PennEast Pipeline Company, LLC
One Meridian Boulevard, Suite 2C01
Wyomissing, PA 19610

October 28, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: *PennEast Pipeline Company, LLC*, Docket No. CP15-558-000
Response to Comments on Arsenic-Related Issues

Dear Ms. Bose:

On May 16, 2016, PennEast Pipeline Company, LLC (PennEast) submitted the results of an independent study on arsenic leachability conducted by Dr. Michael Serfes (Arsenic Study Report) as Attachment 2-1 of PennEast's Responses to the Federal Energy Regulatory Commission's (Commission) April 29, 2016 Environmental Information Request. The Arsenic Study Report evaluated issues raised by commenters on arsenic mobilization and concluded that that there would be no threat of significant arsenic contamination to groundwater resources in the geologic formations as a result of construction and ongoing operation associated with the PennEast Pipeline Project (Project). Following PennEast's submission of the Arsenic Study Report, Drs. Tullis Onstott and Julia Barringer, and Lauren Santi, submitted additional comments and whitepapers regarding the Arsenic Study Report and arsenic-related issues in the Draft Environmental Impact Statement (Draft EIS) for the Project in the above-referenced docket (T.C. Onstott Comments).

PennEast hereby submits, as Attachments A through F, papers authored by Dr. Serfes addressing the claims raised in the T.C. Onstott Comments. An overview of these papers and the specific comments they respond to is contained in the letter from Mott MacDonald provided in Appendix 1 hereto. Dr. Serfes' response papers demonstrate several errors and faulty and speculative assumptions contained in the T.C. Onstott Comments. Dr. Serfes makes the following points, among others:

- The arguments contained in the T.C. Onstott Comments that operation of the pipeline will cause significant arsenic mobilization are based on speculative chemical reduction scenarios that are not supported by available data. The T.C. Onstott Comments also fail to account for conditions that will reduce arsenic mobilization and also increase adsorption of arsenic back into the soil. Any arsenic that may be released is likely to be limited and subsequently immobilized due to adsorption.

- Allegations regarding Boron contamination of the City of Lambertville's drinking water supply are both unsupported and incorrect in light of the location of the Swan Creek Reservoir at a higher elevation and thus upstream of the proposed route.

- The T.C. Onstott Comments are based on extreme scenarios that would not exist along the pipeline trench. These scenarios rely on speculation and an unrealistic presumption of

a complete pipeline system failure without regard to the continually-corrective pipeline maintenance that will occur.

- The conclusions presented in the T.C. Onstott Comments are not supported in any relevant scientific way. No plausible evidence has been presented that the environment or the non-imported fills will be altered to such a degree by operations so as to cause significant arsenic mobilization or pipe corrosion.

- The T.C. Onstott Comments regarding arsenic releases into surface waters fail to recognize that any discharge into surface waters will be subject to the New Jersey Department of Environmental Protection's permitting requirements including testing and sampling to ensure protection of aquatic life and human health.

Should you have any questions concerning this filing, please contact me at (610) 406-4322.

Sincerely,

/s/ Anthony C. Cox
Anthony C. Cox
PennEast Pipeline Company, LLC,
By its Project Manager
UGI Energy Services, LLC

cc: Medha Kochhar (FERC)
All Parties of Record

Appendix 1

MOTT MACDONALD

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PennEast Pipeline Project
Responses from Solution Geosciences, LLC to Various Arsenic Comments Posted by Dr. Onstott and Others

October 27, 2016

Dear Mr. Cox,

As you are aware, Mott MacDonald, formerly known as Hatch Mott MacDonald (HMM), has been providing assistance to evaluate concerns maintained by commenters to FERC related to the potential for PennEast Pipeline proposed construction activities to mobilize naturally-occurring arsenic, as well as other related concerns, in certain areas of Hunterdon and Mercer Counties in New Jersey.

As part of our work, Mott MacDonald retained Dr. Michael Serfes, P.G. of Solution Geosciences, LLC to provide his unique expertise with these evaluations. Dr. Serfes is an expert in arsenic occurrence and mobilization in New Jersey aquifers, and he conducted a 12-week independent study which culminated in a May 2016 report titled, “Final Report of U.S. EPA Method 1627 and HDD Leach Test Results and Implications for Arsenic Related to the Proposed PennEast Pipeline”. The report is commonly referred to by others as the “Arsenic Study Report” (ASR). Following his study, Dr. Serfes concluded that no threat of significant arsenic contamination to groundwater resources in the geologic formations as a result of construction and on-going operation of the pipeline.

We understand that several commenters maintain concerns regarding arsenic mobilization due to construction and operation of the pipeline. We also understand feedback has been received regarding the ASR from commenters and others. Mott MacDonald has continued to work with Dr. Serfes to provide clarifications and dispel several outstanding speculative concerns regarding groundwater impact related to arsenic and other naturally occurring geologic materials.

Attached herewith, please find several letters prepared by Dr. Serfes of Solution Geosciences, LLC which address comments posted to the FERC Docket CP15-558-000 for the PennEast Pipeline. A cover sheet identifying a list of acronyms has been provided to support the attached letter. These letters include the following:

- **Attachment A:** *Response to Dr. T.C. Onstott’s Comments Concerning: Attachment 2-1 – Arsenic Study Report*

- **Attachment B:** *Response to Comment on Potential Boron Contamination of Lambertville Drinking Water by T.C. Onstott*

MOTT MACDONALD

- **Attachment C:** *Response to Additional Arsenic Exposure to Groundwater from PennEast Pipeline by Lauren Santi and Professor T.C. Onstott*

- **Attachment D:** *Response to Abundant Fe, As, and S Bacteria along the Proposed ROW and How They Will Mobilize Arsenic and Corrode the PennEast Pipeline by Lauren Santi & T.C. Onstott*

- **Attachment E:** *Response to Tullis Onstott/Julia L. Barringer, Princeton, NJ letter dated September 23, 2016.*

- **Attachment F:** *Response to (1) Arsenic release into stream waters from the PennEast Pipeline and (2) Arsenic and its effect on stream and freshwater biota by Lauren Santi & T.C. Onstott*

Mott MacDonald notes that multiple comments were posted to the Docket with common subject and repeat comments. Therefore, these items were addressed by a single response. A reference table listing the original comment with Accession Number and the response which has been provided herewith is listed below:

FERC Docket Submission Date and Accession Number	Original Commenter	Comment Description	Response Attachment Provided
8/2/2016 09:27:59 20160802-5034	T. C. Onstott	Comments regarding Arsenic Study Report	Attachment A
8/29/2016 10:49:03 20160829-5085	T. C. Onstott	Comments on potential boron contamination of Lambertville drinking water	Attachment B
9/6/2016 07:11:16 20160906-5247	Lauren Santi & T.C. Onstott	Additional arsenic exposure to groundwater from PE pipeline	Attachment C
9/6/2016 07:21:32 20160906-5248	Lauren Santi & T.C. Onstott	Additional arsenic exposure to groundwater from PE pipeline *(possible duplicate comment)*	
9/6/2016 09:12:14 20160906-5278	Lauren Santi & T.C. Onstott	Abundant Fe, As, and S bacteria along ROW will mobilize arsenic & corrode the pipeline	Attachment D
9/7/2016 07:25:39 20160907-5050	Lauren Santi & T.C. Onstott	Abundant Fe, As, and S bacteria along ROW will mobilize arsenic & corrode the pipeline *(possible duplicate comment)*	
9/23/2016 13:31:51 20160923-5202	T.C. Onstott & Julia Barringer	Comments regarding Dr. Serfes (Solution Geosciences, LLC) submission of Access Number 20160919-5027 with response to Accession Numbers 20160916-5103, 20160916-5104, and associated opinion-editorial articles published on September 15, 2016 in the newspapers the Star Ledger and Express Times.	Attachment E
8/19/2016 15:13:50 20160819-5209	Lauren Santi & T.C. Onstott	Arsenic release into stream waters from the PennEast Pipeline	Attachment F
8/27/2016 10:41:03 20160829-5084	Lauren Santi & T.C. Onstott	Arsenic and its effect on stream and freshwater biota	

We appreciate the opportunity to continue providing valuable clarification and resolution to the commenters for these outstanding concerns. Should you have any questions or require additional detail, please do not hesitate to contact the undersigned at your convenience.

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Attachment A

Response to T.C.Onstott's Comments Concerning Attachment 2-1-Arsenic Study Report; Submitted to FERC on the Draft EIS for the PennEast Pipeline Project

Prepared for: Mott MacDonald, Inc. for PennEast Pipeline Company

October 27, 2016

Prepared by: Michael E. Serfes, PG, Ph.D.
Solution Geosciences, LLC
Bethlehem, PA 18018

Response to T.C. Onstott's Comments Concerning: Attachment 2-1-Arsenic Study Report; Submitted to FERC on the Draft EIS for the PennEast Pipeline Project

Prepared for: Mott MacDonald, Inc. for PennEast Pipeline Company

October 27, 2016

Prepared by: Michael E. Serfes, PG, Ph.D.
Solution Geosciences, LLC
Bethlehem, PA 18018

Response to T.C. Onstott of the Department of Geosciences, Princeton University Comments of the Draft EIS: Attachment 2-1 – Arsenic Study Report

Executive Summary

On behalf of PennEast Pipeline Company, LLC (PennEast), Solution Geosciences, LLC was obtained as an independent reviewer to address comments made by Dr. T.C. Onstott (Dr. Onstott) related to the completeness of the ASR, which was filed with FERC on August 2, 2016[1]. Many of Dr. Onstott's concerns are related to the claim that the ASR did not address the operational phase of the pipeline and potential chemical reduction mechanisms that he had suggested in a February 2015 comment would reduce As (V) to As (III), and reductively dissolve HFO, resulting in increased arsenic mobilization from the pyritic LF argillite non-imported fill to be used in the pipeline trench. After reviewing and addressing Dr. Onstott's comments in this response document, it is concluded that most of the speculative chemical reduction mechanisms proposed: soil organic matter (SOM) oxidation, CP stray electron, stray methane, fusion bonded epoxy dissolution or failure, and reaction rate increases due to increased thermal energy from the pipeline to the surroundings, are not supported by the available data. In summary, the trench biogeochemical environment will predictably be mostly oxic, the small mass of arsenic initially mobilized will be As (V), the As (V) will be adsorbed onto HFO and other mineral phases, limited and sporadic pockets of chemical reduction may occur in some locations and times in the dynamic trench environment, but, will be overwhelmed by the more ubiquitous oxic conditions. Dr. Onstott's speculative redox altering scenarios will predictably have an insignificant effect on arsenic mobility. The possibility of frac-out (drilling mud excursions) during HDD is an obviously undesirable possibility and is unlikely to occur. The probability of drilling mud excursions from the HDD-boring in argillite should be low, as the LF has a low fracture density and permeability as reflected by the very low specific capacities from wells in this aquifer. However, a breakthrough contingency plan is required by FERC in the event that it starts to occur, as described on page 4-56 of the Draft Environmental Impact Statement (Draft EIS) for the PennEast Pipeline Project (Project).[2]. If breakthrough is suspected, all means necessary will be employed to stop it, clean it up if necessary, and evaluate alternatives to avoid it from occurring again.

[1] Accession no. 20160802-5034, Docket No. CP15-558-000 (Aug. 2, 2016) (ASR: Serfes, 2016).
[2] July 22, 2016.

Part 1.0: Response Introduction

The information provided in the ASR should have dispelled concerns that arsenic-mobilization related to the construction and operation of the proposed PennEast pipeline would present any tangible threat to groundwater quality in Hunterdon and Mercer Counties in New Jersey.[3] However, commenters continue to voice concerns specific to the operation of the pipeline and its effect on the biogeochemistry of the trench environment, specifically in the LF. This is a complex subject. Therefore, some necessary background information about the hydrogeological setting, and the pipeline operations that have been proposed as significant biogeochemistry altering mechanisms, are presented and discussed in Parts 1 and 2 of this Response, respectively. Parts 3 to 5 provide responses to specific concerns and, in some cases, refer back to applicable background sections. It must be noted, that some of the commentary made by Dr. Onstott, is based on misinterpretations of the available data, as will be demonstrated below. Section 1.1 follows and discusses some of the preliminary work referenced and possibly not fully understood by Dr. Onstott about the LF.

1.1 Arsenic Mobilization in the Lockatong Formation

Results of dissolved arsenic concentration and speciation testing of samples from four wells, two public and two private, showed that arsenic concentrations range from 11.9 to 45.0 µg/L As, and contained over 63% arsenite (As (III)), with the remainder being arsenate (As (V)).[4]

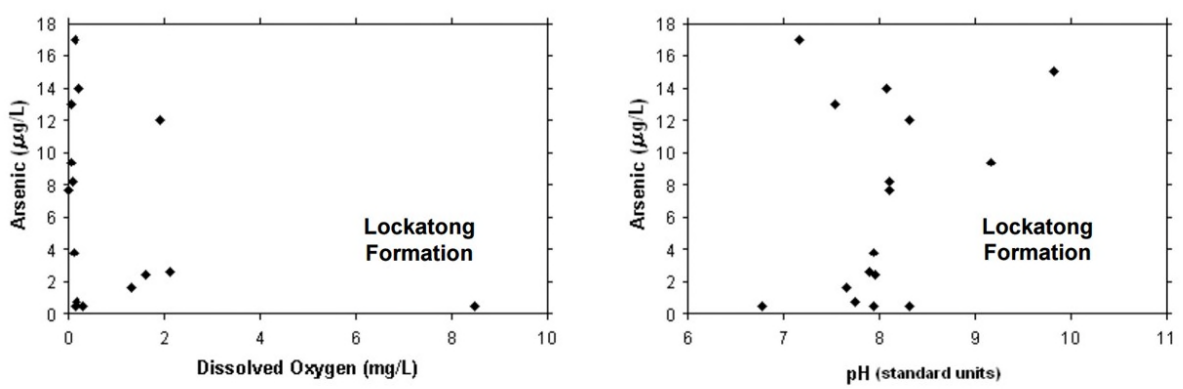

Figure 1. Dissolved oxygen and pH, versus arsenic from potable and other deep wells in the Lockatong Formation in New Jersey (Serfes and others, 2010).

[3] Serfes, 2016.
[4] Steven Spayd, NJDEP, personal communication.

Those wells, like many wells in the LF, had a hydrogen sulfide odor indicative of sulfate-reducing conditions. An early observation, based on the results from 16 other wells tested in the early 2000s, demonstrated that elevated arsenic concentrations (> 10 µg/l), co-occurred with: (1) low Fe (therefore, no apparent HFO reductive-dissolution mechanism); (2) low, or no, dissolved O_2 (chemically reducing, implying pyrite (FeS_2) stability); and (3) a mostly circum-neutral pH (6.5 - 8.5) (Figure 1).

The possibility that arsenic might be derived from the chemically-oxidized unsaturated zone was hypothesized early on because the mineral pyrite (FeS_2), in some un-weathered rock core samples of the LF, and black shale in the Passaic, have micron-scale arsenic-rich segregations; containing up to 4 weight percent arsenic.[5] However, in the surface/near surface oxidizing environment, pyrite is frequently found with HFO oxidation coatings. For example, a slab of rock obtained from an excavation in the LF, approximately 3 feet deep near the Trenton-Mercer Airport (circa 2002), has clusters of HFO after pyrite due to reaction with oxygen (Figure 2). This observation is consistent with HFO pyrite oxidation-reaction products observed on pyrite using EPA-1627, as discussed in the ASR. It is important to note, that at a circum neutral pH the abiotic oxidation of Fe (II) to Fe (lll) is very rapid and may out compete microbial utilization of this reaction.

If dissolved As (III) was present in this oxic-geochemcial environment, it would theoretically be mobile.[6] However, As (III) is not thermodynamically stable there, while As (V) is stable, in addition to being readily adsorbed onto HFO and other surfaces.

Abundant Secondary HFO After Pyrite (FeS_2) Indicating Oxidizing Conditions

Pyrite-derived reaction product coatings of HFO, would adsorb (via surface adhesion) and absorb (trap) arsenic derived from pyrite; thereby immobilizing it.

$$FeS_2\,(s) + 15/4\ O_2 + 7/2\ H_2O \rightarrow 4H^+ + 2(SO_4)^{-2} + Fe(OH)_3\,(s)$$

Figure 2. Pyrite oxidation on an ~ 1-foot wide slab of Lockatong Formation shale-argillite, from an approximately 3-foot deep road-side excavation (circa 2002), near the Trenton-Mercer Airport, in West Trenton, New Jersey.

[5] Serfes, 2005.
[6] Serfes and others, 2010.

Indeed, the naturally enriched concentrations of arsenic above pyritic bedrock, such as found at the Investment Company Corporate Center in Hopewell Township, NJ, which had a mean concentration of 56.2 mg/kg As, and an outlier high of 359 mg/kg As indicate that there is a natural arsenic-sequestering process in the unsaturated zone (see ASR, Figure 19).

The understanding among arsenic mobilization researchers studying Newark Basin unsaturated (soil and regolith) and saturated zones (aquifers) has continually evolved, as more field and laboratory test data have become available and scientifically evaluated. That continued knowledge-based evolution includes the test results included in the ASR.

Finally, since the leach test results using method EPA-1627 showed that the near-surface weathering of pyrite does not yield a significant and temporally consistent mass release of arsenic, another explanation is required. A laboratory-based experimental evaluation of arsenic mobilization[7] showed that sulfide (S^-) can substitute for arsenide (As^-) in the pyrite structure under sulfate-reducing conditions. Therefore, when sulfide (S^-) is produced due to sulfate ion (SO_4^{-2}) reduction along the groundwater flow path, it can substitute for arsenide (As^-) in the pyrite structure, thereby mobilizing arsenic in the form As (III). Since the mechanism proposed by Zhu and others, for the direct generation of dissolved and mobile As (III) from the reduction of sulfate in the LF aquifer is sufficient, there is no need to rely on improbable combinations of conditions in the shallow subsurface to explain the widespread occurrence of dissolved arsenic.

In the field, pyrite oxidation may begin to deplete dissolved O_2 in the shallow aquifer. Ferric iron and sulfate are reaction products of pyrite oxidation. The ferric iron readily reacts with water, forming HFO, and the sulfate, being a conservative ion, is mobile in aqueous solution and would be carried into the underlying groundwater system as recharge advances deeper into the aquifer. Remaining dissolved O_2 would continue to be depleted due to pyrite oxidation along the flow path (even as more sulfate is being generated). Sulfate reduction may not begin immediately upon exhaustion of free oxygen, if other, more thermodynamically favorable oxidizing agents are present; but ultimately specific anaerobic microbes will begin the reduction of sulfate to sulfide.

In summary, many of the LF groundwater samples taken from potable and public supply wells have a hydrogen-sulfide (rotten egg odor) indicative of sulfate to sulfide reduction. Under these conditions, the direct generation of mobile As (III) can occur in a widespread manner (via arsenide-sulfide substitution), very slowly depleting the arsenic stored in pyrite and ultimately producing the regional high concentrations that we observe in supply wells. Based on the most recent data from EPA-1627, it is clear that in the shallow chemically oxidizing unsaturated zone, some arsenic (As V) will be released; however, that release is kinetically limited, in part due to adsorption onto HFO reaction products and other phases.

[7] Zhu and others, 2008.

1.2 Depth to Groundwater in the LF

As clearly demonstrated in referenced responses to Dr. Onstott's specific comments below, the pipeline trench will be in the "unsaturated zone" for most of its length in the LF, except where it transects a stream channel or wetland. The photograph in Figure 3 provides an example of the unsaturated zone setting in the LF.[8] The USDA definition of "water table," used by Dr. Onstott to argue that there is a hydrogeologically-defined water table above the bedrock surface, is a misinterpretation of that definition.[9] The USDA clearly states:

> "Field determinations of water table depth are typically made through the identification of redoximorphic features in the soil profile, **however, local water table monitoring (wells) should be used to calibrate these features** *[emphasis added]*."

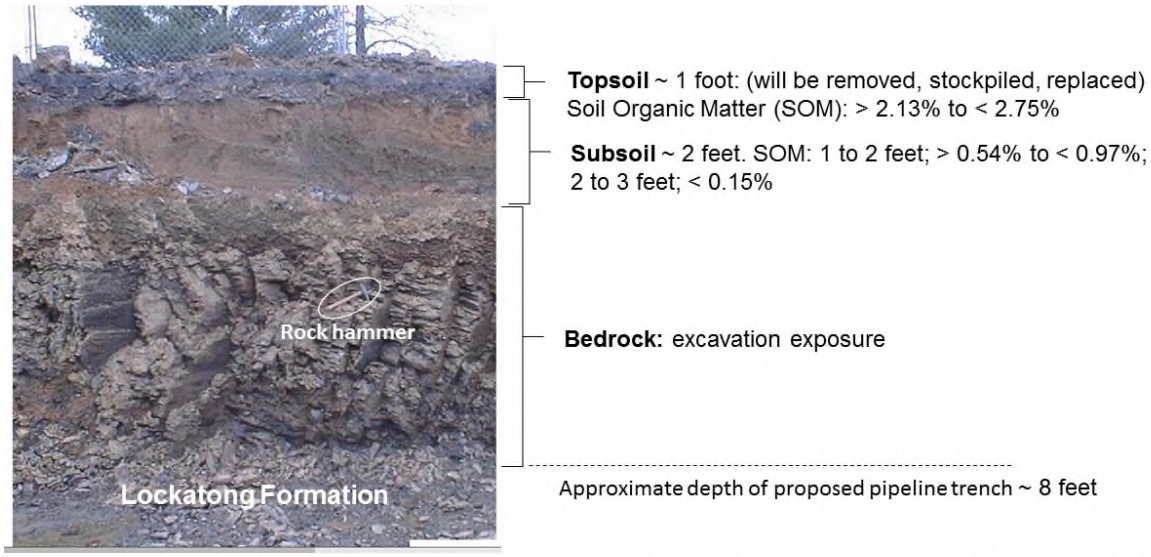

Figure 3. Excavated outcrop of the Lockatong Formation within the unsaturated zone (Herman, 2010). The rock hammer is approximately 1 foot in length and used for scale. Estimated Soil Organic Matter (SOM) data is for the area of interest (USDA, Websoilsurvey GIS application, 2016).

Redoximorphic features (such as a gray color for water table conditions) are determined by the collection (usually with a soil auger) and subsequent interpretation of soil samples. These gray colors, can be caused by seasonal and local perched water in the unsaturated zone where soils are saturated for a period of time after cumulative (or significant single) precipitation events occur. The USDA Websoilsurvey GIS application was used to characterize the prevailing soil types in the area of interest (Figure 4).

The Chalfont and Croton Series, which comprise most of the soils in this outlined area, have a firm, low-permeability, fragipan, usually below the B-horizon, that ranges from 15

[8] Herman, 2010.
[9] USDA TSSH Part 617.

to 40 inches in thickness, and is found approximately 15 to 36 inches below the surface.[10] This fragipan, contains very little root structure, has very low SOM, is rich in silt or very fine sand, and acts as a semi-confining unit in some locations, where soil water can be seasonally perched. As noted in Kratzer (2009), the soils overlying the LF have a slow to very slow infiltration rate, and hydric soils and wetlands, as defined in Figure 5d in that publication, do occur due to perched soil water. Hydric soils are wet long enough to produce periodic anaerobic conditions in the SOM-rich upper soil horizons. Within the fragipan semi-confining unit, the soil profile to bedrock is documented as having a reddish-brown to yellow-brown color (indicative of iron oxy-hydroxides and oxides) which are characteristic of oxic-conditions, in the water that percolates through it. Bedrock in these soils is encountered at approximately 3 to 6 feet, or more, but can also be exposed at the surface.

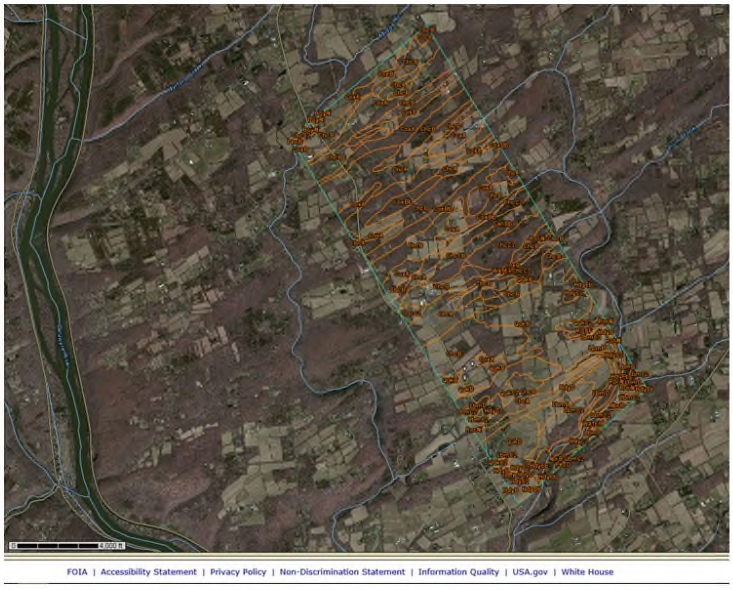

Figure 4. Soil series that will be excavated along the pipeline trench transect, over the Lockatong Formation, in Hunterdon County, NJ. The Chalfont Soil Series comprises 45%, the Croton 21%, the Quakertown 11.5%, the Lansdale 5.3% and other lesser Series by area, the remainder (USDA Websoilsurvey GIS application).

http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Seeps are commonly found at the base of some slopes. Ditches have been used in some places to drain excess water for farming. Although slow to drain water in some locations, this soil is part of the unsaturated zone, as the groundwater levels in the bedrock aquifer are much deeper.

The actual depths to static (non-pumped) groundwater in the LF, were determined from a report prepared for the Kingwood Township Planning Board, based on drilling log reports.[11] In the LF, the static depth to groundwater, based on 20 drilling well-logs, demonstrate, that the actual hydrogeological depth to groundwater ranges from the surface (one well adjacent to a stream) to approx. 110 feet below the ground surface,

[10] USDA, 1974.
[11] Hordon, 1995.

with a median depth of approx. 30 feet (Figure 5). Based on groundwater levels from 165 wells from the LF that continue across the Delaware River into Bucks County, Pennsylvania, Sloto and others (1994), determined depth percentiles ranging from: 25th (10 feet), median (18 feet) and 75th (33 feet) below the ground surface. All of these depths to groundwater represent composite heads from confined, and possibly unconfined, water-bearing zones intersected by the well boreholes. Therefore, the bottom of the pipeline trench (approx. 8 feet) will be in the oxidized unsaturated zone, above hydrogeological groundwater levels, except where it transects streams or wetlands.

1.3 Conceptual Pipeline Trench Hydrogeochemical Model

The trench excavation will remove and separate the topsoil (approx. 12 inches), that has a relatively high SOM content, for subsequent replacement onto the surface after construction (see USDA data in Figure 3).

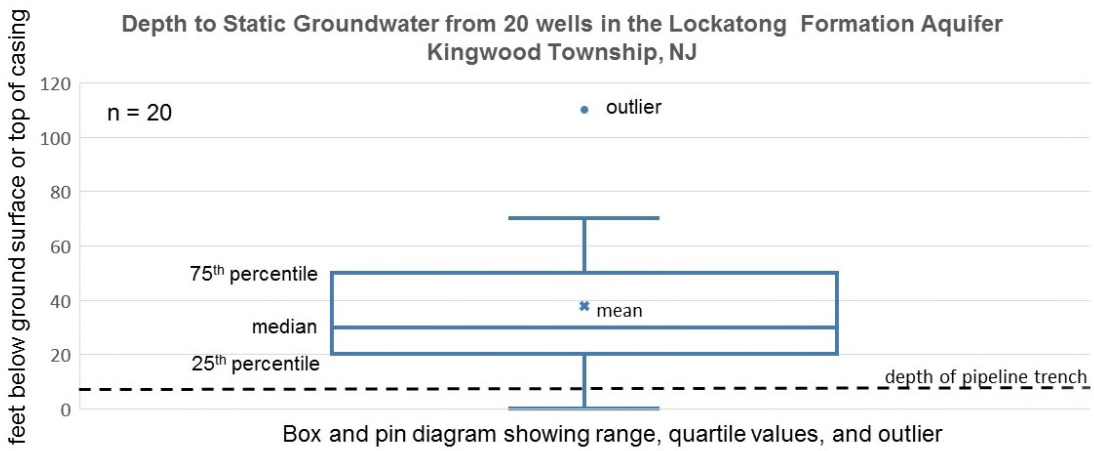

Figure 5. Depth to Static Groundwater in Kingwood Township, Hunterdon County, NJ, based on 20 well-water depths from drilling logs (Hordon, 1995)

Therefore, the fragipan, which is a hard and highly weathered zone, with low permeability and SOM, and a variable amount of bedrock thickness as a function of depth, will be removed. The broken rock, will be returned to the trench up to the existing bedrock level. Screening of the bedrock, or emplacement of inert imported fill (as padding) around the pipe itself will be required for stability, and reduce the chance of surface coating abrasion. The excavated, and disaggregated, fragipan and other subsoil, will be mixed together to comprise the non-imported backfill material. Once emplaced around the pipe, the trench backfill, will have its own unique soil hydraulic

characteristics, which will be much more permeable than the original fragipan, allowing more O_2-rich recharge and aeration. Aquifer recharge will be greater in the trench footprint than in the same footprint of surrounding soils. This will result in an even more geochemically sustainable oxic environment in the trench, that will result in greater SOM oxidation (in the little that will comprise the fill), and reactions with exposed pyrite to form HFO. It is probable that sporadic micro-scale reducing conditions will exist from time to time in scattered locations in the hydraulically dynamic trench environment that is subject to intermittent and variable recharge. However, arsenic released in those isolated reducing pockets will be sequestered once flushed outside of them because the majority of the bulk total fill material, will mainly contain stable metal oxide and hydroxide minerals that will adsorb and absorb the small fraction of available mobile arsenic. Most of the bulk arsenic will remain trapped within the rock materials themselves, that are resistant to further weathering on time scales applicable to the pipeline operation, and beyond (see the ASR).

1.4 Use of EPA-1627 to Model the Pipeline Trench

It must be understood, that the EPA-1627 was used to evaluate the potential flux of arsenic from representative rock materials because it: (1) is a standardized method, and therefore well thought out and repeatable; (2) closely modeled the predicted environmental conditions in the trench setting in the unsaturated zone; and (3) contained unreacted arsenic-enriched mineral phases. In many places, the materials comprising the backfill will be a mix of freshly broken and weathered rock, and, highly weathered and leached B-C soil horizons. Those soil horizons are predictably very chemically inert due to long term weathering and biogeochemical equilibration in the near-surface environment. As per EPA-1627, PSDs ranged from <0.25 mm to 9.53 mm in the 2-inch rock leach columns, and <1mm to 38.1 mm, in the 6-inch. This is in direct conflict with Dr. Onstott's claim that only 2 PSDs were used, thereby biasing the results: "[t]he investigator selected coarser grain sizes for their 6 samples (9.5 mm diameter for the 2" column and 38.1 mm diameter for the 6" column)."

In summarizing the above four points, Dr. Onstott misinterpreted the specified finer PSDs used for EPA-1627, the depth to actual groundwater, and other key information to be pointed out below, that are the basis for much of his comments.

Part 2: Discussion: Critique of Dr. Onstott's Biogeochemical Reduction Scenarios

Solution Geosciences summarizes several common concerns related to the speculative biogeochemical redox-altering scenarios which were not allegedly addressed in the ASR. These issues will be addressed in the order that the comments pertaining to those concerns are presented below.

Those several scenarios presented by the original author are mainly based on speculative, necessarily co-occurring, and sometimes misinterpreted conditions, that according to Dr. Onstott, will ultimately create a ubiquitous reducing chemical environment in the unsaturated zone. This is in conflict with the reality that, with the possible exception of scattered pockets, the zone will be continually recharged with O_2-enriched precipitation, and interact with atmospheric-derived soil gas with a high O_2 content, both conducive to an oxidizing chemical environment. The scenarios envisioned by Dr. Onstott that would result in the widespread mobilization of arsenic during the operational phase of the pipeline, include ubiquitous: (1) microbial-mediated reductive dissolution of HFO with consequent mobilization of adsorbed and absorbed arsenic, (2) microbial-mediated As (V) to As (III) reductive transformations, resulting in enhanced arsenic mobility, (3) methanogenic chemical reduction due to stray methane releases, leading to (1) and (2) above; (4) pipeline protective epoxy induced chemical reduction leading to (1) and (2) above; (5) CP-induced chemical reduction leading to (1) and (2) above; and (6) heat enhanced chemical reduction reaction rates leading to (1) and (2) above. The speculative redox scenarios (SRS 1 through 6), are discussed below.

2.1 Microbial Mediated Chemical Reductions: Fe (III) in HFO and As (V)

Outside of ARD, the reductive dissolution of HFO (SRS 1), and other oxides, represents the worst case condition for significant arsenic mobilization. A redox-ladder diagram representative of a circum-neutral pH, is given in Figure 6 for illustration purposes.[12] Atmospheric oxygen in air, and dissolved in water, is the most oxic and ubiquitous natural condition at the earth's surface. Oxygen yields the greatest amount of usable energy to bacterial mediators and is the first reactant to be consumed in oxidation-reduction reactions. Oxygen is consumed during reactions involving the oxidation of organic matter, nitrogen, nitrite, manganese, iron, sulfide and other elements. Oxidation of iron and sulfide will occur during pyrite oxidation, producing HFO and soluble sulfate (Figure 2). The abiotic oxidation of Fe (II) to Fe (lll) is very rapid and may out-compete microbial utilization of this reaction. The microbial-mediated reductive dissolution of HFO and reduction of As (V) to As (III) (SRS 2) will only occur if all of the oxygen is consumed in an open system, and all of the reduction reactions shown in Figure (6), from the top down, are utilized by microbes until an anoxic state is attained. However,

[12] Borch and others, 2010.

when materials are rich in HFO and other oxides, only sustained and long-term reducing conditions can lead to complete depletion of arsenic sorbent phases, resulting in significant arsenic mobilization.[13]

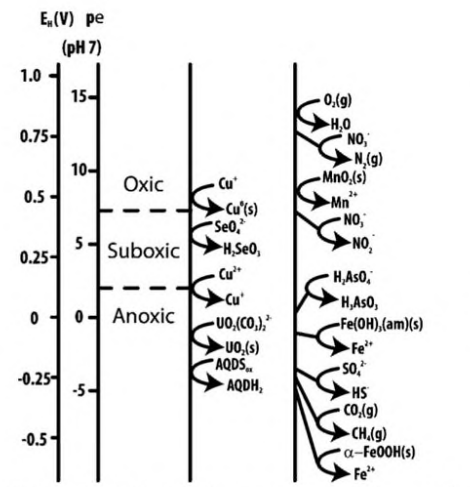

FIGURE 1. Redox ladder showing examples of environmentally relevant redox couples. Couples were calculated at pH 7 using standard techniques. Concentrations of all dissolved constituents in each half reaction are 1 M except for Fe^{2+} (1×10^{-5} M), U^{6+} (1×10^{-6} M), and CO_3^{2-} (3×10^{-3} M).

Figure 6. Redox ladder, showing from the top-down, the order of geochemically important oxidation-reduction reactions as a function of Eh and pe (oxidation state of system at a pH of 7.0). Important redox couple reactions would occur in the order shown after molecular oxygen is reduced by microbial mediators. Note: as long as molecular oxygen is available in the system, the reactions will not proceed downward. The pipeline trench system will mostly be Oxic, as it is open to dynamic inputs of O_2-rich water and air. Therefore, HFO and As(V) will be stable. The figure is from Borch and others (2010).

Many cases of the significant sustained chemical reduction of previously oxic systems are documented and they all have one key ingredient: the introduction and systemic exposure to a copious and sustainable supply of electron-donating organic matter. Two examples are given here: (1) Tube wells in Bangladesh have been shown to draw organic-rich deltaic surface and underlying subsurface waters deeper into local aquifers creating a more microbial-mediated significant reducing environment, leading to the reductive dissolution of ferric hydroxides, like HFO, containing arsenic, and, reduction of As (V) to As (III), thereby increasing dissolved arsenic concentrations in the deeper aquifer system;[14] and (2) in Winthrop Maine, organic-rich leachate from a landfill (the Winthrop Landfill Superfund Site) has similarly caused arsenic, naturally sequestered in and on iron-oxides and hydroxides, to become mobile due to microbial-mediated iron and arsenic reduction.[15] Neither of these extreme situations is relevant to the near surface transect route the pipeline trench will take in the LF hydrogeological setting.

The other speculative scenarios envisioned by Dr. Onstott to cause the reductive dissolution of HFO and reduction of As (V) to As (III) are: (3) methanogenic chemical reduction due to stray methane releases, (4) pipeline protective epoxy induced chemical reduction, and (5) CP-induced chemical reduction. Safeguards to such scenarios fall

[13] Borch and others, 2010.
[14] Polizzotto and others, 2005.
[15] p.7 of EPA, 2007, https://www3.epa.gov/region1/superfund/sites/winthrop/260744.pdf

under the USDOT division, PHMSA. PHMSA develops and enforces regulations for the safe, reliable, and environmentally sound operation of the nation's 2.6-million-mile pipeline transportation system and the nearly 1 million daily shipments of hazardous materials by land, sea, and air.[16] These scenarios will be discussed separately below, along with item (6), heat enhanced reaction rates.

2.2 Potential for Stray Methane Induced Chemical Reduction

The significance of stray methane (SRS 3) releases in regard to creating a chemically reducing environment is a multivariate consideration. Natural gas pipelines are specifically designed to avoid this potentially dangerous possibility. There is no doubt that this can occur under rare circumstances, will be very localized, and will only last until the leak is corrected. Given the seriousness of such a condition, the response would be swift. As per page 4-258 of PennEast Draft EIS:

> During inspections, PennEast employees would look for signs of unusual activity on the right-of-way and would immediately respond to assess the nature of the activity and remedy with prescribed corrective action. In addition, the PennEast Gas Control Center would electronically monitor the operations of the pipeline system and would be staffed 24 hours a day, 365 days a year, and would use a computerized gas-monitoring system to read pressures along the pipeline on a continuous basis. In the event of a leak, the Gas Control Center would have the ability to isolate a segment of pipe by sending commands to close the remotely operated main line valves.

Also, on page 4-260:

> We received scoping comments requesting that the gas be odorized in order to help Project personnel and the public identify leaks. All gas within the pipeline would be odorized with mercaptan to provide an added level of safety and security to the gas system by providing a warning mechanism for the public.

From tables 4.11.2-1 and 4.11.2-2 on page 4-261, past corrosion of natural gas transmission pipelines has resulted in significant incidents. However, the use of coatings such as FBE in combination with CP, has been found to offer the best level of protection against corrosion, with an incident rate from 1970 to 1984 of approx. 0.01 per 100 miles of pipe. Modern technology coupled with optimization engineering of the pipe metals, FBE, and the CP systems offer much less risk of corrosion than in the past. FBE

[16] http://www.phmsa.dot.gov/pipeline/naturalgas.

and CP, which together offer the best protection against corrosion and related stray methane leaks, over the lifetime of pipeline operation, are discussed below.

2.3 Potential for FBE and CP-Induced Chemical Reduction

FBE pipeline coatings (SRS 4) are electrical isolating barriers (electrical insulators) and supplement and isolate the electron flow in the pipeline induced by the CP system from the corrosive electrolytes in soil water. If intact, electrons will not flow into the surroundings, and the corrosive electrolytes in the soil water cannot contact the pipe. This is a highly effective, protective, dual system, if there are no holidays (nicks and scratches) in the coating itself. This dual system is used in natural gas, petroleum, water and sewage pipes, as well as pipe systems for refineries, petrochemical plants, power plants and paper mills. FBE can have NSF-61 certification in some applications, for use in potable water and FDA certification for use in food handling applications. These coatings, like any applied material, obviously have a certain effective life span, but, must meet or exceed requirements of PHMSA to protect the public health and environment. Once cured, they are by all practical purposes, insoluble in the environments they will be exposed to just below the surface. There is no reason to suspect that they will induce chemical reduction reactions in the fill materials and associated soil water. In addition to this dual corrosion protection, the pipeline will have stray current detections systems in place, so that proper continued maintenance can reduce the risk of corrosion.

CP (SRS 5) is a common application to safeguard buried pipelines of all types from possible corrosion. Basically, a buried anode (source of electrons resulting in local oxidation reactions) is the source for electrons that travel along the pipeline to maintain a reduced metal charged state so that, for example, iron metals do not oxidize due to iron's tendency to be an electron donor during oxidation, thereby, inhibiting the formation of rust on exposed surfaces. An electrical DC rectifier controls the flow of electrons, which are lead to an electrical ground (in the earth outside of the excavation) to complete the circuit, which will only occur if the FBE is compromised. If these electrons could escape into the surrounding environment, then it would be possible to aid reduction reactions, similar to organic carbon which is an electron donor. Unless there are: (1) ubiquitous holidays (nicks in the bonded protective epoxy coating the pipeline, which will be carefully avoided), (2) degradation of the FBE coating, or (3) the metal comprising the pipe has a high linear electrical resistance (which it is designed not to), leaking of electrons into the surrounding fill materials (attenuation), should not occur. These cathode protective systems are designed so that this does not take place, but if it does, it will be very sporadic and localized to spotty environments along the pipeline length, and corrected, when the stray current is detected. In fact, Norsworthy (2009) concludes the following:

> Not all coating failures result in corrosion on the pipeline. Some coating failures have little or no effect on the corrosion rate of the pipe. FBE, as mentioned above, is one such coating. Rarely is external corrosion found on a pipeline coated with FBE if adequate cathodic protection is available. Therefore, in the presence of CP, it appears that the pipe will remain protected and blistering and coating disbondment of FBE coatings does not present an integrity threat to a pipeline.

Therefore, this dual corrosion protection system is not going to lead to a significant geochemical reduction of fill materials contained in the trench.

2.4 Potential Pipeline Heat Induced Chemical Reduction

It is well known that increasing temperature (SRS 6) can increase the rate of most thermodynamically stable chemical reactions. Reactions that are already taking place in a chemical system, within chemical equilibrium constraints, will continue to do so, except faster. This assumes that key reactants are not altered or driven away, due to the increased heat, and product stability and mobility are not altered to any significant degree. It is uncertain exactly how much heat (assumed to be modest) will be conducted into the surroundings from the natural gas pipeline, or the heat-conduction properties of the fill materials under dry and semi-saturated conditions. From a physical conceptual model perspective, increased heat conducted to the surroundings from the pipeline, would accelerate upward venting of soil gas and thereby increase lateral flow of it into the trench.

Heat would also cause water in the trench to evaporate more quickly, thereby, drying the fill materials faster. Dry environments are known to be less chemically reactive than wet ones, which might tend to decrease reaction kinetics. It should also be noted that the adsorption-desorption of arsenic at increasing temperatures is conflicting. However, a recent thermodynamic equilibrium evaluation for temperatures ranging from 50º F to 122º F, indicated it is an endothermic process, with adsorption favored at higher temperatures.[17] Also, it is expected that reactions rates, if significantly affected at all, would favor the prevailing geochemical environment. For example, HFO would form more rapidly, therefore increasing the surface area of arsenic sorbents. Much work has been conducted to evaluate how global warming will affect SOC stores in soils. Increases in soil temperature may accelerate losses of SOC due to effects of temperature on the reactions performed by soil microbes, which lead to the more rapid mineralization of SOC to CO_2.[18] This will tend to reduce the availability of the already predictably-limited amount of SOC (contained in SOM) in the trench fill materials from participating in reduction reactions. Indeed, SOM content in the topsoil (which will be

[17] Feng and others, 2013.
[18] Davidson & Janssens, 2006; Trumbore & Czimczik, 2008; Conant and others, 2011.

removed, stored, and replaced) along the pipeline transect above the LF, is highest, and subsoil SOM contents are much lower (Figure 3). Therefore, it would be reasonable to conclude that additional heat may actually reduce the potential for increased arsenic mobilization, not, enhance it.

In summary, the trench biogeochemical environment will be mostly oxic, the small mass of arsenic initially mobilized will be As (V). The As (V) will be adsorbed onto HFO and other mineral phases. Limited and sporadic pockets of chemical reduction may occur through space and time in the dynamic trench environment but will be overwhelmed by the more ubiquitous oxic conditions. Speculative redox altering scenarios will predictably have an insignificant effect on arsenic mobility. The possibility of frac-out during HDD, an obviously undesirable event, and, questions concerning the TCLP evaluation of the drilling mud for hazardous classification, in addition to other comments made by Dr. Onstott concerning the ASR, are addressed below.

Part 3: Responses to Dr. Onstott Section: Major Flaws Regarding the Arsenic Leach Experiments

On pages 5 to 9 of Dr. Onstott's comments, the three "major flaws" regarding the arsenic leach experiments were listed. Each of Dr. Onstott's proposed "major flaws" are presented below, followed by a response to each item.

> Major Flaw 1**: "**Grain size of shattered rock was increased above the normal grain size thereby reducing the As release rate of the leaching experiment. The investigator selected coarser grain sizes of their 6 samples (9.5 mm diameter for the 2" column and 38.1 mm diameter for the 6" column) than they had used in previous experiments (0.177 mm diameter) for the standard EPA acid mine drainage test because PennEast Pipeline claimed that the grain size of the backfill will be 1 to 30 cm." *(Page 5 and 6)*

<u>Response 1</u>: This is a misinterpretation of the information provided in the ASR. As per EPA-1627, PSD ranged from < 0.25 mm to 9.53 mm, in the 2-inch leach columns, and, < 1 mm to 38.1 mm, in the 6-inch. Most of the grain sizes used in the leach test were much smaller than the maximum particle sizes used, 9.5 mm for the 2-inch and 38.1 [mm] for the 6-inch leach columns. Therefore, the basis of the comment is incorrect.

> Major Flaw 2a: "This assay was conducted in a mostly dry aerobic experiment that produces arsenate that is retained at pH conditions less than 7 by ferric iron oxides,[19] particularly the HFO produced during pyrite oxidation. This assay was

[19] Dixit and Hering, 2003.

then treated as a kinetic experiment, knowingly ignoring the redox nature of the As species, especially the mobility of As at neutral pH, under hypoxic (low-O_2) and water saturated conditions, and the microbial processes that are responsible for the As redox chemistry and reductive dissolution of ferric oxides." *(Page 7)*

Response 2a: This is a misinterpretation of the information provided in the ASR. EPA-1627 required placing method-defined masses of specific PSD of rock into 2-inch diameter leach columns (6-inch columns also tested) and exposing them to chemically aggressive conditions (10% CO_2-rich humidified laboratory air for 6-days, followed by a 24-hour saturation with deionized water, once per week, and was therefore not dry. This method was selected because it simulates (as closely as possible) the trench and ditch spoil environments exposed to soil gas and precipitation conditions expected in the outdoor setting. The pH of all leachate samples collected, were circum-neutral (6.5 to 8.5), or slightly above, and therefore conducive to As (V) mobilization. There was no alteration of the atmospheric-equilibrated DIW O_2 used during humidification or saturations to create an artificially hypoxic environment, as there was no clear justification to do so. Please refer to Parts 1.3: Conceptual Pipeline Trench Hydrogeochemcial Model, and 2: Critique of Dr. Onstott's Speculative Biogeochemical Reduction Scenarios, above for detail. The non-imported fill proxy, was allowed to reach its own ambient chemical equilibrium, as it would in the trench environment. The representative samples of the LF were from field-exposed, therefore naturally microbiologically active, rocks.

Major Flaw 2b: "These conditions will also exist along the pipeline after it is buried (organic-rich soil mixed in with pulverized arsenic-rich bedrock, epoxy coating leakage, and natural gas leakage and natural DOC, since the water table is above the pipeline in the As-rich formations being crossed by the pipeline (see below)." *(Page 8)*

Response 2b: This is a misinterpretation of information provided by the USDA on their Websoilsurvey GIS application that the commenter used to assess SOM and the water table. First, SOM results should have been stratified as a function of depth, but instead, were blended down to 60 cm (approx. 2-feet), as shown in Dr. Onstott's Comments, Figure 8. Soils are well known to be enriched in SOM in the A-horizon and less so in the B and C. Since the organic rich topsoil (approx. 12-inches) is going to be removed, stored, and then placed back onto the surface after pipeline emplacement, any inadvertent mixing of SOM with the trench ditch spoil, would expectedly be very minimal. Estimated SOM concentrations for the upper 12-inches (> 2.13% to < 2.75%), 12-inches to 24-inches (> 0.54% to < 0.97%), and, 24-inches to 36-inches (< 0.15%), are shown in Figure 3, above. These data were derived using the same USDA Websoilsurvey application used by commenter. Second, as discussed in Part 1.2: Depth to Groundwater in the LF, as demonstrated by the USDA, Dr. Onstott confuses the water-table designation. The USDA clearly states:

> Field determinations of water table depth are typically made through the identification of redoximorphic features in the soil profile, **however, local water table monitoring (wells) should be used to calibrate these features** [*emphasis added*]**.**

The medium depth to groundwater, calculated to be 30-feet in the LF in Kingwood Township as shown in Figure 5, was determined using local well data.[20] The USDA use of the term: "water table" generally, defines perched soil water, that in the area of concern, occurs seasonally above the local fragipan subsoil. This perched water, is still technically in the hydrogeologic unsaturated zone, since it is not necessarily saturated below the fragipan. Before the perched water can recharge the underlying aquifer, it must first pass through the aerated saturated zone.

Please refer Part 2.1: Microbial Mediated Chemical Reductions: Fe (III) in HFO, and As (V), above for discussions concerning the speculative redox altering scenarios: (1) microbial-mediated reductive dissolution of HFO, with adsorbed and absorbed arsenic mobilization, and, (2) microbial-mediated As (V) to As (III) reductive transformation, potentially resulting in enhanced arsenic mobility. Also refer to Parts: 2.2, 2.3, and 2.4, for discussions about the speculative pipeline operational issues: stray methane, fusion bonded epoxy, CP, and heat (conducted thermal energy).

The conceptual model for the trench as described in Part 1.3, is that the biogeochemical environment will be mostly oxic. This model is based on realistic assumptions: (1) the small mass of arsenic initially mobilized will be As (V), (2) the As (V) will be adsorbed onto HFO and other mineral phases, and (3) limited and sporadic pockets of chemical reduction may occur through space and time in the dynamic trench environment but will be overwhelmed by the more ubiquitous oxic conditions. The speculative redox altering scenarios proposed by Dr. Onstott that rely on the chance of co-occurrence of conditions that would have limited lateral and temporal extent will predictably have an insignificant effect on arsenic mobility. When the pipeline is truly in a sustained saturated condition, such as under streams or in some wetlands, the rock materials surrounding the pipeline will chemically equilibrate, and reactivity will be stabilized. The initial and temporary chemical disequilibrium may induce some, but predictably insignificant, arsenic mobilization as occurred in EPA-1627.

> Major Flaw 3a: "The EPA Publication SW-846 and the Federal Title 40 are irrelevant to the concern Prof. Onstott stated about the drilling mud frack-out**.**

[20] Hordon, 1995.

Response 3a: The HDD experiment was evaluated to address Dr. Onstott's "extra measure" request 5 of his Comments Regarding PennEast Pipeline Project: Arsenic and Earthquakes**."**[21] *(Page 8)*

As per Dr. Onstott's "extra measure" request 5:

> During HDD the drilling muds must be analyzed for arsenic before, during and after drilling and reaming by the designated EI's. This data must be made available to the public. The disposal of the drilling mud must be performed in compliance with NJDEP regulations regarding arsenic disposal based on observed concentrations.

Therefore, a preliminary assessment using a modified version of EPA SW-1846 Method 1131 (TCLP), as the ASR, was used because of the viscous nature of the mud-matrix. The results were compared to the Maximum Concentration of Contaminants for Toxicity Characteristic (the D List) for arsenic, which is 5 ppm. Note that the results of this testing do not preclude the HDD drilling company from having to test used drilling mud to meet the qualifications for disposal, as that is required by regulation, under both Federal and state law. This was just a preliminary test to determine the range of dissolved arsenic concentrations in the mud-derived leachate, and any associated implications. Besides providing information about waste classification, it provided information about arsenic mobility in the most liquid phase of the mud-gel-rock-powder mix itself, which turned out not to be an issue because the mud-gel is extremely difficult to separate from the non-gel liquid fraction. Therefore, the mud gel very effectively holds the rock particles and dissolved arsenic fraction, and therefore predictably, there should not be any stray mud-gel derived aqueous excursions.

Breakthrough (frac-out) of drilling mud into surface-water bodies is a very undesirable event, and all engineering means practicable are taken to avoid its occurrence. Rock cuttings containing naturally-occurring arsenic in the mud, would be less of a concern than the mud itself, as the stream bed-load contains much of that same rock formation material. The LF is a hydraulically tight formation based on having some of the lowest well yields of aquifer formations in the Newark Basin. Therefore, the probability of drilling mud excursions from the HDD boring route should be low. However, a breakthrough contingency plan is required as per page 4-56 of the Draft EIS for the PennEast Project, which states:

> Crossings employing HDD or conventional bore technologies would not be expected to impact TSS/total dissolved solids or turbidity levels in the open channel of waterbody and wetland areas being crossed using these technologies. Breakthrough of HDD drilling muds into the waterbody during drilling could also result in siltation or exceedance of water quality standards for TSS or turbidity. The Project E&SCP, SPCC Plans, HDD

[21] Accession no. 20150224-5023, Docket PF15-1-000 (Feb. 24, 2015).

> Inadvertent Returns and Contingency Plans, and HDD construction BMPs would be followed during HDD and conventional bore installation activities to minimize potential breakthrough events during HDD operations.

Two key Best Management Practices listed among the 10, are: (1) that drilling fluid pressures will be monitored closely, and (2) an environmental inspector will be onsite monitoring for inadvertent releases. If breakthrough is suspected, all means necessary will be employed to stop it, clean it up if necessary, and evaluate alternatives to avoid it from occurring again.

> Major Flaw 3b: "The experiment fails to provide the necessary data because it did not include any samples of the LF, which is the formation being drilled at Lockatong Creek and which is much harder than the Passaic Formation." *(Page 8)*

Response 3b: Most of the HDD activity associated with Lockatong Creek will be in the lower Passaic Formation, although, the LF could be encountered upon exiting south of the creek. The main goals of the modified TCLP testing of the drilling mud-rock mixtures was to assess arsenic concentration range, and, the mobility of that arsenic in the non-gel filterable liquid fraction. The results of the two tests conducted answered both those questions as it is possible to determine a maximum theoretical concentration and compare that to the TCLP regulatory limit.

The idea of determining an MTC by simply dividing the total constituent concentration by 20 is described by USEPA in their document, "Use of Total Waste Analysis in Toxicity Characteristic Determinations".[22] Therefore, if the MTC is less than the appropriate regulatory limit the material cannot exhibit the toxicity characteristic and the TCLP need not be run. Therefore, the rock-mud mixture would have to have < 100 ppm (100 ppm/20 = 5 ppm) to require testing. The maximum arsenic concentration of the LF samples used and reported in Serfes (2016) was from the ML (15 ppm) and was therefore well below the MTC. However, it should be remembered that all of the used drilling mud to be disposed, will have to be tested for arsenic, and many other constituents, per Federal and state regulations.

> Major Flaw 3c: "It is disturbing that in the two measurements made during this assay the As released in the presence of the bentonite mud (41.4 ppb) was twice as high as that produced by DIW (18.8 ppb) and the author fails to explain why this occurs." *(Page 8)*

[22] https://yosemite.epa.gov/OSW/rcra.nsf/Documents/FA78484D3BD7D29C852565DA006F0ACF

Response 3c: It must be understood that the modified TCLP was conducted as a preliminary evaluation, not a separate research study. The bentonite and rock material chemical interactions are likely complex and beyond the scope of the evaluation's main intent. The main test outcomes: (1) that the results were less than 1% of the 5 ppm standard, and (2) the filterable liquid fraction was difficult to separate from the mud gel, were the key findings.

> Major Flaw 3d: "Finally, the investigator concludes that the drill mud slurry is nonhazardous because its concentration is less than 5,000 ppm. If the point of the assay was to determine whether the drilling mud was less than 5,000 ppm,[23] then why perform it on rocks that only have 6 ppm in them? Obviously the mud slurry would be less than 5,000 ppm." *(Page 9)*

Response 3d: See Response 3b above. To clarify, the regulatory limit is 5 ppm, not 5,000 ppm and the drilling mud leachate as per the modified TCLP was less than 1% of the limit.

Part 4: Responses to Dr. Onstott Section: "Additional Specific Flaws in HMM/Solution Geosciences Report"

On pages 9 to 20 of the Dr. Onstott comments, the 9 additional "specific flaws" are listed, starting with specific flaw 4 and ending with 13. Each of Dr. Onstott's proposed "specific flaws" are presented below, followed by a response to each item.

> Specific Flaw 4a: "Reductive Dissolution of HFOs by Fe(III)-reducing bacteria - The investigator claimed that the formation of HFOs will create a coating on pyrite that can sequester As molecules, and thus, limit their transport (p. 5 [referencing the ASR, Serfes 2016]). Yet again, his experiments were run in an aerobic environment, which is not a realistic representation of conditions after the pipeline is buried. HFOs are readily reduced by Fe(III)-reducing bacteria releasing the As, which limits their effectiveness."[24] *(Page 9)*

Response 4a: The HFO that formed on the pyrite surfaces, will not only adsorb arsenic, but will impede any further release of arsenic. The trench environment will be more aerobic than Dr. Onstott recognizes and the HFO will be stable. Please refer to Part 2.1 above, for detail. Essentially, you would have to have sustained reducing conditions over large portions of the trench environment to result in the complete depletion of arsenic adsorption products.

[23] EPA Publication SW-8.
[24] Lee, 2013.

Specific Flaw 4b: "We propose that these bacteria will be stimulated by the pipeline operation and that their activity is not dependent on the presence of landfills specifically. Reducing conditions (as above) can be associated with septic-system leach-fields, where inputs of nutrients (primarily organic carbon) promote the growth of reducing environments through microbial degradations of the organic carbon." *(Page 9)*

Response 4b: Please refer to Part 2.1 above, for detail. Essentially, sustained reducing conditions would be necessary over large portions of the trench environment to result in the complete depletion of arsenic adsorption products. Also, as discussed in Introduction Part 1.2, the topsoil that contains the most SOM will be removed, stored and replaced on the surface and the subsoil contains much less SOM. Hypothetically, if the system did become anoxic as per Figure 6 above, the coatings of HFO would reductively dissolve and the adsorbed arsenic would be more mobile; however, the pyrite would then be more chemically stable and therefore, less reactive.

Specific Flaw 5a: "Time duration of the experiment was too short for determining important microbial processes that release As. The rate of As release could possibly increase after 12 weeks, were microbial communities to develop that could harness energy from materials in the columns." *(Page 9)*

Response 5a: The column leach testing was performed within the requirements of the EPA-1627 test method, and lasted for 3 months. The Lockatong Argillite samples were boulders collected near out-crops, and had been exposed to the surface environment, therefore, presumably were microbiologically active.

Specific Flaw 5b: "Given that, it is obvious that, even under the conditions of the experiments, substantial amounts of As were mobilized from the rock fragments to the surrounding DIW." *(Page 10)*

Response 5b: iIt was reassuring how quickly the concentrations trended toward expected background over the 12-week leach test period. Most of the samples did not leach significant concentrations, or a total mass, of arsenic at all. For those that initially did, the concentrations in the groundwater mixing zone below the trench based on dilution modeling were not significant and will become even lower over a short period of time.

Specific Flaw 6: "Temperature of the experiment was kept low reducing the rate of As release. Higher temperatures accelerate both abiotic and biotic reactions rates. Thus, the leaching experiment should have been run under higher temperatures." *(Page 10)*

Response 6: The leach testing was conducted at approximately standard room temperature as per method EPA-1627, it was not kept low. Increasing the temperature, by an amount not clearly defined, would have turned a standardized test into an experiment, which may have caused unforeseen problems. Please refer to Part 2.4: Potential Pipeline Heat Induced Chemical Reduction**,** above for detail. Increased thermal energy in the surrounding fill material would likely increase arsenic sequestering, not decrease it.

Specific Flaw 7a: "Experiments should have used groundwater - Competitive desorption was classified as 'highly unlikely in the agricultural and undeveloped land-use areas surrounding the proposed trench transecting Hunterdon and Mercer Counties, NJ'." *(Page 12)*

Response 7a: Using natural groundwater as the aqueous solvent could have yielded results that could not be generally applied. Groundwater chemistry is variable to some degree, from well to well, even within the same land use and local area, due to the multi-layered nature of the Newark Basin stratigraphy. It may also represent composite water-bearing zone conditions, yielding younger and older, more geochemically mature water, which are not representative of the expected O_2-rich recharge water chemistry. Also, it would be inconsistent with EPA-1627. Competitive desorption was never declared as highly unlikely, only that phosphate containing fertilizers would be applied locally and seasonally. Although it is well known that phosphate can compete with arsenate for sorption sites, it was not found to be a significant contributor to the high dissolved arsenic concentrations existing in the Newark Basin aquifers.[25] Indeed, it was found that by just mixing fresh powdered rock samples of the Lockatong and Passaic Formation with DIW, arsenic is readily mobilized to varying degrees depending on the sample, via initial desorption surface reactions (abiotic chemical weathering); however, that release is limited once the reactive labile arsenic fraction has been leached.[26]

Specific Flaw 7b: "The investigator argues that competitive desorption from phosphate-containing fertilizers is on a local scale, and both sporadic and seasonal. Therefore, disturbance of such materials can result in mobility of phosphate (note that, in the results of the New Jersey Piedmont study of

[25] Serfes et al., 2010.
[26] Serfes et al., 2010; Serfes, 2016.

Mumford et al. (2015), high concentrations of Phosphorous were present in the subsurface pore water with elevated As concentrations for the stream running through agricultural land. The experiment, therefore, should have used shallow groundwater or surface runoff water from areas of appropriate land use to match with what the ditch spoils and backfill will experience." *(Page 12)*

Response 7b: As per above, the water chemistry would be variable from location to location and possibly not representative of the average, thereby, potentially leading to spurious leachate chemistry. The phosphorus in the stream channel pore water[27] is a mix of older groundwater discharging to the stream channel through the stream bed, possibly mixed with younger more stream-proximal groundwater. It is well known that phosphate can mobilize arsenic via competitive desorption. However, any potentially influential nutrient spreading in agricultural areas transected would be a seasonal event. Much of that phosphate, would be adsorbed onto soil particles (including HFO) and used by the plants themselves. Also, most of the land use associated with the proposed pipeline transect through the LF in Kingwood and Delaware Townships, NJ, are in existing woodland ROWs, woodlands and intermittent patches of agricultural land use. Therefore, any phosphate applications would be areally sporadic, and expectedly not be a significant arsenic mobilization factor in a system that has many natural sorbents.

Specific Flaw 7c: DOC and SOC

"Thus, clear-cutting along the pipeline right-of-way poses a problem because this process will release organic carbon to soil pore waters and shallow groundwater, and organic carbon is a known driver of microbial-produced reducing conditions.

Since the soil organic carbon is degraded by bacteria,[28] these areas are at risk for increased As mobilization for an indeterminate period of time due to microbial activity." *(Page 14)*

Response 7c: Please refer to Part 1.2: Depth to Groundwater in the LF, above, for detail. There will not be significant SOM in the backfill.

Specific Flaw 8a: Depth of bedrock

"The investigator cited an average water table depth of 6-8 feet (183-244 cm), thus implying that the pipeline would safely be buried in the soil above the bedrock."[29] *(Page 16)*

[27] Mumford et al., 2015.
[28] Postma et al., 2008.
[29] HMM/Solution Geosciences Report, p. 14.

Response 8a: That 6-8 feet referred to above, is the depth to bedrock at that one location, not the depth to the water table.

> Specific Flaw 8b: "In Hunterdon County, there are numerous areas where the bedrock is shallower than 100 centimeters, particularly where stream channels cross the proposed route, indicating that the pipeline would be deeply buried below the bedrock (Figure 9). This trend is important because burial of pipelines below bedrock represents the emplacement of a highly permeable pathway formed by organic-rich soil mixed with finely fragmented As-rich rock below a formerly low permeability barrier, and the creation of conditions under which As can be released from geologic materials to shallow groundwater that can discharge to areas streams." *(Page 16)*

Response 8b: Please refer to Part 1.2: Depth to Groundwater in the LF, above for detail. Bedrock depth will be variable, but likely shallow (less than 6-feet) in the area of concern, and may crop out at the surface. However, the bottom of the trench will be above the groundwater except at stream crossings and some wetlands. Soil will not be mixed with the rock fragments and the topsoil that contains the highest percent of organic carbon will be segregated and reapplied to the surface. Therefore, no significant amount of organic carbon will be available to react with adsorbents such at HFO. The groundwater dilution models presented in Figures 17 and 18 of Serfes (2016), evaluated that hydrogeological setting and demonstrated that arsenic concentrations in the groundwater mixing zone will not be significant.

> Specific Flaw 9a: Arsenic in deep versus shallow groundwater
>
> "The occurrence of elevated As concentrations in water from deep wells rather than water from shallow wells was mentioned by the HMM/Solution Geosciences report, with the implication that only deep groundwater can be affected by As release from geologic materials. What the HMM/Solution Geosciences report fails to mention is that the CFC dates for the well water at both locations were 22 years, meaning that this inference is incorrect, and water does in fact move from the surface to depth over the time interval for pipeline operation." *(Page 17)*

Response 9a**:** The available groundwater data from the area of interest indicates that shallow groundwater from monitor wells generally has lower arsenic concentrations than

samples taken from deeper potable wells.[30] The Newark Basin aquifers are characterized by a LMAS, and significant groundwater flow is confined to water-bearing zones in select individual beds. HW-3, the shallow well (As of 1.1 µg/l) adjacent to HW-6, is open from 10 to 35 feet through pyritic black-gray shale strata beds. It does not intersect any significant high conductivity water-bearing zones and therefore flow within the beds are slow.

By contrast, HW-6 (As of 44 µg/l) is cased through the shallow pyritic black-gray shale and open from 50 to 400 feet through beds of red mudstone, some of which, have significant water-bearing zones. The similar CFC age of well water from both support the hydrogeological scenario that groundwater flows quicker from the recharge areas to HW-6, then that from the recharge areas to the HW-3. HW-6 and HW-3 are hydraulically isolated from each other. The main inference in the ASR, is that more chemically evolved water-rock interaction conditions along groundwater flow paths are generally more conducive to arsenic being mobilized. Potable wells are cased (therefore hydraulically isolated) down to at least 50 feet, and drilled to whatever depth is necessary to supply useful quantities of water. Therefore, they generally intersect one or more relatively significant deeper water-bearing zones to meet their intended use. Those water-bearing zones yield: (1) water exposed to greater water-rock interaction, (2) more chemically mature groundwater, and (3) provide the most water to the well. If the bed containing the water-bearing zone(s) happens to be arsenic enriched, then the water will be enriched in it and result in elevated arsenic concentrations.

There was no intended inference that water in the footprint of the pipeline trench that recharges the aquifer, could not travel to nearby potable wells over the time interval of pipeline operation as it is possible in some cases. The intended inference is that shallow groundwater generally has lower arsenic concentrations than some deeper and since arsenic mobilization in the shallow trench will be limited (as in shallow wells in general), there should not be any significant impact to deeper potable wells from it. The dilution modeling demonstrated that.

> Specific Flaw 9b: "In a recent study by Raritan Headwaters of 14,000 wells within the North and South Branch of the Raritan Watershed, which overlies the Passaic Formation, As was found to have been increasing in concentration from 2003 to 2015 (MacDonald and Mitchell Thomas, 2016)." *(Page 17)*

<u>Response 9b</u>: The data suggests a somewhat subtle, although statistically significant, increase in detected arsenic and nitrate concentrations over the time period of record. Data from future sampling should provide more insight. I do not believe an interpretive

[30] Serfes, 2016.

study of this trend has been performed, so, direct causal relationships have not been identified.

> Specific Flaw 9c: "As reported by Serfes et al. (2010), increasing the water/rock ratio will significantly increase the As release rate (Fig. E18). That experiment[31] showed that when the water/rock mixing ratio is 40, 4% of the total arsenic in Passaic mudstone could be released in just 16 hours! Such a ratio will not exceptional for the highly permeable trench backfill, that sits below the water table on occurs on slopes entering and leaving water crossings. The HMM/Solution Geosciences report fails to mention the results of this experiment even though they use the same figure in their report."[32] *(Page 18)*

<u>Response 9c</u>: The leach test referred to was an aggressively agitated (16-hour) DIW-very fine rock powder (less than 80 mesh sieve opening size, i.e. less than 0.177 mm) mixture SEBT. It is not comparable to the static-material, flow-through testing conducted in the leach columns or would exist in the trench. However, the MET results presented in Serfes[33] using ASTM: D 5744-96(2001) was similar, and arsenic concentrations lower, to EPA-1627. Again, the trench setting is more similar to a MET simulation than a SEBT, as the continual flushing of reaction products will occur. As per the EPA-1627 test results in the ASR, once the labile arsenic is leached, the concentrations trend toward background.

Specific Flaw 10: Depth of water table

> "This depth range implies that for every location marked on Figure 10 as red or yellow, the pipeline will lie below the water table."
>
> "According to PennEast Resource Report 1, all pipelines will be buried 'with a minimum of 48 inches of cover, except where rock prevents this depth. In all other areas it will be installed with a minimum of 36-inches depth of cover' (p. 66)." *(Page 18)*
>
> "Thus, As contamination in aquifers upstream due to input from the underlying pipeline would threaten both nearby aquifers and down gradient rivers. In this scenario, increased precipitation would not simply work to dilute As in groundwater, but rather, would create a movement of As-rich water from aquifers to down gradient streams and wetlands, thus potentially increasing As in the streams (Mumford et al., 2015)." *(Page 19)*

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[31] Serfes et al. (2010).
[32] HMM/Solution Geosciences Report, Figure 7.
[33] Serfes 2005; Serfes and others, 2010.

Response 10: Please refer to Part 1.2: Depth to Groundwater in the LF, above, for detail**.** The depth to the water table will mostly be below the trench in the areas marked on Figure 10 as red or yellow. Therefore, there will not be free-flowing water within the pipeline trench in that area as required by Specifc Flaw 10 to impact downgradient aquifers and rivers. The water will directly recharge the underlying aquifer.

> Specific Flaw 11: "The dilution model uses only a one-time time input of trench arsenic thus minimizing the expected As contamination." *(Page 19)*

Response 11: Those one-time inputs are the worst case, highest arsenic concentration, conditions. There will be continued, but decreasing, arsenic loading from the trench with time. The EPA-1627 test results presented in the ASR, demonstrated, the input concentrations to groundwater will decrease over time to expected background levels. Therefore, the concentration in the groundwater mixing zone (although not significant initially) will predictably become increasingly lower.

> Specific Flaw 12: "Lack of pH measurement in EPA acid mine drainage assay results." *(Page 20)*
>
> Conditions for pH of fluids in the assay used are not reported; therefore, it is not known what the starting pH was in the experiments, whether it varied throughout the experiments, and whether concentrations of As in the leachate had any relation to pH of the experiment fluids. Groundwater pHs elsewhere have been measured at >7. If cement is used in the pipeline construction as water barriers, then the pH of surrounding pore waters is likely to increase, thus promoting desorption of As(V). Senior and Sloto (2006) effectively show how As in groundwater of Newark Basin aquifers increases as pH increases.

Response 12: The pH data are reported in Appendix 2, table 2 of: Attachment 2-1 – ASR.[34] Leachate derived from column saturations using EPA-1627 were circum-neutral with a chemical pH of 6.5 to 8.5.

> Specific Flaw 13: "The HMM/Solution Geosciences Report mentions that the As concentrations in soils overlying bedrock can be particularly high, up to 359 ppm[35] during excavation of the Investment Company Corporate Center

[34] Serfes, 2016.
[35] HMM/Solution Geosciences Report, Fig. 19.

Campus.[36] Although the HMM/Solution Geosciences Report claims that this demonstrates the immobility of the As in unsaturated zones, they do not present groundwater As concentration data from wells around the construction site following the construction so they cannot conclude that the construction has not had any influence on the surrounding wells." *(Page 20)*

Response 13: There was no study conducted by the NJDEP or anyone else to evaluate how groundwater chemistry was affected by construction at the Investment Company Corporate Center Campus. Some domestic wells within a mile of the center were known to have arsenic concentrations up to approx. 45 µg/l before that construction started. The fact that the regolith immediately above the bedrock was highly enriched in arsenic, was presented as evidence that those weathered bedrock materials have a high natural arsenic-adsorptive capacity**.** No conclusion, definitive or implied, was ever made in the ASR that the construction did, or did not, impact groundwater quality.

Part 5: Responses to Dr. Onstott Section: Appendix

On pages 21 to 23, Dr. Onstott has 5 comments. Each comment with respective responses are:

Comment 1: "Acid Rock Drainage was never raised as a particular concern by Dr. Onstott and is not an appropriate test for determining the mobility of As under the conditions of pipeline operations." *(Page 21)*

Response 1: Given that the results from EPA-1627, not only evaluated arsenic mobilization due to desorption-adsorption, but the stability of the pyrite, Solution Geosciences believed it was very important to discuss the potential for acid-rock drainage (ARD) from the non-imported fill comprised of pyritic-argillite of the Lockatong Formation, as it had not been specifically addressed before, and would be the worst-case arsenic, and other contaminant, mobilization scenario. Thankfully, it is not a factor in the Lockatong Formation, but again, it had to be addressed and discussed, even if Dr. Onstott never recognized it.

Comment 2: "On page 2 in the Executive Summary, the HMM/Solution Geosciences Report states the following: 'However, it has never been definitively demonstrated if the As in water from these affected potable wells is the result of

[36] Shick, 2008.

> near surface geochemical or deeper processes in the water-bearing zones that feed them. There are much data to support the latter.'
>
> This statement is in direct conflict the results of the USGS publication by Gross and Low (Gross and Low, 2013) on the occurrences of elevated As concentrations in a survey of hundreds of wells within the Newark Basin of Pennsylvania are correlated with anthropogenically contaminated sites." *(Page 21)*

Response 2: See response 9a above for a detailed explanation about what page 2 of the ASR Executive Summary was referring to. One of the concluding statements in Gross and Low (2016) was that:

> The occurrence of arsenic in groundwater of Pennsylvania is largely the result of mobilization of arsenic from natural sources in the aquifer and the geochemical conditions of groundwater.

Further, work by Senior and Sloto (2006) mentioned in that publication, demonstrated with data from 58 wells that:

> Arsenic correlated most strongly and positively with pH, boron, and molybdenum; correlated positively with selenium, uranium, nickel, lithium, fluoride, and strontium; and correlated negatively with total organic carbon, copper, and dissolved oxygen.

They concluded that arsenic concentrations may be controlled partly by pH affecting adsorption of arsenate and that the correlation of arsenic with the presence of many trace elements indicates similar geochemical controls and (or) distribution in aquifer materials in the Newark Basin. Therefore, the occurrence of elevated arsenic appears to be mostly due to natural processes.

A statistical relationship was noted by Gross and Low (2016) that arsenic concentrations > 4.0 µg/l were more prevalent closer to urban areas (which generally have a high density of contaminant sites), suggesting that anthropogenic contamination sites could have released chemicals containing arsenic or chemicals containing constituents that affect redox environment or pH and, hence, promote arsenic mobilization. No one is arguing that that could not locally be an influential variable. However, that has nothing to do with the trench environment, unless, anthropogenic inputs, particularly of organic carbon rich pollutants, would directly enter it. Outside of an accidental spill, which would have that same effect anywhere it occurred in these naturally-enriched geological formations, this is not an influential variable.

> Comment 3: "Section 5.3. p. 28. Princeton University Campus building stone - The investigator performed an 'experiment' on the Princeton University campus,

where he observed a low degree of weathering and HFOs associated with pyrite oxidation on Cleveland Tower, a building made of rock from the Lockatong Formation. He claimed that this is evidence of 'an intrinsic resistance to readily weather and decompose'.

This 'experiment' fails to take into consideration the high levels of water saturation, anaerobic conditions, elevated temperature that surround the buried gas pipeline buried in pulverized Lockatong Formation. Not only is such an 'experiment' irrelevant to the weathering of pulverized material, in a peer reviewed scientific journal this argument would be immediately rejected." *(Page 22)*

Response 3: The fact that the LF building stone was competent and only slightly weathered on surfaces was presented as supportive evidence, not defining evidence. It was an observable example of how that material chemically and mechanically weathers when exposed to wet-dry, freeze-thaw, O_2-rich acidic atmospheric conditions over a century-long time frame of exposure, not necessarily, how it would weather when buried in the unsaturated zone. Princeton University was the only well documented location where buildings used Lockatong Formation building stone and it was important to observe them and report their state of weathering. Solution Geosciences looked for other documented examples of similar stone constructed buildings but could not readily find any.

Comment 4: "A calculation of rock fragment sizes that would be produced during blasting in this rock (blasting will be applied where needed in the field during the trench excavation) using the updated Kuz–Ram model as per Cunningham (2005) indicated that the particle sizes will be even coarser (10 mm to 300 mm) and that at least 80% of the fragments will be greater than 25 mm with an average fragment size of 61 mm'." [ASR, Serfes 2016]

"It provides no PSD, the investigator made no serious effort to measure a PSD of ditch spoil and the investigator made no effort to measure the surface area of the sieved chunks that he utilized in his experiment. All of these factors would not be acceptable in a peer-reviewed scientific publication." *(Page 22)*

Response 4: This example was not used for the basis of the major conclusions, it was only used for comparison purposes. As previously mentioned, the PSD used in EPA-1627 was much finer.

Comment 5: Conceptual Assumptions in the Trench Environment:

"This assumption is invalid because the water table depth for much of the As-rich region traversed by the pipeline in Hunterdon County and in water crossings elsewhere is less than 50 cm (Figure 9)." *(Page 22)*

Response 5: Not correct. Please refer to Part 1.2: Depth to Groundwater in the LF, above for detail.

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Attachment B

Solution Geosciences LLC
Michael Serfes, P.G., Ph.D.

October 27, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

RE: Docket CP15-558-000, PennEast Pipeline Company LLC
Response to Comment on Potential Boron Contamination of Lambertville Drinking Water by T.C. Onstott (Dr. Onstott)

Dear Ms. Bose,

This letter is in response to a document filed by Dr. Onstott on Potential Boron Contamination of Lambertville Drinking Water.[1] I have summarized my response to the document below, in addition to providing detailed explanations and responses to the comments made by the original author.

Review Summary:

The key concern proposed by the author is that boron, which occurs naturally in the mineral component of the diabase rock, upon which the Swan Creek Reservoir was constructed on, will be mobilized by excavation activities associated with the PennEast pipeline. Therefore, as Lambertville, New Jersey receives most of its drinking water from the reservoir, the presumed increase in boron caused by construction will degrade their drinking water quality.

This scenario is highly unlikely for one main reason: the proposed pipeline is west of the Swan Creek Reservoir, and is at a lower elevation and hydraulically down gradient from it. Therefore, any water associated with the excavation trench will not flow overland, or in the subsurface, up gradient or upstream to it. Also, as described below, it is considered highly unlikely that the shallow excavation will induce any significant mobilization of boron (for which no drinking water standard exists, only health advisories or guidelines). Therefore, the potential concern for boron contamination is unsupported.

[1] Accession Number 20160829-5085, Docket CP15-558-000 (Aug. 29, 2016)

I respectfully provide the following explanations and responses to the original author's comments below. Key issues from the authors' original comments are provided numerically below and addressed similarly as responses.

Issue (1): "A study by the U.S. Geological Survey has found elevated boron concentrations in well water near the New Hope, Pennsylvania area immediately across the river from Lambertville, New Jersey (Senior and Sloto, 2006). The boron concentrations in 10 wells sampled between October of 2004 to April of 2005 ranged from 6 to 3,170 ppb. The highest concentrations, 2,030 to 3,170 ppb, were found in wells located in the diabase of Jericho Mountain. Of the 10 wells analyzed 4 exceeded the lifetime Health Advisory (HA) of 600 ppb recommended by the U.S. EPA and this high frequency of exceedance is greater than that observed for the Newark Basin at large."

Response (1): No exception is taken to the factual data and findings by Senior and Sloto (2006).

The USEPA has established a Lifetime Health Advisory Level recommendation for boron of 2.0 mg/L per day for children and 5.0 mg/L per day for adults; however, there is no drinking water standard.

From USEPA (2008), the state drinking water guidelines for boron are as follows: California, 1000 µg/L; Wisconsin, 900 µg/L; Florida, Maine, and New Hampshire, 630 µg/L; and Minnesota, 600 µg/L. Note that New Jersey has not established a state drinking water standard.

The State of California; State Water Resources Control Board Division of Water Quality GAMA Program, has recently updated their Groundwater Information sheet on boron (B) as of May, 2016. A table excerpt from this sheet is provided as Figure 1.[2]

REGULATORY AND WATER QUALITY LEVELS[1]		
Type	**Agency**	**Concentration**
Federal Health Advisory for non-cancer health effect	US EPA[2] US EPA[2]	NA[5] 5,000 µg/L
State Notification Level (NL)[3]	SWRCB[4]	1,000 µg/L
Detection Limit for Purposes of Reporting (DLR)	SWRCB[4]	100 µg/L

[1]These levels generally relate to drinking water, other water quality levels may exist. For further information, see *A Compilation of Water Quality Goals,* 17th Edition (Marshack, 2016).
[2] US EPA – United States Environmental Protection Agency
[3] Notification levels are non-regulatory health-based advisory levels established by CDPH for chemicals for which maximum contaminant levels have not been established.
[4]SWRCB- The California Department of Public Health Drinking (CDPH) Water Program was transferred to the State Water Resources Control Board Division of Drinking Water in 2014.
[5]US EPA did not establish a drinking water standard for boron.

Figure 1 - EPA health advisory for boron in drinking water, top row, with CA notification and detection limits.

[2] Source: http://www.waterboards.ca.gov/gama/docs/coc_boron.pdf.

Issue (2): “The source of the boron in the groundwater is likely due to the mineral datolite, which is found in the metamorphosed sediment, or hornfels, adjacent to the intrusive diabase (Van Houten, 1971). Boron-stable isotopic analyses have confirmed that the boron in the groundwater near New Hope originated from the hornfels or veins in the diabase. The concentration of boron in datolite is 4,000 times that of mafic magma and likely originated from the clay-rich sediments deposited in the Triassic lake of the Newark Group (Senior and Sloto, 2006). Even though boron concentrations are correlated with arsenic concentrations in the sediments of the Newark Group, boron has a single valence state and thus is not influenced by the same redox processes that affect the mobilization of arsenic. The principal aqueous species of boron is boric acid, and is typically mobile.”

Response (2): It is understood that the mineral datolite which is referenced does exist in the mentioned formation. However, I further note that the mineralogy of the trap rock (basalt and diabase) quarries in New Jersey was investigated by Mason (1940). He noted at least three minerals containing boron in quarries in the Lambertville, NJ area, one which includes datolite:

- Datolite, $Ca(HBSiO_5)$, which is common and widely distributed in trap rocks. It is not readily soluble in water, but slightly soluble in hydrochloric acid (HCl), leaving a mineral gel residue;
- Axinite, $(Ca,Fe,Mg,Mn)_3Al_2BSi_4O_{15}(OH)$, which has been recorded in some quantity in the quarry at Lambertville. It is not readily soluble in water or HCl; and,
- Tourmaline, $(Ca,K,Na,)(Al,Fe,Li,Mg,Mn)_3(Al,Cr,Fe,V)_6(BO_3)_3(Si,Al,B)_6O_{18}(OH,F)_4$, which is not readily soluble in water or HCl.

Therefore, I concur that given the common and widely distributed nature of datolite, and its slight solubility in HCl, it is the probable source of the dissolved boron found in local groundwater, as per Senior and Sloto (2006).

Issue (3): “The proposed PennEast ROW crosses the hornfels facies of the Passaic shale and the diabase of Bald Pate Mountain in the immediate vicinity of the drinking water supply for Lambertville. Drilling and blasting will be required because of the thin soil cover resulting in an increase of fracture porosity and ground water flow along the back-filled trench and will likely increase the dissolution of boron-bearing mineral phases in both rock types.”

Response (3): Logical inferences as to the source of boron in groundwater in and around the diabase have been made by others and there is no reason to believe they are incorrect. The degree to which a shallow excavation will induce the element boron to become mobile is not known; however, it is doubtful that, given the very low solubility of datolite in water and slight solubility in HCl, it will likely be insignificant, if it occurs at all. Further, no drinking water standard exists per EPA and NJDEP which could be used to provide an actionable comparison.

It is recognized that the Swan Creek Reservoir is a major, local, surface-water resource for the City of Lambertville, NJ. The reservoir is along Route 518 in West Amwell, NJ and is presently operated by Suez Water (formerly known as United Water).

The proposed pipeline transect is downslope and down gradient from the Swan Creek Reservoir dam. Therefore, there is no direct hydraulic connection from the pipeline to reservoir. It would be impossible for groundwater and surface water at the pipeline trench to naturally flow into the Swan Creek Reservoir.

Issue (4): "The application filed by PennEast with FERC fails to mention the possible effects of boron contamination. FERC also fails to mention this in their DEIS statement despite the fact that the PennEast document cites the Senior and Sloto (2006) study at the top of page 6-39 of Resource Report 6. Field studies need to be undertaken to determine whether the proximity of the proposed pipeline to the water supply of Lambertville risks exposure of the citizens of Lambertville to elevated boron concentrations exceeding the U.S. EPA. These studies need to begin with measurements of the boron concentrations in private wells in the immediate vicinity of the proposed ROW where it crosses outside of Lambertville."

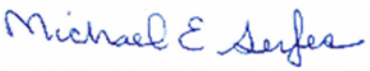
Response (4): It is perfectly reasonable for FERC to not have mentioned the possible effects of boron contamination since no drinking water standard exists to provide an actionable comparison. Furthermore, as mentioned earlier, the area of possible concern is up gradient of the proposed pipeline crossing and is therefore not a practical issue.

Issue (5): "We also point out that spring sources with boron concentrations up to 741 ppb have been identified in the Lockatong headwaters by NJ Water Supply Authority. Since PennEast has proposed horizontal directional drilling (HDD) in the Lockatong Creek, further studies of the boron load on the Lockatong Creek and potential sources is warranted before approving of the HDD plan."

Response (5): It is not anticipated that HDD activities will cause any significant increase in boron due to limited bore diameter and cross sectional area for water-rock contact. By nature of HDD, the material which is bored will be suspended in a water-bentonite clay mixture which is flushed and disposed properly off-site as HDD activities complete. Furthermore, the annulus between the final installed pipe and drilled borehole is filled with water-bentonite clay mixture; therefore, any remaining exposed minerals will be encapsulated within the filter cake material.

It is repeated that there are no SWQS or GWQSs for boron indicating it is not an element of reasonable concern to surface water biota or contaminant groundwater quality. Current SWQS and GWQS can be found at N.J.A.C. 7:9B and 7:9C, respectively.

Sincerely,



Michael E. Serfes, P.G., Ph.D.

Solution Geosciences, LLC
Bethlehem, PA 18018

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Attachment C

Solution Geosciences LLC
Michael Serfes, P.G., Ph.D.

October 27, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

RE: Docket CP15-558-000, PennEast Pipeline Company LLC
Response to Additional Arsenic Exposure to Groundwater from PennEast Pipeline by Lauren Santi and Professor T.C. Onstott

Dear Ms. Bose,

This letter is in response to a document filed by Lauren Santi & T.C. Onstott titled, "Additional Arsenic Exposure to Groundwater from PennEast Pipeline."[1] I have summarized my response to the document below, in addition to providing detailed explanations and responses to the comments made by the original author.

Review Summary:

In their paper, the authors allege that a continuous, diffusive leak of methane (CH_4) will occur along the full length of the pipeline during its operation. This, as they allege, would produce a key underlying biogeochemical condition where CH_4 leakage from the pipeline will result in the microbial aided reductive dissolution of hematite (Fe_2O_3) in the Passaic Formation, thereby releasing arsenic into groundwater. As a result of this leakage and reductive dissolution reaction, two possible outcome scenarios are predicted to follow:

(1) the initially released arsenic will be subsequently reabsorbed; and,

(2) that a time-delayed, high pH groundwater flow front due to initial chemical reduction (which requires H+ consumption) up gradient will subsequently slowly migrate downgradient inducing additional arsenic desorption.

[1] Accession No. 20160906-5248, Docket CP15-558-000 (Sept. 6, 2016).

Field evidence, consisting of data from the New Jersey Private Well Testing Act, specifically data adjacent to the Algonquin Pipeline, is provided in attempted support of a pipeline's operation as an additional source causing arsenic mobilization.

These scenarios are based on misconceptions, miscalculations, and misinterpretations of the referenced materials, as well as an assumption that continuous CH_4 leaks will occur. There is also a clear misunderstanding of the physical and chemical behavior of liquid petroleum hydrocarbon versus that of gaseous CH_4. The authors' speculative scenarios are a mix of well-known geochemical principals, with select (but hardly comparable) snippets of published information. Below, we respectfully provide the following explanations and responses to the original authors' comments which demonstrate the unsupportable nature of "additional arsenic exposure to groundwater" ultimately caused by alleged methane leakage.

Key issues from the authors' original comments are provided numerically below, followed by my responses.

Issue (1): "The problem of hydrocarbon leakages from pipelines stimulating microbial mobilization of As from the mineral matrix into the groundwater is so significant that the American Petroleum Institute (API) published a manual on the topic (API, 2011)."

Response (1): The referenced API Groundwater Arsenic Manual, "Attenuation of Naturally-Occurring Arsenic at Petroleum Impacted Sites", is directed at liquid petroleum hydrocarbon (ex: crude, diesel and gasoline) releases— not natural gas. If natural gas had been considered an issue by the API, it would have been discussed, yet it was not mentioned once.[2]

Issue (2): "One of the best-characterized sites where these processes occur is an aquifer located near Bemidji, Minnesota, that was contaminated by ~2 million liters of crude oil when a pipeline ruptured in 1979 (Cozzarelli and others, 2016)."

Response (2): This is a (liquid) crude oil release, not (gaseous) CH_4 which the PennEast pipeline will transport.

Issue (3): "Such a leak rate would produce the equivalent of a Bemidji-size organic source in approximately one week."

Response (3): The authors assume that 0.1% of the transported CH_4 will leak from the proposed 120-mile PennEast Pipeline and try to compare the effect of the carbon released to that of the very localized (point-source) Bemidji oil spill. The two are not comparable. From a physical perspective, CH_4 is a lighter-than-air gas and, if there was a leak, most would escape upward into the atmosphere-- not recharge the groundwater system. Crude oil is a liquid and would get flushed downward.

[2] http://www.api.org/oil-and-natural-gas/environment/clean-water/ground-water/managing-arsenic-ingw.

Notwithstanding, to evaluate their alleged comparison, the following calculations are presented:

- Carbon in a US gallon of diesel/fuel oil (3.785 liters) = 2.77 kg carbon

- The amount of carbon associated with the 2,000,000-liter Bemidji crude oil spill was:

$$\frac{2,000,000 liters}{3.785 liters / gallon} x 2.77 kg carbon / gal$$ = 1,500,000 kg carbon (rounded)

The amount of carbon released along a pipeline, moving 1 billion standard cubic feet (SCF) of gas per day with a hypothetical 0.1% leak, would be a loss of 1 million SCF a day or 7 million SCF in a week.

- A cubic meter of methane (CH_4) contains 0.49 kg carbon

- There are approximately 35.3147 SCF in a cubic meter, therefore (7,000,000 SCF/35.3147 SCF) x 0.49 kg carbon = <u>97,000 kg carbon</u> (rounded, per week of continuous leakage)

- Number of weeks of continuous CH_4 leakage along the 120-mile pipeline would it take to equal the Bemidji carbon release:

  1,500,000 kg carbon / 97,000 kg carbon = <u>15 weeks</u>

Conclusion: <u>Even if 0.1% of the gas were to leak out along the full, 120-mile pipeline, somehow be transported to a location in the Newark Basin, and then contained within a volume equivalent to that of the Bemidji oil spill, it would require 15 weeks to accumulate a comparable mass of carbon-- not 1 week as the original authors' state.</u>

Following this initial miscalculation and misunderstanding of gaseous CH_4 versus liquid petroleum hydrocarbon, the authors provide a two-dimensional reactive transport model to simulate the biogeochemical reactions that would occur due to this hypothetical methane leakage.

In their reactive transport model, the authors use a simulated length of 25 meters of pipeline for analyses. As the proposed PennEast pipeline is approximately 120 miles long, at 1,609 meters per mile, this equates to 193,080 m total length. The authors' 25 meters is approximately 1/7,700 of the total pipeline length and therefore, on a per week basis, it would yield 12.8 kg carbon per 25 m at the hypothetical 0.1 % CH_4 loss. Based on this, it would take 114,200 weeks or 2,200 years, if all the CH_4 hypothetically released in that 25 meters could be trapped within this one spot to equal the amount of carbon released at Bemidji.

Although there is no reason to believe a leak would occur, since CH_4 is a lighter-than-air gas, even if there was a hypothetical leak in the porous backfill trench environment as the authors' suggested, it would vent to the atmosphere, be detected, and the leak fixed. It cannot be overstated that the pipeline will be constructed, protected and maintained using modern techniques and is designed not to leak since FBE coating of the pipe coupled with CP will be employed.

Furthermore, a reference cited by the authors in an attempt to support their concern of methane leakage resulting from pipe corrosion, actually weakens their argument, in the case of the PennEast Pipeline. The authors extract information from the Norsworthy (2009) citation that corrosion can occur to natural gas pipelines that are not properly protected. However, Norsworthy (2009) also indicates the effectiveness of a FBE coating when coupled with CP, a system similar to that which will be used by the PennEast Pipeline, in maintaining the integrity of the pipeline metal. He states:

> Not all coating failures result in corrosion on the pipeline. Some coating failures have little or no effect on the corrosion rate of the pipe. FBE, as mentioned above, is one such coating. Rarely is external corrosion found on a pipeline coated with FBE if adequate cathodic protection (CP) is available. Therefore, in the presence of CP, it appears that the pipe will remain protected and blistering and coating disbondment of FBE coatings does not present an integrity threat to a pipeline.

It is very well known that bacteria can aid in the significant release of arsenic under certain hydrogeological and biogeochemical settings, such as:

> (1) Over pumping well waters to the point that organic-rich surface and near-surface waters are pulled toward the pumping well (for example, in Bangladesh the tropical Ganges River deltaic system migrates downward into more oxic aquifer sediments thereby creating more chemically-reducing conditions that destabilizes [dissolves] the arsenic-bearing iron oxyhydroxide [not hematite] aquifer-matrix grain coatings, thereby releasing arsenic);
>
> (2) The downward migration of organic-rich landfill leachate into more oxic underlying groundwater systems. This also may lead to microbial aided chemical reduction and destabilization of arsenic-bearing iron oxyhydroxides; or,
>
> (3) Liquid petroleum hydrocarbon spills that migrate downward, thereby contaminating the unsaturated zone and underlying groundwater system creating a microbial-aided chemically-reducing environment and similarly releasing arsenic as per (1) and (2) above.

However, none of these extreme biogeochemical-altering scenarios exist along the pipeline trench transect specific to PennEast Pipeline.

In summary, the authors' suggestion that spatially-significant CH_4 leakage and stray-electron release from cathodic protection will occur, and that it will alter the pipeline trench geochemical system, similar to examples 1 and 3 above, is clearly unsupported.

Authors' misunderstanding of the intrinsic stability of hematite in the Passaic Formation:

Issue (4): Another statement made in authors' paper is that the dissolution of hematite (Fe_2O_3) in the Passaic Formation can be readily aided by microbes. This is absolutely not true, and some of the same references cited by the authors are used to show that.

Response (4): Crystalline hematite, formed in an oxic environment, is a highly stable mineral when subsequently exposed to a large range of environments: oxygen-rich, anoxic (as shown in Figure 1 below), abiotic and biotic, and conditions at the circum-neutral pHs that exist in the Passaic Formation.[3] Although it is well known that groundwater in the Passaic Formation is mostly oxic to sub-oxic, studies have clearly defined the difficulties that microorganisms have in utilizing iron reduction in hematite for metabolism in these geochemical settings.[4] Ferric iron in hematite is very stable at circum-neutral pHs, and unavailable to microbial reductive utilization in oxic environments.[5] The insoluble nature of Fe^{+3} oxide minerals at pH values > 4 creates a metabolic dilemma (difficulty using the reaction for metabolism) for microorganisms utilizing Fe^{+3} oxides as a respiratory terminal electron acceptor.[6]

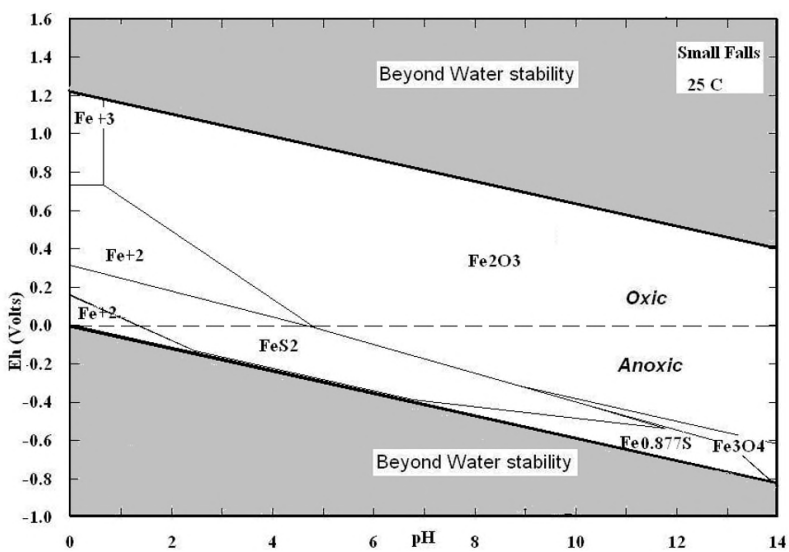


Figure 1. Stability of hematite (Fe_2O_3) in Oxic and Anoxic water as a function of pH and Eh used to demonstrate stability of existing hematite to intermittent anoxic conditions. (Wilde and Quinby-Hunt, 2010.)

[3] Wilde and Quinby-Hunt, 2010; Zachara and others, 2002.
[4] Schlesinger, 2005; Weber and others, 2006; Liu and others 2007.
[5] Schlesinger, 2005 at page 132.
[6] Weber and others, 2006.

Furthermore, it is well known that amorphous ferric oxyhydroxides (such as HFO) are readily reductively dissolved by microbes under certain biogeochemical conditions. However, hematite, which contains much less exposed surface area, is very resistant to this process. It has also been observed that, because of the negative surface charge on hematite at alkaline pHs, the adsorption of cations such as Fe^{+2}, which might have been initially solubilized by microbial reduction, actually shields the surface of hematite from further microbial interaction with Fe^{+3} thereby halting further dissolution.[7] Therefore, hematite is very chemically stable in the Passaic Formation and it is highly unlikely to be reductively dissolved, particularly where pH is circum-neutral or higher.

One of the assumptions used in the reactive transport model by the authors is that arsenic will be more readily desorbed at a reaction-induced high pH created by H^+ consumption during the reductive dissolution reaction of hematite. It has already been discussed why that will not occur. The groundwater in the Passaic Formation is circum-neutral (pH: 6.5 to 8.5) and the potable well water data presented in Serfes (2005) clearly shows that at a pH of approx. 8.0, arsenic is most mobile. At a pH higher than approx.8.0, conditions for arsenic mobilization will not be optimal, and therefore the rate of arsenic mobilization may even decrease, if the speculative reaction increases the pH further.

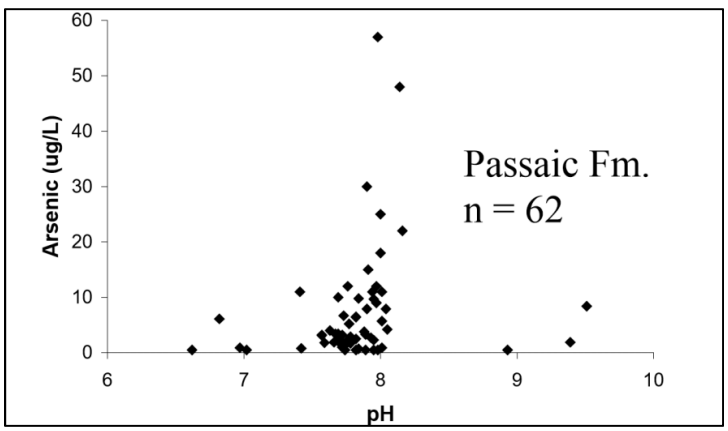
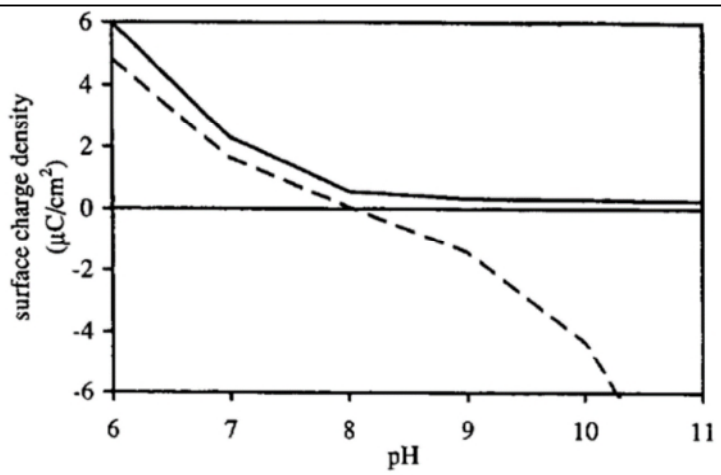


Figure 2. Potable well water samples showing As µg/l versus pH (Serfes, 2005)

At a pH above approx. 8.0, the surface of hematite, and other iron-oxyhydroxides, become so negatively hydroxylated (that is, surfaces become covered with bonded OH^- ions and therefore have a strong negative surface charge) that cations, such as calcium (Ca^{+2}) and magnesium (Mg^{+2}), are readily attracted and adsorb onto the surface thereby shielding (trapping) arsenate and other oxyanions from reductive desorption and actually enhancing their adsorption (Figure 3). This phenomenon was noted by Wilkie and Herring, (1996), when conducting experimental work using HFO as an arsenic absorbent, and similarly by Liu and others, (2007), when discussing how the further reduction of structural Fe^{+3} is halted, via shielding by Fe^{+2} at a high pH, when it adsorbs to the surface. Therefore, hematite in the Passaic Formation is

[7] Liu and others, 2007.

biogeochemically stable, will not reductively dissolve as per one of the initial conditions required to support the speculative biogeochemical scenario presented by the authors, and will not desorb more arsenic when the pH is greater than approx. 8.0.



Calculated surface charge density of HFO as affected by calcium. Model predictions for $[Fe]_T$, 50 μM in 0.01 M $NaNO_3$ with (– – –) no calcium and (—) 3.0 mM calcium.

Figure 3. Surface charge density, (+) versus (-) of HFO, in the presence and absence of Ca^{+2}. Note that the surface charge is (+) at pH > 8.0 due to the presence of dissolved Ca^{+2} adsorbing to the HFO surface, thereby adsorbing the arsenate anion (-). Dissolved Ca^{2+} is a major ion in the Passaic Aquifer (Wilkie and Herring, 1996 [Figure 10], Serfes, 2005).

<u>Misinterpretation and Use of Arsenic Potable-Well Water Data near The Algonquin Pipeline:</u>

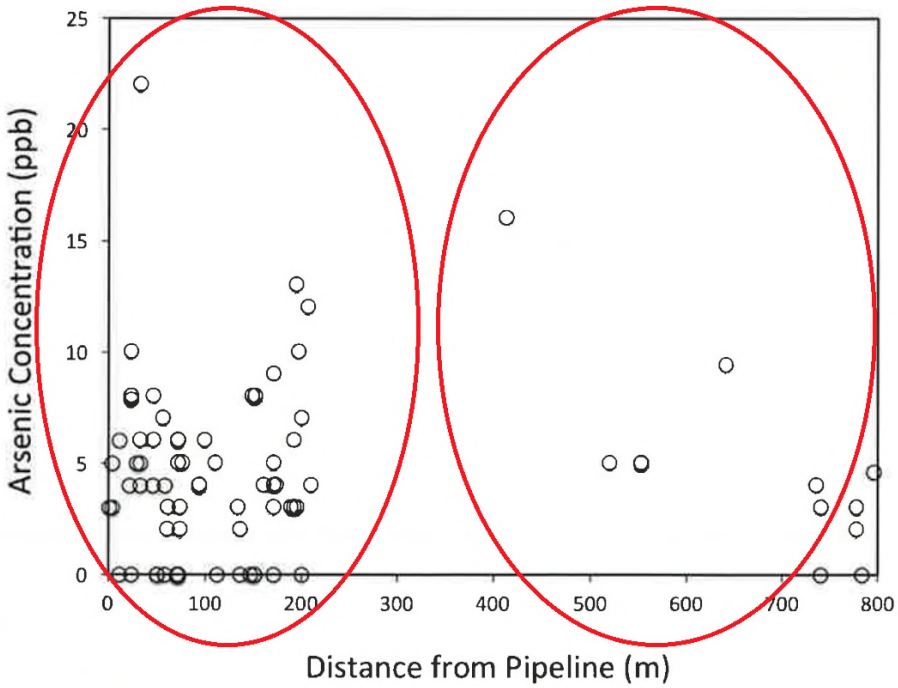
Issue (5): As part of their paper, the authors provided speculation that the existing Algonquin pipeline, which has been in service for greater than 50 years, has influenced arsenic concentrations in groundwater based on data available and obtained from the New Jersey Private Well Testing Act.

Response (5): During my time at New Jersey Department of Environmental Protection/NJ Geological Survey (NJDEP/NJGS), I was directly involved in providing input and attending meetings during the inception of the New Jersey Private Well Testing Act. One key covenant of the Act, which is enforced by New Jersey Administrative Code,[8] was to maintain confidentiality of the data and avoid plotting owners, addresses, or locations to identify specific areas of concern.

Notwithstanding, the authors provided a graphic within their paper which was intended to clearly demonstrate that the existing Algonquin natural gas pipeline influences the

[8] N.J.A.C. 7:9E-5.1.

concentration of arsenic, as a function of distance from the pipeline. The graphic (which has been copied and pasted below) depicted a high density of potable wells between 0 and 200 meters, and very few between 200 and 750 meters. The data set does not extend beyond 800 meters.



If the argument was to be made that the Algonquin pipeline influenced arsenic concentrations, one would expect that the concentration of arsenic would noticeably decrease with increasing distance away from the pipeline. The few data between 200 and 750 meters do not look convincingly different than that obtained between 0 and 200 meters. Furthermore, the distribution of data is not expectedly different than what one would expect within this geologic setting. There are many areas in the Newark Basin with clusters of wells with elevated arsenic concentrations—the majority of which are not near any natural gas pipeline for the widely-recognized fact that natural concentrations of arsenic in groundwater are elevated in various locations in the Lockatong and Passaic Formations.

Therefore, this graphical depiction of arsenic concentration data, provided by the authors to demonstrate an impact from the Algonquin pipeline, instead demonstrate that their assumption that the old pipeline has caused an impact is not supported.

Sincerely,

Michael E. Serfes

Michael E. Serfes, P.G., Ph.D.

Solution Geosciences, LLC

Bethlehem, PA 18018

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Attachment D

Solution Geosciences LLC
Michael Serfes, P.G., Ph.D.

October 27, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

RE: Docket CP15-558-000, PennEast Pipeline Company LLC
Response to Abundant Fe, As, and S Bacteria along the Proposed ROW and How They Will Mobilize Arsenic and Corrode the PennEast Pipeline by Lauren Santi & T.C. Onstott [Dr. Onstott]

Dear Ms. Bose,

This letter is in response to a document filed by Lauren Santi & T.C. Onstott titled, "Abundant Fe, As, and S Bacteria along the Proposed ROW and How They Will Mobilize Arsenic and Corrode the PennEast Pipeline."[1] I have summarized my response to the document below, in addition to providing detailed explanations and responses to the comments made by the original author.

Review Summary:

The authors allege that a key underlying biogeochemical condition, described as an "unusually high" proportion of bacteria involved in the reduction of Fe(III) and sulfate, and in the cycling of arsenic in soils within the pipeline ROW, would create two alleged scenarios related to arsenic mobilization and corrosion of the proposed pipeline. As a result of this condition, alleged scenario (1) indicates a supposed "certainty" that arsenic will be mobilized, since the metabolic mechanism exists in those microbial communities; and scenario (2) that beyond just mobilizing arsenic, the "unusually high" proportion of sulfate-reducing bacteria that are the principal microbial agents involved in the corrosion of steel, results in an extreme corrosion risk, if the pipeline coating is compromised. Field evidence of the microbial biodiversity in the proposed pipeline ROW is based on 10 soil samples that were collected, analyzed and the data presented by the authors in the first table of their white paper (see original Accession 20160906-5278 and other subsequent revisions for identically titled submissions).

[1] Accession no. 20160906-5278, docket no CP15-558-000 (Sept. 6, 2016).

Both scenarios are based on misconceptions and misunderstandings of the predictive power of their soil microbial assay data. First, the qualifier, “unusually high” used to describe the proportion of bacteria, is not based on a comparison against any other data sets and is therefore not statistically validated in any way. The authors present data, which includes %Fe, S, As bacteria (that is, percent of the total bacteria species present) from samples which they’ve collected from each of the Stockton, Lockatong, and Passaic Formations. This is important because the percent population of the bacteria are similar for all three formations; however, the Stockton aquifer does not have a significant arsenic issue while the other two do. This similarity of percent bacteria populations between the Stockton and the other two Formations is contrary to their arguments and does not support the contention that the proportion of key bacteria is a reliable indicator of the arsenic mobilization potential.

Second, the presence of this specific bacteria demographic does not necessarily mean that arsenic will be mobilized into groundwater, or that the pipeline will be corroded, as there are also secondary safeguards which are not discussed. Fusion-bonded epoxy coating of the pipeline coupled with cathodic protection is declared by Norsworthy (2009) to be extremely effective in protecting pipelines from corrosion. These secondary safeguards are not discussed in this original assertion of corrosion potential due to the specific bacteria demographic.

Therefore, the title subject heading is totally unsupported by the data and assumptions presented. I respectfully provide the following explanations and responses to the original authors’ comments below. Key issues from the authors’ original comments are provided numerically below and addressed similarly as responses. Section headings are noted in quotes to mirror the section titles used in the original authors’ paper.

“Summary”

Issue (1): “Analyses of the microbial communities present along the proposed ROW of the PennEast pipeline have revealed an unusually high proportion of bacteria involved in the reduction of Fe(III), sulfate and in the cycling of As.”

Response (1): It is not surprising that the predominant bacteria types would be those that utilize the geochemistry that exist in the materials in question and proliferate accordingly. However, unless a similar and statistically-significant set of microbial data also exist from outside the right-of-way (ROW) for comparison, making a statement that there is an unusually high proportion of bacteria in it, cannot be verified. It is likely that the proportions of bacteria the authors found in the ROW are similar to what would be found throughout the Newark Basin. Furthermore, as summarized above, the Stockton aquifer does not have a significant arsenic issue, while the other two do. This similarity between the Stockton and the other two Formations is contrary to their arguments and does not support the assumption that the proportion of bacteria is a key indicator of arsenic mobilization potential.

Issue (2): "Unfortunately, the cathodic shield that will be required raises the pH of the groundwater surrounding the pipeline, desorbing As from the iron oxyhydroxide minerals and releasing it into the groundwater."

Response (2): The commenters speculation that cathodic protection (CP) is going to cause chemically reducing and high pH conditions in the trench along the entire pipeline length is totally and unequivocally wrong and in direct conflict with Norsworthy's (2009) paper that they reference as part of their supporting literature. This subject is discussed in more detail our responses within the Results and Discussion section below.

"Introduction"

Issue (3): "As in the rock occurs predominantly as fine-grained arsenopyrite, FeAsS, or arsenopyrite inclusions within pyrite, and or as As anion species adsorbed to ferric oxides and hydroxides (Serfes et al., 2010)."

Response (3): Actually the predominant arsenic bearing sulfide mineral in the Newark Basin, particularly the LF, is arseniferous (arsenic-rich) pyrite, not arsenopyrite. In the Passaic Formation most of the arsenic is associated with hematite.[2]

Issue (4): "But at pH values greater than the zero point of charge (ZPC), the surface charge becomes negative and arsenate is no longer strongly attracted to the HFO."

Response (4): This particular topic was covered in my response to "Additional Arsenic Exposure to Groundwater from PennEast Pipeline" by Lauren Santi and Dr. Onstott.[3] However, in summary, researchers have found that, where a pH is greater than approx. 8.0, the surface of hematite and other iron-oxyhydroxides become very hydroxylated (where exposed surfaces are surrounded by OH^- ions). Therefore, they have such a strong negative surface charge that major cations such as calcium and magnesium are readily attracted and adsorb onto the surface. This phenomenon thereby shields (traps) arsenate and other oxyanions from desorbing and also enhances their adsorption to the surface of oxyhydroxides, including arsenate. This phenomenon was noted by Wilkie and Herring (1996), when conducting experimental work using HFO as an arsenic absorbent and similarly by Liu and others, (2007), when discussing how the further reduction of structural Fe^{+3} is halted via shielding by adsorbed Fe^{+2}, when it adsorbs to the surface. Therefore, published data indicate that at a pH greater than the ZPC of iron oxyhydroxides in a solution containing cations such as calcium (which Newark Basin groundwater does) arsenic adsorption is likely to be enhanced.

[2] Serfes and others, 2010.
[3] Accession No. 20160906-5248, Docket CP15-558-000 (Sept. 6, 2016).

Issue (5): "Additionally, sulfate-reducing bacteria can cause the release of As from the sulfide mineral arsenopyrite, FeAsS, under anoxic conditions (Zhu et al., 2008)."

Response (5): As previously mentioned, the predominant arsenic sulfide mineral in the Newark Basin, particularly in the LF, is arseniferous pyrite, not arsenopyrite. In the Passaic Formation, most of the arsenic is associated with hematite. The authors are correct that sulfide-arsenide substitution, as deduced by Zhu and others (2008), could be a significant arsenic mobilization mechanism in the LF, after microbial-aided sulfate reduction has occurred along the groundwater flow path deeper within the aquifer. The significance of this sub-surface substitution mechanism was supported by well-water data showing that arsenic concentrations in shallow wells are generally lower than in deeper ones.[4] The shallow oxic-suboxic portion of the unsaturated (where the pipeline trench will mostly be) and saturated aquifer is where pyrite oxidizes, HFO forms, and sulfate is mobilized and transported downward, and not where most of the arsenic is mobilized.

<u>"Results and Discussion"</u>

Issue (6): "At the phylum level, results were dominated by Proteobacteria (36-51%), especially Deltaproteobacteria (16-29%) and Betaproteobacteria (9-12%), as well as Bacteroidetes (3-22%). Samples from more arid soil environments (3-6) tended to have a lower percentage abundance of Bacteroidetes (Figure 1)."

Response (6): The authors' study is interesting, but does not provide any evidence that groundwater will be impacted by arsenic due to the construction, operation and maintenance of the proposed PennEast Pipeline in Hunterdon and Mercer Counties regardless of the inherent microbe types. For example, it is pointed out in Serfes (2005) that, unlike the Lockatong and Passaic Formations, there is no significant occurrence of arsenic in water from wells open in the Stockton Formation. However, in their Table 1 (reproduced below), the soils from all formations overlap in arsenic concentration and the percent of bacterial genera known to mobilize arsenic. Therefore, these variables in soil do not successfully predict arsenic mobilization behavior in the three Newark Basin formation aquifers.

Table 1: Bedrock, As-abundance, and Percentage of bacterial genera known to mobilize As

	1	2	3	4	5	6	7	8	9	10
Underlying Formation	S	S	S	S	L	L	P	P	P	P
As (ppm)	3.30	3.30	0.70	0.70	4.20	4.20	1.80	1.80	2.50	2.50
%Fe, S, As bacteria	25.02	24.85	23.95	27.17	18.14	18.10	25.55	24.10	20.19	19.24

Key: S = Stockton, L = Lockatong, P = Passaic

[4] Serfes, 2016.

Issue (7): "Geobacter is the quintessential Fe(III)-reducing bacterium (Lovley,1991) that is widespread in aquifers in mainly continental settings and is capable of reductively dissolving all Fe(III) mineral phases including hematite."

Response (7): As already discussed in my response to "Additional Arsenic Exposure to Groundwater from PennEast Pipeline" by Lauren Santi and Dr. Onstott,[5] crystalline hematite formed in oxic environments is a highly stable mineral in a wide range of environments. In the Passaic Formation, these include: oxygen-rich, anoxic, abiotic and biotic environments at a circum-neutral pH.[6] It is well known that groundwater in the Passaic Formation is mostly oxic to sub-oxic with a circum-neutral pH.

Studies have clearly defined the difficulties that microorganisms have in utilizing iron reduction in hematite for metabolism in these geochemical settings.[7] Ferric iron in hematite is very stable at circum-neutral pHs, and unavailable to microbial reductive utilization in oxic environments.[8] The insoluble nature of Fe^{+3} oxide minerals at pH values > 4 creates a metabolic dilemma for microorganisms utilizing Fe^{+3} oxides as a respiratory terminal electron acceptor.[9] It is well known that amorphous ferric oxyhydroxides (such as HFO) are readily reductively dissolved by microbes, under certain biogeochemical conditions; however, hematite, which contains much less exposed surface area, is very resistant to this process. It has also been observed that because of the negative surface charge on hematite, when conditions are alkaline, the adsorption of cations such as Fe^{+2}, which might have been initially solubilized by microbial reduction, actually shields the surface of hematite from further microbial interaction, thereby halting further Fe^{+3} dissolution.[10]

In summary, hematite is very chemically stable in the Passaic Formation and it is highly unlikely to be reductively dissolved, particularly at pH levels that are circum-neutral or higher. Existing HFO could be reductively dissolved, if the biogeochemical setting is altered, such as if organic-rich liquids from landfill leachate or liquid petroleum hydrocarbons enter the system.

Issue (8): "Such a high abundance of SRB means that any failure of the epoxy coatings or the cathodic shield (Lilly et al., 2007) will expose the gas pipeline to external MIC from the outside in (see Figure 3). Unfortunately, the cathodic shield also raises the pH of the groundwater surrounding the pipeline to 9-13 (Norsworthy, 2009), and though this may somewhat reduce SRB activity, it will desorb the As from the HFO."

Response (8): The article by Norsworthy (2009) discusses the effectiveness of a FBE coating coupled with CP, similar to that which will be used in the PennEast Pipeline, in maintaining the integrity of the pipeline metal. The corrosion example the authors

[5] Accession No. 20160906-5248, Docket CP15-558-000 (Sept. 6, 2016).
[6] Wilde and Quinby-Hunt, 2010, Zachara and others, 2002.
[7] Schlesinger, 2005; Weber and others, 2006; Liu and others 2007.
[8] Schlesinger, 2005, page 132.
[9] Weber and others, 2006.
[10] Liu and others, 2007.

provided in their Figure 3 (reproduced below) is not a demonstration of a FBE coated pipe with CP, but an asphalt coated pipe.

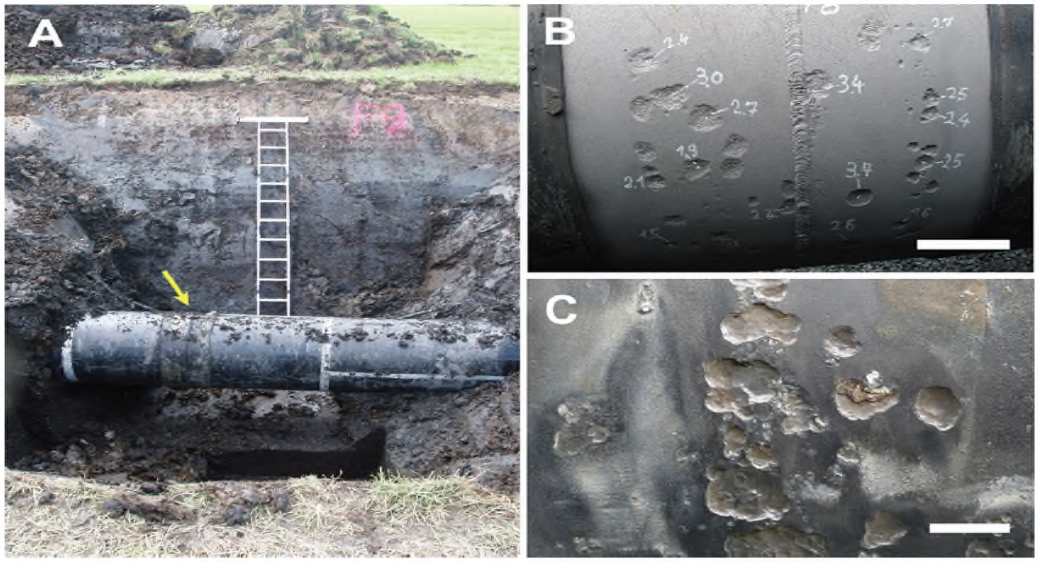


Figure 3. From Figure 1 of Enning and Garrelfs (2014). External corrosion on buried gas transmission pipeline in bog soil of Germany. (A) Trench with coated carbon steel gas pipeline in water-logged, anoxic soil. External corrosion has occurred under disbonded asphalt coating at welding sites (arrow). (B) Welding site with corrosion pits. Disbonded asphalt coating and corrosion products ($FeS/FeCO_3$) were removed. Numbers indicate pit depth in millimeters. Scale Bar=20 cm. (C) Higher magnification of corrosion pits from a different site at the same pipeline. Scale Bar=2 cm.

In fact, it is important to note that the reference to Norsworthy (2009), which the original authors cite, actually concludes the following:

> Not all coating failures result in corrosion on the pipeline. Some coating failures have little or no effect on the corrosion rate of the pipe. FBE, as mentioned above, is one such coating. Rarely is external corrosion found on a pipeline coated with FBE if adequate cathodic protection is available. Therefore, in the presence of CP, it appears that the pipe will remain protected and blistering and coating disbondment of FBE coatings does not present an integrity threat to a pipeline.[11]

In addition, Norsworthy (2009) notes that, to test the performance of CP in protecting the pipeline metal from corrosion, the pH should be measured under spotty locations which exhibit signs of blistering and coating disbondment. If the pH is highly alkaline (in a range of 9 to 13), then CP is protecting the metal from corrosion. Norsworthy (2009) further states:

> Field testing is the most effective way to determine if a coating is truly compatible with CP. A simple method is to test the pH of any liquid under disbonded coating. Since CP changes the pH of the electrolyte at the pipe

[11] Norsworthy, 2009.

surface to an alkaline pH, this is an excellent way to determine the effectiveness of the CP under disbonded coating.[12]

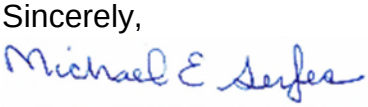
Basically, in the presence of CP, the high pH would only occur under the spotty locations at breaches in the FBE. Therefore, the high pH that is indicative of effective CP performance, does not occur along the entire pipeline, only at spots where breaches occur, if any. The commenters' speculations that CP is going to cause chemically-reducing and high-pH conditions in the trench along the entire pipeline length is totally and unequivocally wrong and in direct conflict with Norsworthy's (2009) paper that the authors reference.

"Conclusion"

Issue (9): "Analyses of the microbial communities present along the proposed ROW of the PennEast pipeline have revealed an unusually high proportion of bacteria involved in the reduction of Fe(III), sulfate and in the cycling of As. This means that As release into the groundwater from the construction and operation of the proposed PennEast pipeline is a certainty as the metabolic potential clearly exists in the microbial communities that will be surrounding the pipeline. Furthermore, the unusually high proportion of sulfate reducing bacteria, the principal microbial agents for microbial induced corrosion of steel, means that the safety of the pipeline is in jeopardy should any failure of the epoxy coating or cathodic shield occur. Unfortunately, the cathodic shield that will be required raises the pH of the groundwater surrounding the pipeline, desorbing As from the iron oxyhydroxide minerals and releasing it into the groundwater."

Response (9): The conclusions presented by the authors are not supported in any relevant scientific way, as indicated in the responses to each individual comment, as examined above. The proposed PennEast Pipeline, with FBE and CP, will maintain its intended integrity during operation. No plausible evidence has been presented that the ambient biogeochemical environment in the pipeline's natural non-imported fill materials will be altered to such a degree by pipeline operations as to cause any significant arsenic mobilization or pipe corrosion.

Sincerely,



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[12] Norsworthy, 2009.

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Attachment E

Solution Geosciences LLC
Michael Serfes, P.G., Ph.D.

October 27, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

RE: Docket CP15-558-000, PennEast Pipeline Company LLC - Response to Tullis Onstott [Dr. Onstott]/Julia L. Barringer, Princeton, NJ letter dated September 23, 2016

Dear Ms. Bose,

This letter is in response to Dr. Onstott and Dr. Julia Barringer's September 23, 2016 response[1] to a letter submitted to FERC by Dr. Michael Serfes on September 16, 2016.[2] The key issues made by the above authors are numerically listed below as issues, and addressed similarly as responses.

Issue (1): "To reiterate our original letter, we take scientific issue with the fact that PennEast's arsenic experiments did not study the fine-grained material that is typically packed around such pipelines. This is problematic because it is widely-documented that fine-grained material leaches contaminants more readily than do coarser particles."

Response (1): The particle size distribution used in the leach experiments captured all of the finer sizes that will be used to refill the trench around the pipeline. It is well known that finer particle sizes, per unit mass, yield more reactive surface area than larger sizes, and will therefore initially leach a greater mass of elements. However, after the initial ready element mass release from the freshly broken (abraded) particle surfaces, the remaining leached (weathered) rock material surfaces yield much less solute per unit mass of solvent. Basically, the easily leached fraction has been washed (desorbed) away and the remaining particle surfaces are more chemically inert.

Issue (2): "Further, we found that the experiments did not replicate the biogeochemical environment (including the elevated temperature) that will surround the pipeline, from which arsenic can be released from the surrounding geologic materials. A detailed

[1] Accession no. 20160923-5202, Docket CP15-558-000 (Sept. 23, 2016).
[2] Accession no. 20160919-5027, Docket CP15-558-000 (Sept. 19, 2016).

analysis of Dr. Serfes' experiments was submitted by Dr. Onstott to FERC, and is visible here: http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20160906-5248."

Response (2): The pyritic Lockatong samples, which would be the most susceptible to microbiological activity, were derived in the field and not inoculated. Therefore, they were naturally microbiologically active. In a response to the August 2, 2016 filing by Dr. Onstott,[3] I will demonstrate that an increased temperature, if it is significant, will increase the rate of secondary arsenic adsorptive mineral formation (HFO), the possible rate of arsenic adsorption, and the possible rate of soil organic carbon oxidative decomposition. Therefore, rather than increase arsenic mobilization, an increased temperature would arguably decrease it. The results from EPA-1627 that were conducted at room temperature demonstrated that the initial release of arsenic from the rock fragments is insignificant to overall groundwater quality.

Issue (3): "We also explained the well-documented geological facts that the action of bacteria have been shown to cause arsenic removal from geologic materials, and that this release most commonly occurs in biogeochemical environments of low-to-no oxygen. That is the same environment created by the cathodic shield that extends along the full length of the pipeline, by the leakage of methane from the pipeline, and by the microbial respiration of soil organic carbon buried with the pipeline. The microbial mobilization of arsenic and its transportation into the groundwater, streambeds, and stream water would, therefore, likely to be accelerated by the pipeline. The presence of bacteria responsible for this and the impact on the stream ecosystems and groundwater has been documented in detail in four additional reports that we submitted to FERC."

Response (3): It is very well known that bacteria can aid in the significant release of arsenic under certain hydrogeological and biogeochemical settings such as: (1) Over pumping well water in Bangladesh to the point that organic-rich surface and near-surface waters from the tropical Ganges River deltaic system migrates downward into more oxic aquifer sediments thereby creating more chemically-reducing conditions that destabilizes (dissolves) the arsenic- bearing iron oxyhydroxide aquifer-matrix grain coatings thereby releasing arsenic; (2) The downward migration of organic-rich landfill leachate into more oxic underlying groundwater systems, also leading to microbial aided chemical reduction and destabilization of arsenic- bearing iron oxyhydroxides; or (3) Liquid petroleum hydrocarbon spills that migrate downward thereby contaminating the unsaturated zone and underlying groundwater system, creating a microbial-aided chemically-reducing environment and similarly releasing arsenic, as per (1) and (2) above. However, none of these extreme biogeochemical-altering scenarios exist along the pipeline trench transect. The premise that spatially-significant methane leakage and stray-electron release from cathodic protection will occur to such a degree as to alter the pipeline trench geochemical system, similar to (1) to (3) above, is pure speculation. That premise is based on the presumption of a complete pipeline system failure, and without any of the continually corrective pipeline maintenance that will occur.

[3] Accession no. 20160802-5034, Docket Cp15-558-000 (Aug. 2, 2016).

Issue (4): "Dr. Serfes, who was not named in our original letter [Accession 20160916-5103] but who self-Identifies in his follow-up response, claims some credentials in the study of arsenic. On the other hand, Dr. Barringer is considered an expert on arsenic geochemistry. She has authored numerous publications in peer-reviewed international scientific journals, including several publications on bacterial release of arsenic from geologic materials in New Jersey. Dr. Onstott's extensive publications record includes many on bacterial interactions in geochemical settings."

Response (4): I have conducted, published and presented much significant and ground-breaking research on the sources and mobilization behavior of arsenic in the Lockatong and Passaic Formation aquifers in Hunterdon and Mercer Counties, NJ. My research on that topic has been a continuum since circa 2000, due to the then pending reduction in the federal drinking water MCL of 50 µg/l to a lower but yet to be determined MCL. As a Research Scientist 1 and project manager at the NJDEP/ NJGS at that time, I noted elevated arsenic concentrations in the Newark Basin using the available data from the NJ Ambient Groundwater Quality network that I managed. I headed a team of NJGS scientists to evaluate the arsenic concentrations, spatial distribution and sources of it in potable well water in this geologic region. The results demonstrated that the aqueous arsenic was lithogenic in origin, and related to water-rock interactions.

Evaluating the specific sources and mobilization mechanisms of arsenic in the Newark Basin became my doctoral dissertation topic at Rutgers University and the subject of many publications and presentations over the years. My most recent presentation was at the National Geological Society of America conference held in Denver, Colorado in September 2016 where I provided geochemical evidence demonstrating the greater significance of deep versus shallow aquifer mobilization of aqueous arsenic in the Lockatong and Passaic Formations. Therefore, I am a very seasoned expert on that particular subject. Dr. Onstott has even cited selected parts of my publications to support his speculative arguments.[4]

Issue (5): "We find it ironic that Dr. Serfes, with a long record of work for our State's Department of Environmental Protection, is now contesting our call for further studies to determine the environmental impact of the PennEast pipeline. Also, we still feel, however, that it is extremely important to undertake field studies of arsenic mobilization by existing gas pipelines in central New Jersey and the results of these studies be included in the EIS being developed for the PennEast pipeline by FERC."

Response (5): No one is contesting that applicable and appropriate environmental studies to evaluate realistic potential impacts due to the construction and operation of the proposed PennEast Pipeline should be undertaken. That is exactly why the EPA-1627 leach study was conducted (to address Dr. Onstott's concerns) -- to directly evaluate the arsenic leach potential of broken rock fragments of the Lockatong and Passaic Formation materials at size fractions that will be used as non-imported backfill in the pipeline trench. The additional field- and laboratory-intensive biogeochemical

[4] Accession no. 20150224-5023, Docket CP15-558-000 (Feb. 24, 2015).

studies that Dr. Onstott is requesting for groundwater are far beyond the proof-of-concept results provided by EPA-1627, and are speculative in that they require significant pipeline system failures in order to possibly be applicable. Unless there is clear supportive evidence that these biogeochemical arsenic mobilization scenarios will occur under normal pipeline operating conditions, I do not think the pipeline construction schedule should be postponed, or that PennEast should be obligated to fund those speculative studies. However, State and or Federal grant monies may be available to fund studies of the potential impacts (arsenic and otherwise) from all existing human infrastructure in the Newark Basin to groundwater in New Jersey, including various pipelines, and I sincerely look forward to any findings obtained from those studies.

Dr. Onstott also mentioned that scientists familiar with arsenic biogeochemistry from US EPA Regions II and III, NJDEP, the Delaware River Basin Commission and other scientists, have reviewed his proposed additional arsenic studies. A letter submitted to FERC, dated September 12, 2016,[5] supporting those proposed studies has been submitted by 6 scientists: Dr. J.L. Barringer (unsigned) formerly USGS, Dr. T.C. Onstott (signed) from Princeton University, Dr. H. Dong (signed) from Miami University, Dr. B.J. Mailloux (signed) from Columbia University, Dr. P.C. Ryan (unsigned) from Middlebury College in Vermont, and Dr. N. Yee (signed) from Rutgers University. Although the letter indicates six authors, it is only officially signed by four.

Reviewing each authors' credentials, their backgrounds are mainly in biogeochemisty in general. Dr. Mailloux has done much work on the arsenic issue in Bangladesh, and Dr. Ryan published a paper on arsenic in groundwater, associated with ultra-mafic rocks in Vermont. Their concerns are basically the same as the issues listed above and have been responded to in turn. Most of the responses above are related to the potential impacts of arsenic to groundwater which, as discussed above, will be short-lived and insignificant to overall groundwater quality during the construction and operation of the pipeline. A response to Dr. Onstott's filing, "Arsenic and its effect on stream and freshwater biota,"[6] is forthcoming.

I appreciate the opportunity to submit this letter for consideration regarding speculative concerns of arsenic mobilization in groundwater due to the proposed PennEast pipeline.

Sincerely,

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[5] Accession no. 20160912-5411, Docket CP15-558-000 (Sept. 12, 2016).
[6] Accession no. 20160829-5084, Docket CP15-558-000 (Aug. 29, 2016).

Attachment F

Solution Geosciences LLC
Michael Serfes, P.G., Ph.D.

October 26, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

RE: Docket CP15-558-000, PennEast Pipeline Company LLC
Responses to: (1) Arsenic release into stream waters from the PennEast Pipeline and (2) Arsenic and its effect on stream and freshwater biota by Lauren Santi & T.C. Onstott [Dr. Onstott]

Dear Ms. Bose,

This letter is in response to two documents by Ms. Santi and Dr. Onstott that focus on potential impacts to surface water quality and associated biota due to proposed construction-related arsenic mobilization. These documents are: (1) Arsenic release into stream waters from the PennEast Pipeline[1], and (2) Arsenic and its effect on stream and freshwater biota by Lauren Santi and Professor T.C. Onstott.[2] I have summarized my understanding of the content of each document and have provided my responses to each below.

Review Summaries:

Document (1): "Arsenic release into stream waters from the PennEast Pipeline"

The author(s) allege that, based on their collection and analyses of 44 samples of stream and wetland sediments, and soils along the ROW of the PennEast pipeline, the potential exists that the New Jersey Surface Water Quality Standard (SWQS) of 0.017 µg/l for arsenic will be exceeded, during stream and wetland crossings. It was noted that the average As concentration of soils derived from the Passaic Formation grey beds is 5.3 parts per million, and less elsewhere. However, no distinction was made between the soil and sediment arsenic concentrations. This lack of distinction appears confounding. Based on that unsorted data, the authors conclude that more intensive

[1] Accession No. 20160819-5209, Docket No. CP15-558-000, (Aug. 19, 2016).
[2] Accession No. 20160829-5084, Docket No. CP 15-558-000, (Aug. 27, 2016).

arsenic surveys at stream crossings and soil/wetland soil zones are needed. The authors' main conclusion was drawn from the assertion that, due to the lack of this arsenic survey data in the DEIS, an alternative pipeline ROW should be sought.

Document (2): "Arsenic and its effect on stream and freshwater biota"

The authors start by referring to Document (1) noted above, stating that trenching activities along the PennEast pipeline will result in an exceedance of New Jersey's SWQS for arsenic since arsenic occurs in soils. The authors then proceed to describe the potential impact that arsenic will have on freshwater biota based on various arsenic exposure and release scenarios.

RESPONSE: In both documents, additional work to assess arsenic occurrence, release and impacts to surface-water biota (ecosystems) are proposed. However, no additional work is needed as specific Federal and State enforced regulatory requirements, based on applicable research to protect biota and human health, are already in place.

The NJDEP has established SWQSs (N.J.A.C. 7:9B-1.14)[3] to protect aquatic life and human health based on a variety of designated uses. Any discharge to any surface-water body in New Jersey requires a NJPDES surface water permit from the NJDEP Bureau of Surface Water Permitting. The type of permit required is determined by the discharge type (ex: simple dewatering versus remediation cleanup) which considers: 1. the concentration of constituents to be discharged, 2. background water-quality, and 3. the SWQSs, as a function of the designated use. All regulatory permit requirements must thoroughly be met before any work crossing surface-water bodies, which would result in a discharge, can be legally conducted. Through these NJDEP regulatory requirements, rather than the speculation described in documents (1) and (2), aquatic life and human health will be protected.

Therefore, as required by NJDEP (and possibly other agencies), approvals via permit or regulatory requirements already otherwise established will be in place to protect aquatic life and human health (related to arsenic and other substances) when stream or wetland crossing work are conducted.

Sincerely,

Michael E Serfes

Michael E. Serfes, P.G., Ph.D.

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[3] http://www.nj.gov/dep/rules/rules/njac7_9b.pdf