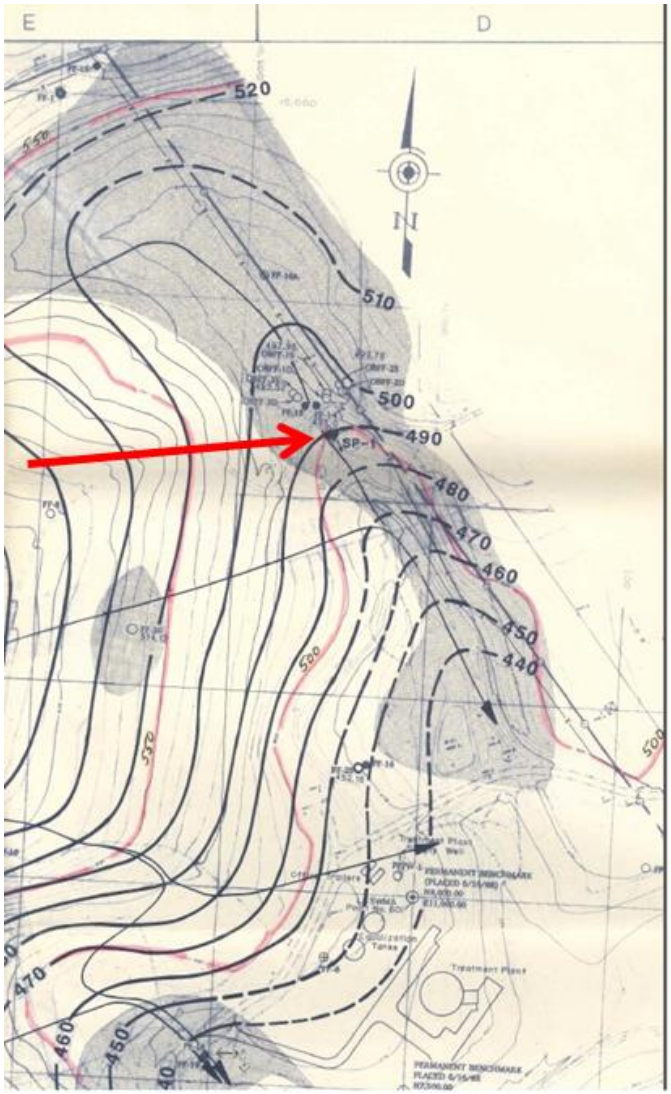
Taken from LCSWMA FFL Phase II Permit Modification Application – Sheet 17 – MSE Berm Plan and Profiles 1
ARM Group Inc., June 3, 2016

Figure 4



Name: PAMAP_DEM_Statewide_Hillshade; Data Type: Mosaic Dataset
PADEP Catalog Path: \\nrnas01\PAMap\LIDAR\PAMAP_LIDAR_Mosaics.gdb

Figure 5



LEGEND

- SPRING
- OBSERVATION WELL
- MONITORING WELL IN MONITORING PROGRAM
- MONITORING WELL NOT IN MONITORING PROGRAM
- PIEZOMETER
- ABANDONED WELL

590.4 — GROUNDWATER ELEVATION (FEET ABOVE MSL)

590 — GROUNDWATER CONTOUR LINE, DASHED WHERE INFERRED (FEET ABOVE MSL)

SATURATED UNCONSOLIDATED/WEATHERED BEDROCK

GROUNDWATER FLOW DIRECTION (ANISOTROPY BASED ON 10:1 PERMEABILITY RATIO)

SCALE

0 100 200 400 600

Note:
Topographic contours - pink

PLATE 6

NO.	DATE	REVISION	BY

LANCASTER COUNTY SOLID WASTE MANAGEMENT AUTHORITY

1299 HARRISBURG PIKE P.O. BOX 4425 • LANCASTER, PA 17604 • (717) 397-9968

DER
WASTE MANAGEMENT
NOV 09 1989
HARRISBURG REGION

r. e. wright associates, inc.
earth resources consultants
middletown, pa. westminster, md.

FREY FARM LANDFILL

MANOR TOWNSHIP LANCASTER COUNTY, PA

DESIGN:	DRAFTED: V.H.G.	APPROVED: H&B Jr.
SCALE: 1" = 200'	DATE: 9/22/89	FIELDBOOK:
GROUNDWATER CONTOUR MAP 7/27/89		FILE NO.:
		DWG. NO. 89037-005-C

6

Table 1

Well Location	Total Depth FT	* Depth to Bottom of Casing FT	Ground Surface Elevation FT MSL	Ground Surface Elevation from well log FT MSL	Measuring Point Elevation FT MSL	Measuring Point Description	Measuring Point Description Should Indicate	Miscellaneous Comment
FFMP002W	90	40 (OR)	611.60		613.20	~~TPC~~	TIC	
FFMP03AW	148	59 (OR)	~~587.00~~	589.70	590.90	~~TPC~~	TIC	
FFMP04AW	299	49 (OR)	~~558.00~~	558.20	560.72	TPC	?	TIC = 558.6 (well log)
FFMP005W	148	30 (OR)	535.70		537.40	~~TPC~~	TIC	
FFMP013W	148	35 (OR)	506.20		507.60	~~TPC~~	TIC	
FFMP014W	29	19 (S)	505.70		507.30	~~TPC~~	TIC	
FFMP015W	150	59 (OR)	~~574.00~~	574.50	576.40	~~TPC~~	TIC	
FFMP016W	150	29 (OR)	472.80		474.60	~~TPC~~	TIC	
FFMP017W	151	38 (OR)	478.70		480.70	~~TPC~~	TIC	
FFMP018W	48	18 (S)	469.74		472.20	TPC	?	TIC = 472.43 (well log)
FFMP019W	127	97 (S)	470.16		472.00	TPC	?	TIC = 471.95 (well log)
FFMP023W	75	55 (S)	610.30		612.30	TPC	?	TIC = 611.8 (well log)
FFMP024W	195	165 (S)	610.60		612.10	~~TPC~~	TIC	
FFMP025W	38.5	18.5 (S)	475.30		475.80	TPC	?	TIC = 476.8 (well log)
FFMP026RW	111	61 (S)	462.50 (Table 7-2) 544.90 (Table 18-1)		465.61 (Table 7-2) 547.40 (Table 18-1)	TPC	?	MSL elevations were not on well log; Elevations noted in Table 18-1 had an ~82 FT discrepancy with Form 7; if this well was reworked/replaced please include the revised well log
FFMP027W	50	30 (S)	519.60		522.10	~~TPC~~	TIC	
FFMP028W	57.5	37.5 (S)	462.50		465.61	TPC	?	TIC = 465 (well log)
FFMP029W	58.5	38.5 (S)	475.30		477.3	~~TPC~~	TIC	
FFMP030RW	90	25 (S)	560.88?		562.3?	TPC	?	MSL elevations were not on well log
FFMP001P	NA	NA	NA		NA	NA	NA	Spring SP-01 outfall
FFMP02SW	22.6	12.6 (S)	507.7		509.9	TPC	?	
FFMP02DW	150	32 (OR)	507.6		509.6	TPC	?	
FFMP031W	140	100 (OR)	610.28		612.66	TPC	?	
FFMP032W	75	55 (OR)	592.03		594.09	TPC	?	
FFMP033W	Not Yet Drilled							
FFMP034W	Not Yet Drilled							
FFMP035W	70	~~55~~ 20 (OR)	476.11		477.56	TPC	?	
FFMP036W	140	~~20~~ 100 (OR)	476.32		478.23	TPC	?	
FFMP037W	70	40 (OR)	458.99		458.99	TPC	?	
FFMP038W	50	19 (OR)	451.89		454.05	TPC	?	
FFMP039W	130	100 (OR)	453.42		455.46	TPC	?	

* Note: Heading should indicate: Depth to Bottom of Casing for open rock wells (OR). Top of Screen for screened wells (S).

FT MSL = Feet Mean Sea Level

TIC = Top of Inner Casing

TPC = Top of Protective Casing