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

June 21, 2016

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

Re: PennEast Pipeline Company, LLC, Docket No. CP15-558-000
First Supplemental Response to April 29, 2016 Environmental Information Request to Address Comments
OEP/DG2E/Gas 2

Dear Ms. Bose:

On May 16, 2016, PennEast Pipeline Company, LLC (PennEast) provided responses (May 16 Response) to the Environmental Information Request issued by the Federal Energy Regulatory Commission (FERC or Commission) on April 29, 2016 (April Data Request) in the above-referenced proceeding. On May 17, 2016, comments[1] regarding PennEast's response to Resource Report 6, Data Request 1, of the April Data Request, were submitted in the above-referenced proceeding. While PennEast's May 16 Response contains a complete and accurate response to Resource Report 6, Data Request 1, PennEast hereby submits a supplemental response to Resource Report 6, Data Request 1, of the April Data Request in order to address these comments.

Pursuant to Section 385.2010 of the Commission's regulations, 18 C.F.R. § 385.2010 (2015), PennEast is contemporaneously serving copies of this submission to persons whose names appear on the Official Service List in this proceeding.

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

---

1 PennEast Pipeline Company, LLC, Comment of Stephen Garofalini in Docket(s)/Project(s) CP15-558-000, Accession No. 20160517-5155 (May 17, 2016).

VERIFICATION

THE STATE OF PENNSYLVANIA)
)
COUNTY OF BERKS)

Tamara R. Bernstein, being first duly sworn, states that she is the Manager – Regulated Asset Administration for PennEast Pipeline Company, LLC; that she is authorized to execute this Verification; that she has reviewed the supplemental response to the April 29, 2016 Environmental Information Request in Docket No. CP15-558-000; and that after reasonable diligence and review, the information provided in such response constitutes a complete and accurate response to the best of her knowledge, information and belief.

PennEast Pipeline Company, LLC,
By: UGI Energy Services, LLC
Its Project Manager

Tamara R. Bernstein
Tamara R. Bernstein
Manager – Regulated Asset Administration

Subscribed and sworn to before me this ____ day of June, 2016.

Joan T. Neustadter
Notary Public,
State of Pennsylvania

My Commission Expires:
March 8, 2020

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Joan T. Neustadter, Notary Public
Spring Twp., Berks County
My Commission Expires March 8, 2020
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

Resource Report 6 - Geology

Data Request 1

Provide correspondence, from Trap Rock Industries regarding future quarry expansion plans, and that the Project is located at a safe distance from the planned expansion area of this quarry.

Response 1

PennEast has made multiple attempts to get an update from Trap Rock Industries regarding future quarry expansion plans. An extensive tract of land owned by Mercer County (PE-ME-016) extends between Trap Rock Industries and the proposed PennEast Pipeline. It is very unlikely that Trap Rock Industries would be able to expand onto the County lands. The closest point to the proposed PennEast construction workspace is approximately 0.5 mile away. Therefore, PennEast does not expect that the proposed Project will have any impact on Trap Rock Industries' plans.

Supplemental Response 1

Comments regarding PennEast's response, above, state that PennEast has ignored addressing any impacts associated with the Trap Rock Industries, Inc. (Trap Rock) quarry located in Delaware Township, Hunterdon County.[1] Similar comments have been filed in response to information that PennEast has provided to FERC about Trap Rock's Hunterdon County quarry and other Trap Rock quarries.[2] PennEast's response above regarding its efforts to obtain information from Trap Rock regarding future expansion plans is applicable to all of Trap Rock's quarries in the vicinity of the Project.

In response to concerns that PennEast has not considered Trap Rock's Hunterdon County quarry in evaluating the safety of the Project, PennEast has been considering the Hunterdon County quarry in relation to the Project location throughout the development of the Project. As PennEast stated in its draft Resource Report 6, filed in April 2015 in the pre-filing Docket No. PF15-1-000 (Pre-Filing),

1 PennEast Pipeline Company, LLC, Comments of Stephen Garofalini, Docket No. CP15-558-000, Accession Nos. 20160517-5155 (May 17, 2016) and 20160609-5168 (June 9, 2016).

2 PennEast Pipeline Company, LLC, Comments of Stephen Garofalini, Docket Nos. PF15-1-000 and CP15-558-000, Accession Nos. 20150105-5019 (January 5, 2015); 20150302-5032 (March 2, 2015); 20150805-5029 (August 5, 2015); 20150806-5003 (August 6, 2015); 20150812-5146 (August 12, 2015); 20150918-5120 (September 18, 2015); 20150918-5134 (September 18, 2015); 20151228-5230 (December 28, 2015); 20160223-5057 (February 23, 2016); and 20160325-5198 (March 25, 2016).

and in its final Resource Report 6, filed as part of the September 2015 Application, Trap Rock's three (3) crushed stone quarries are all greater than 0.25 mile from the Project area, including the one in Lambertville, New Jersey (Hunterdon County). Further, as PennEast summarized in its August and September 2015 monthly status reports during Pre-Filing, PennEast specifically addressed Trap Rock's Hunterdon County quarry, located approximately 0.75 mile from the proposed route, when stating that the Project is located at a safe distance from Trap Rock's applicable expansion plans. These monthly status reports also included maps showing the distance of Trap Rock's Mercer and Hunterdon County quarries from the pipeline route. In addition to these filings, PennEast also discussed all of Trap Rock's quarries, including the one located in Hunterdon County, in response to FERC's December 2015 Data Request.

As noted in recent comments, the latest known information regarding an expansion of Trap Rock's Hunterdon County quarry is from a 2008 meeting between Trap Rock and the Delaware Township Committee reported in the Delaware Township Post on July 22, 2008. Trap Rock has not provided PennEast with any additional information regarding specific plans to expand any of its quarries in the vicinity of the Project. Trap Rock's Hunterdon County quarry remains dormant, and PennEast is unaware of any pending application for a blasting permit for Trap Rock's Hunterdon County quarry. In the event that Trap Rock activates and expands its Hunterdon County quarry, the expanded quarry will still be greater than 0.25 mile from the PennEast pipeline at its closest point.

PennEast does not anticipate any impact on the PennEast pipeline from Trap Rock's blasting activity at any of their currently active or inactive quarries in the vicinity of the Pipeline in Hunterdon or Mercer Counties, New Jersey. PennEast requested a complete evaluation of the impact of Trap Rock's quarry blasting in Hunterdon County on the PennEast Pipeline and the report, attached hereto as Attachment 1, concludes that blasting at the Trap Rock quarry in Hunterdon County is not anticipated to have any disruptive or damaging effect on the proposed pipeline and that based on the analysis in the report and other studies conducted by PennEast, PennEast does not anticipate blasting will impact the safety of the proposed pipeline.

Hatch Mott MacDonald

MEMO

To Anthony Cox, Project Manager (PennEast)

From Vatsal A. Shah, Ph.D, PE

Date June 21, 2016

Project # 353754

Document # 353754-HMM-EN-CO-026

Page 1 of 13

Subject Evaluation of the Hunterdon County Trap Rock Quarry Blasting Activities Effects on the Proposed PennEast Pipeline

CC PennEast- Jason Doersom, Tamara Bernstein
HMM- Mike Wilcox, Mike DeNichilo, Carlos Chaves, Danny Hartman

1. Overview

The proposed PennEast Pipeline Project (Project) will begin in Dallas, Pennsylvania (Luzerne County), end in Pennington, New Jersey (Mercer County), and will be approximately 115 miles long. In the locale of milepost (MP) 100 (based on the alignment sheets submitted to the Federal Energy Regulatory Commission [FERC] in February 2016), the pipeline will be installed proximate to the existing Trap Rock Quarry in Delaware Township (Hunterdon County), New Jersey. A Site Location Plan depicting the Hunterdon County Trap Rock Quarry's relation to the pipeline is provided below as Figure 1.

PennEast Pipeline Company, LLC (PennEast) is sensitive to safety concerns raised about the potential effects of blasting at the Hunterdon County Trap Rock Quarry to the installed pipeline (*see* comment submitted to FERC Docket No. CP15-558-000, Accession No. 20160517-5155 [May 17, 2016]). PennEast has retained Hatch Mott MacDonald (HMM) to evaluate the potential for concerns caused by blasting that may be performed at the Hunterdon County Trap Rock Quarry, as those activities relate to pipeline safety and operation.

This memorandum has been prepared specifically regarding the Hunterdon County Trap Rock Quarry, however, where noted, portions of this evaluation are generally applicable to quarries within the vicinity of the PennEast pipeline Project.

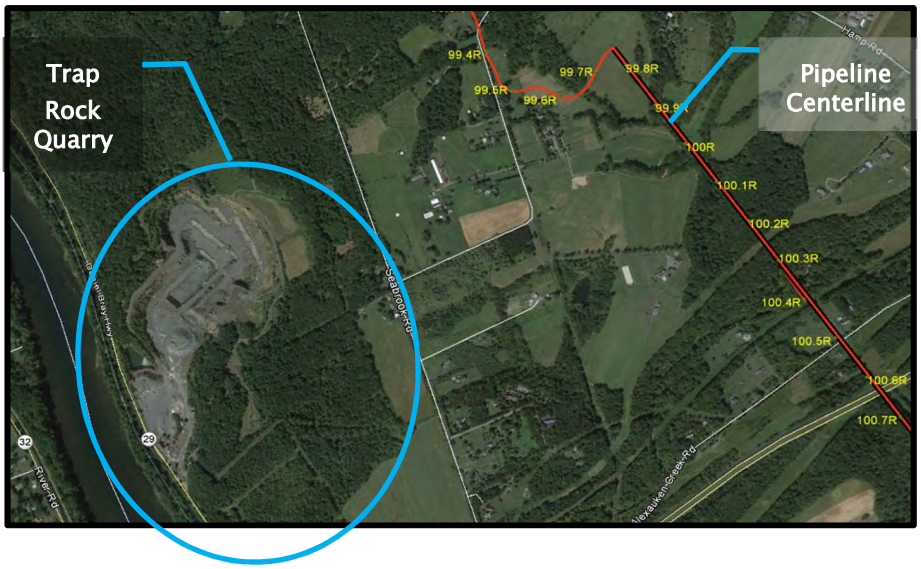


Figure 1 – Site Location Plan

2. Geologic Background

From available information, the Hunterdon County Trap Rock Quarry, located in Delaware Township, New Jersey opens in the lower half of the Mt. Gilboa (Stockton) diabase. The formation, which is a small, fault-bounded segment of the Palisades intrusive complex, has been mined by Trap Rock Quarry Industries, Inc. since 1966, and has been historically quarried since as far back as 1860 (Husch, 1988) (Johnson, 1957).

According to New Jersey Department of Environmental Protection's (NJDEP) GeoWeb online GIS Database, surficial geology of the region consists of Weathered Diabase deposits and Weathered Shale, Mudstone, and Sandstone deposits. The existing Hunterdon County Trap Rock Quarry falls primarily in the Weathered Diabase deposits, with its southeastern edge in the Weathered Shale, Mudstone, and Sandstone deposits. The Weathered Diabase deposits are described as clayey sand to silty clay, with diabase fragments and boulder and can be as much as 20 feet thick. The Weathered Shale, Mudstone, and Sandstone is typically a silty sand to silty clay with shale, mudstone, or sandstone fragments and can be as much as ten (10) feet thick on shale and mudstone and 30 feet thick on sandstone. These soils are typically deposited in the headwater areas of valleys or in modern floodplains and channels and can be as much as 20 feet thick, however, in some areas, there may be exposed bedrock or a very thin layer of surficial soil overlying bedrock. The depth to bedrock in the area may range between exposed outcrops to a depth of 5 feet, with the bedrock having an average depth of 3.6 feet from ground surface.

Bedrock geology of the region falls in three (3) different bedrock formations- the Jurassic Diabase, the Lockatong Formation, and the Passaic Formation. The existing Hunterdon County Trap Rock Quarry falls primarily in the Jurassic Diabase, with its southeastern edge in the

Lockatong Formation. The Jurassic Diabase is described as a medium to coarse grained diabase. The Lockatong Formation is described as a dolomitic or silty argillite, mudstone, sandstone, or siltstone with minor silty limestone, while the Passaic Formation is primarily a siltstone and shale. It is not anticipated that the Hunterdon County Trap Rock Quarry's operations will extend significantly into the Lockatong and Passaic Formations and will therefore be limited to activity in the Jurassic Diabase formation. Diabase formations, which are typical hard rock formations, exhibit longitudinal shear wave velocities of between 6,500 meters per second and 7,000 meters per second (Goodman, 1989). Figure 2 depicts the regional bedrock geology of the Hunterdon County Trap Rock Quarry and the PennEast Project's pipeline alignment. Areas highlighted in purple indicate Jurassic Formation, while clear and green coloring represent Lockatong and Passaic Formations, respectively.

From aerial photography, it is observed that the Hunterdon County Trap Rock Quarry's side slopes have been opened with varying slope angles with benches excavated to facilitate access into the working area and to provide a haul road to access the base of the excavation for transporting extracted material.

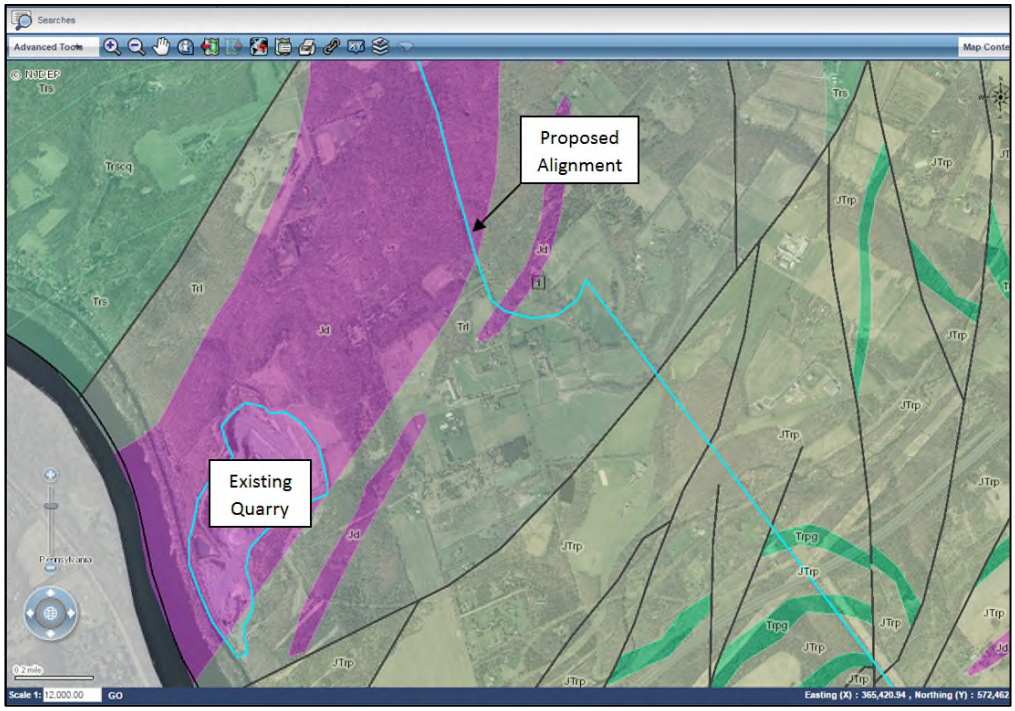


Figure 2 – Regional Bedrock Geology Map

3. Proximity of Blasting Operations to Pipeline

Based on PennEast's current alignment with route deviations submitted to FERC in February 2016, the closest radial distance between the existing edge of the Hunterdon County Trap Rock Quarry's operations and the proposed PennEast pipeline is approximately 2,800 feet.
From a review of available Delaware Township records and a newsprint article (Katz, 2008) referenced in comments submitted to the Project's FERC docket, it is gathered that the Hunterdon County Trap Rock Quarry's owner/operator intends to continue mining within the confines of its property located at Block 59, Lot 3, and within a portion of its property at Lot 4. PennEast expects the Hunterdon County Trap Rock Quarry to be excavated to a depth of approximately 480 feet below existing grade, or 400 feet below sea level. A 12,000 linear foot earthen berm barrier, which is 50 feet tall and 200 feet wide at base, is expected to be placed as a visual and noise barrier at the edge of the Hunterdon County Trap Rock Quarry's Lot 3 and Lot 4 property line, thereby creating a 200-foot setback from Seabrook Road, which is east of the quarry. Figure 3 is provided from the referenced 2008 newsprint article to depict the anticipated future use plans of the Hunterdon County Trap Rock Quarry.

Although unlikely due to benching requirements and sloping to reach extraction depth, if one assumes that the Hunterdon County Trap Rock Quarry's operations will extend up to the limit of the earthen berm, the closest future use radial distance between the Project pipeline and quarry operations will be 2,000 feet. An aerial map with reference scale is provided as Figure 4.

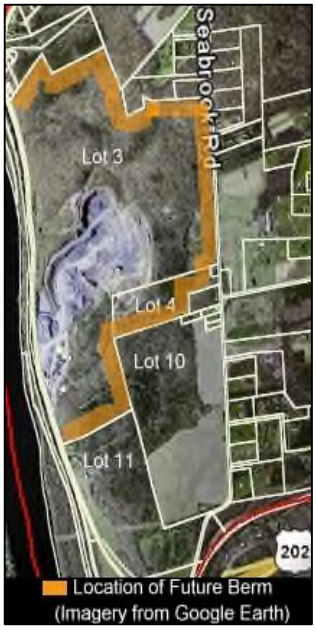


Figure 3
Quarry Operations Plan

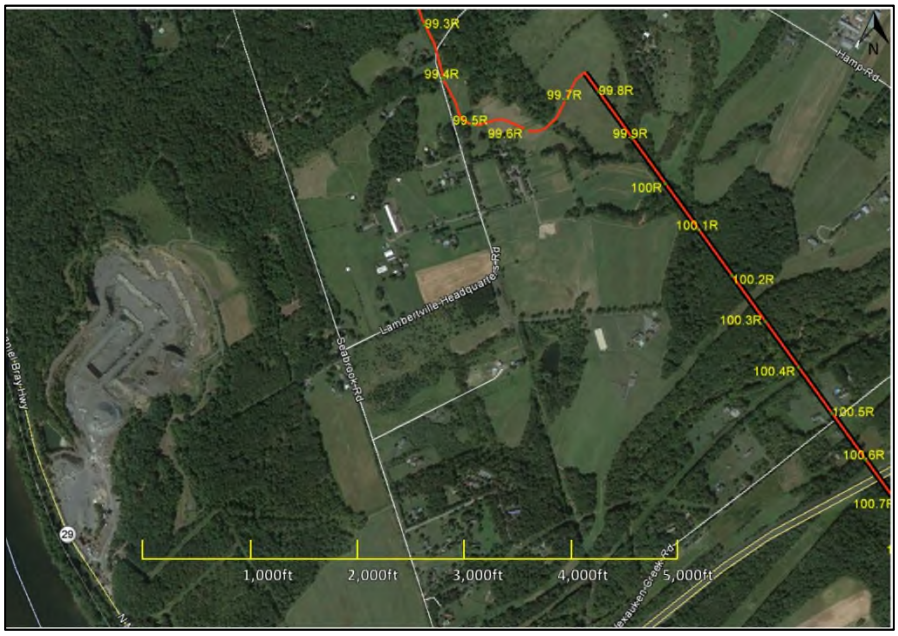


Figure 4 – Aerial Map with Scale

It is not expected that the Hunterdon County Trap Rock Quarry's operations will come closer than the 2,000-foot separation distance, as the existing Delaware Township zoning indicates the area outside of this quarry to be preserved for open space and residential use. Should the Hunterdon County Trap Rock Quarry intend to expand operations, it would need to seek approval from Delaware Township to re-zone the surrounding area to an industrial (I-2) zone. Therefore, a subsequent discussions and this evaluation will maintain an assumed separation distance of 2,000 feet. Notwithstanding these observations, the specific safety concerns associated with the potential effects of blasting at the Hunterdon County Trap Rock Quarry are evaluated herein.

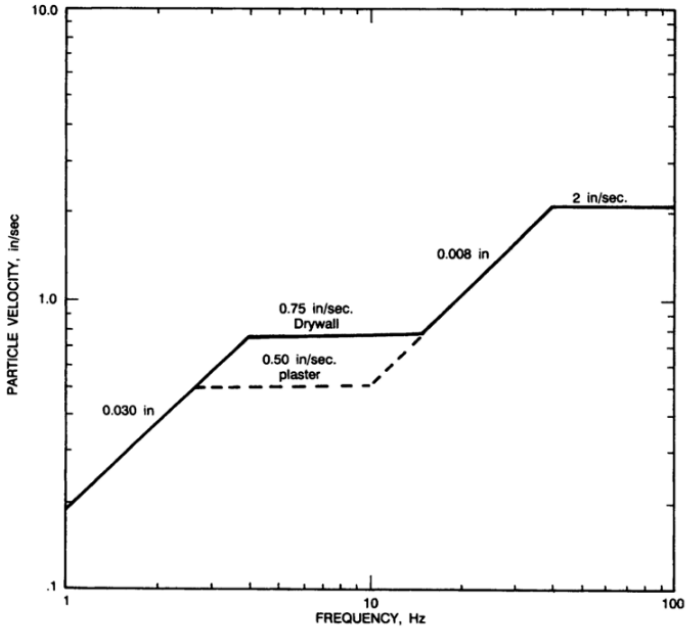
4. State Blasting Requirements and Proposed Pipeline Construction

Prior to discussing the implications of blasting impacts, it should be noted that the requirements for permitted blasting at any quarry within the State of New Jersey are based on the State of New Jersey's Explosives Act (N.J.S.A. 21:1A-128 et seq.) and related Regulations contained within New Jersey Administrative Code (N.J.A.C.) (Title 12 – Labor and Workforce Development, Chapter 190: Explosives [N.J.A.C. 12:190]). The following relevant requirements are re-stated below:

- *For blasting in vicinity of utility lines, in accordance with the blasting, Contractor shall make every reasonable effort to verify the exact location of utility lines located in the vicinity of such operations. Whenever blasting is being conducted within 200 feet of any pipe distributing liquefied petroleum, manufactured, mixed or natural gas, the blasting Contractor shall notify the gas utility company having control of such gas at least three full working days (excluding Sundays or holidays) prior to blasting. Such notice shall be in writing and served personally or by registered mail.* N.J.A.C. 12:190-7.7(g).

- *The limits for ground vibration when blasting shall be in accordance with Table 7.26(e) or (f) below.* N.J.A.C. 12:190-7.26(c).

Figure 7.26(e)
Frequency Versus Particle Velocity Method



Note to Figure
*Figure from U.S. Bureau of Mines, Report to Investigation 8507

- *In no case shall the peak particle velocity at a property line exceed two [2] inches per second except when permitted by N.J.A.C. 12:190-1.6.* N.J.A.C. 12:190-7.26(c).

HMM notes that the above-mentioned requirements are institutional controls which are in place and enforced by the State of New Jersey to limit the off-site impact caused by blasting activities. In addition, once the PennEast pipeline is constructed and operational, additional safeguards such as State One-Call and Call Before You Dig programs will trigger notifications to PennEast operational staff, which will prompt additional work-specific safeguards, as required.

PennEast's proposed pipeline will consist of high-strength Grade X-70 steel with welded connections. The pipe will be installed within an excavation at least four (4) feet deep and will be enveloped in an engineered backfill consisting of compacted sand, gravel, or cementitious fill ("flowable fill") which will extend at least six (6) inches in all directions around the pipe. The engineered backfill is designed to support the pipe evenly and protect the pipe's corrosion-protection coating. Native or select fill material will be replaced above the engineered fill to prevent impact to the pipe from shallow excavations. During manufacturing and construction, PennEast's installed piping will undergo quality control and/or quality assurance testing, including inspections at the manufacturing facilities and construction inspections during all welding, coating, and backfill operations. PennEast intends to inspect and non-destructively test a portion of the welds using radiographic methods, however, the full pipe will be strength tested by means of hydrostatic testing to a pressure of 1.5 times the planned operating pressure for eight (8) hour intervals.

HMM would note that blasting in proximity to utilities, specifically natural gas pipelines, is not an unusual occurrence. Pipeline integrity has been studied and established based upon extensive research by the Pipeline Research Committee International, the United States Bureau of Mines, and through observation of performance of existing in-service pipelines within proximity to construction and blasting activities. These studies have been conducted on "close-in" blasting, with the blast source as close as five (5) feet away from the pipeline, and on the blasting effects on a pipeline several hundred feet away from the blast source (Esparza, 1981; Esparza, 1991; Oraid, 1994; Siskind et.al, 1993; Siskind et.al, 1994). Each of these safeguards provides a baseline level of safety for an operational pipeline.

5. Blast-Induced Vibrations and Resulting Effects

Ground vibrations and the effects on structures are well-studied and documented as a result of extensive research on seismic events and surface mine blasting for mineral resources. Several authors, including Bender, Esparza, Siskind, have specifically studied the response and effects of blasting on gas product pipelines[1]. These studies have helped to develop an understanding of the blast wave and energy propagation through various soil and rock formations, and the effects of these vibrations on structures at various frequencies, magnitudes, and distances away from the energy.

By nature, the activity of rock blasting can generally be summarized as drilling blast holes at a preset spacing (based on rock type), controlled blast cartridge installation, followed by a series of blast charges, each separated by a delay to split and fragment the rock in a controlled fashion. Each blast cartridge's size (weight) is proportional to both the energy imparted to the rock and the magnitude of the resulting energy front created by the blasting activity. A larger cartridge and shorter delay will create greater overlap between each blast, which would result in a greater magnitude of energy imparted, while a smaller cartridge and/or longer delay would reduce the magnitude of energy imparted. In addition to blast energy at source, site-specific subsurface conditions and radial distance from blast affect how vibrations transmit, attenuate, and reflect before reaching the location of concern.

As vibrations propagate, their energy travels, attenuates, and reflects radially in three (3) principal directions (X, Y, and Z) through geologic materials. For the purpose of measuring and evaluating the intensity of vibrations and their effect on structures, regulations including United States Code of Federal Regulations and N.J.A.C. as well as the scientific community and engineering, testing, and construction industries have adopted the use of the practical measurement of peak particle velocity (PPV), or the dominant amplitude between the three (3) principal directions measured in inches per second (ips).

1. Unless otherwise noted, studies referenced herein are related to gas product pipelines are defined as any pipe distributing liquefied petroleum, manufactured, mixed, or natural gas.

The number of cycles per second of this energy wave, measured in Hertz, defines the vibration as it moves through the subsurface.
The frequency and PPV can be readily measured using seismograph equipment. Using the readily-measurable parameters of PPV and frequency, researchers have compiled extensive observational data that provide guidance to predict blasting-induced vibrations as a function of cartridge charge and radial distance from the blast.

The following Table 1 includes information from several researchers and organizations which have provided suggested PPV threshold for gas product pipelines based on their observational experience.

Table 1 – Comparison of Threshold PPVs for Pipelines

PPV [ips]	Limit Description	Authors/Source
50 to 150	Explosive near a buried pipe; no damage observed	Siskind, D.E. & Stagg, 1993
25	Explosive near a buried pipe; no damage observed	Oriard, 1980 & Oriard 2002
12 to 15	Predicted PPV of an explosive near buried pipe where no damage occurred	Bender, 1981
12	Suggested threshold limit for construction of pipeline trench parallel to existing high-pressure gas lines	International Society of Explosives Engineers (ISEE) Handbook
10	Blasting 50 feet from buried pipe with no observed loss of pipe integrity	Siskind et. al, 1994 (US Bureau of Mines RI 9523)
5	Recommended conservative limit for any steel buried pipe under any conditions based on allowable stress of pipe	Pipeline Engineering Journal, 2009 pg. 260-262

It can be noted from the above table that various authors are of the opinion that safe PPV thresholds for pipelines range between five (5) to greater than 25 ips without damage to the pipeline. Notwithstanding, multiple other references, such as the U.S. Bureau of Mines publication (RI-8507) (referenced by N.J.A.C. 12:190-7.26[c]), indicate a safe PPV threshold limit[2] of no greater than 2.0 ips.

In addition, the U.S. Bureau of Mines publication (RI-8507) suggests a range of limiting PPV for sensitive structures and aged, historical monuments constructed of brittle material (i.e. mortar, brick) installed within competent rock between 0.3 and 0.75 ips. HMM recognizes that the allowable PPV thresholds specific to gas transmission pipelines is at least 10 times greater than those allowable PPVs for sensitive structures.

Although the proposed PennEast pipeline will not be made of brittle material or classified as a historic structure, for the purpose of this evaluation, HMM considered a conservative average

2. The threshold limit is defined as the maximum vibration which can be experienced before perceivable damage results to the structure. If the threshold is not exceeded, damage is unlikely.

limit of 0.5 ips to demonstrate the safety of the PennEast pipeline, even when applying the most stringent blasting standards at the Hunterdon County Trap Rock Quarry and other Pennsylvania and New Jersey quarries.

6. Evaluation of PennEast Pipeline and Safe Distance from Blasting Operations

In practice, blast-induced PPV are controlled by developing a scaling relationship between the nearest sensitive receptor such as a structure (in this case the PennEast pipeline) and the vibration threshold that the receptor can accept. The scaling relationship essentially normalizes the distance against the square root of weight of charge being used and produces a "scaled distance," which can be used to evaluate the maximum PPV transmitted at any distance away from the source. As each blast and each site is unique, HMM applied a site-specific constant to the scaled distance that takes into consideration all the unique parameters of the charge and environment including blast pattern and hole spacing, depth of stemming, site geology, and topography. Once evaluated, this site-specific relationship can be used to predict PPV from future blasts at the same general location.

The scaling relationship developed by Oraird (1994) takes the form:

$$PPV = A\left(\frac{R}{\sqrt{W}}\right)^{B}$$

Where:

PPV = Peak particle velocity at the sensitive receptor [inches per second]
A = Site-specific constant based on geology, distance, and wave propagation (no unit)
R = Radial distance between blast and sensitive receptor (feet)
W = Charge weight per delay (pounds)
B = Variable based upon scaling relation referenced = -1.6 (Siskind, et al., 1980)
$\left(\frac{R}{\sqrt{W}}\right)$ = the scaled distance

The variable "*A*" is often determined using empirical data-fitting based on a series of test blasts representative of quarry operations with data collected at multiple seismographs aligned at several distances (such as 10, 100, and 1,000 feet away) from the charge. This allows for a more accurate determination of the reflection and attenuation caused by the site's geology, however, treating the geology as a single material with continuous, infinite half-space would yield a conservative approach. This conservatism results from not considering layered soil conditions where only some of the energy generated at a source is refracted through one layer into the next; the rest is reflected in multiple directions at the layer interface, thus reducing vibrations forward-moving in the direction of the pipeline.

Based on observations by Oraird (1994) and Bender (2007), the variable "*A*" generally ranges between a value of 24.2 and 242, with a maximum of 605. For the purpose of this evaluation, the conservative assumption of a single material (diabase hard rock) is considered, and a value of *A* = 500 has been considered.

Using the scaling relationship for the specific evaluation of the Hunterdon County Trap Rock Quarry and the PennEast pipeline, the PPV anticipated at the PennEast pipeline can be evaluated using the following site-specific parameters:

A = 500
R = 2,000 feet
W = 1 lb. (typical for hard rock)
B = -1.6

Therefore, ***PPV*** = $A\left(\frac{R}{\sqrt{W}}\right)^{B} = 500\left(\frac{2{,}000\ feet}{\sqrt{1lb}}\right)^{-1.6}$ = **0.0026 ips**

Therefore, in the case where blasting will be occurring at the closest allowable distance to the Hunterdon County Trap Rock Quarry property line (2,000 feet from pipeline), the peak particle velocity experienced at the pipeline will be approximately 0.0026 ips. Although the PennEast pipeline will not be considered a historic structure, using even the most stringent damage threshold of 0.5 ips, the vibration experienced at the pipeline will be substantially below the most stringent limit. Furthermore, using this most stringent limit, there is a safety factor of greater than 100 before the Hunterdon County Trap Rock Quarry's blasting activities would create a damage risk to the PennEast pipeline at the currently proposed distance of 2,000 feet.
In reality, a limit of 0.5 ips, which is used for historic structures, is overly conservative since natural gas pipelines are constructed of high-grade steel and do not demonstrate the same behavior as brittle structures. Using the higher threshold limit of 2.0 ips adopted by the State of New Jersey as outlined in N.J.A.C. 12:190-7.26(c), there is an even larger safety factor applied before concerns about pipeline damage could even be considered.

Using the 2.0 ips limit, an approximate safe (minimum) separation distance between the pipeline and quarry blasting can be determined by rearranging the scaling relationship and solving for distance, R. The equation can be rearranged to be expressed in terms of "R" as follows:

$$R = \sqrt{W}\left(\frac{PPV}{A}\right)^{1/B}$$

Using a damage-limiting threshold of 2.0 ips for PPV as outlined in N.J.A.C. 12:190-7.26(c) and the site-specific inputs for A, B, and W variables, the safe (minimum) separation distance between the pipeline and blasting is defined as:

$$R = \sqrt{W}\left(\frac{PPV}{A}\right)^{1/B} = \sqrt{1lb}\left(\frac{2.0ips}{500}\right)^{\frac{1}{-1.6}} = 31.53\,ft$$

From the above evaluation, a safe separation distance of 32 feet between the pipeline and blasting should be maintained to avoid pipeline safety concerns related to vibration effects from blasting. The separation distance should not be misconstrued to suggest that the pipeline cannot be installed closer than 32 feet from blasting operations. Rather, it suggests that, if the pipeline were to be installed at a distance closer than this spacing, a site-specific evaluation should be completed of the planned blast with specific charge weights, spacing, stemming, and other details to determine the blast-induced circumferential and longitudinal pipe stresses (Esparza, 1981). Protective measures such as installing a seismograph above the pipeline, vibration-attenuation trenching, or instrumentation of the pipeline, may be established to mitigate effects.

PennEast is aware that, at one (1) location along the current Project alignment, blasting may possibly be occurring within this distance of the pipeline. At this Pennsylvania quarry, in accordance with the United States Code of Federal Regulations (CFR) (Title 29 CFR 1926.900 et seq. Subpart U - Safety and Health Regulations for Construction - Blasting and Use of Explosive) requires any blaster is required to notify the gas utility company when blasting is being conducted within 200 feet of any pipeline distributing liquefied petroleum, manufactured, mixed, or natural gas. Therefore, PennEast will almost certainly be consulted and involved in planning the safety maintenance of its pipeline. At other locations along the currently proposed pipeline route alignment, PennEast maintains the previously calculated safe distance of 32 feet from blasting operations.

7. Conclusion and Discussion

Based on HMM's evaluation, PennEast may conclude the following:

- The Hunterdon County Trap Rock Quarry, located in Delaware Township, is an active quarry where blasting operations will take place at least 2,000 linear feet away from the closest radial intersection to the Project's pipeline alignment. The local geologic formation consists of Jurassic diabase, a hard rock formation.

- In accordance with the State of New Jersey's Explosives Act (N.J.S.A. 21:1A-128 et seq.) and New Jersey Administrative Code (N.J.A.C. 12:190), any quarry blasting shall limit off-site vibrations to below 2.0 ips.

- HMM notes that blasting in proximity to utilities, specifically natural gas pipelines, is not an unusual occurrence. The integrity of natural gas pipelines has been studied and established based upon extensive research by numerous researchers.

- The upper limit of safe PPVs below which damage is not likely ranges between 5 to greater than 25 ips. The most conservative threshold limit, reserved for historic structures installed within competent rock, ranges between 0.3 and 0.75 ips.

- Using a conservative set of circumstances for blasting at closest setback distance from quarry property line, geologic constants, and charge weight, the vibration expected at the proposed PennEast pipeline is nearly 0.003 ips. This expected vibration is less than even 1/100th of the tolerable PPV limit for the most stringent threshold limit assigned to a historic structure. This conservative evaluation leads to a factor of safety greater than 100 before damage to the pipeline is expected. Using more appropriate PPV threshold limits, variable blasting configurations and distances, and a layered geologic subsurface, the factor of safety would be even greater than 100.

- Using a damage-limiting threshold of 2.0 ips for PPV, as outlined in N.J.A.C. 12:190-7.26(c), a safe (minimum) separation distance between the PennEast pipeline and any hard-rock quarry blasting can be determined to be approximately 32 feet. Installing pipeline closer than this distance would require additional site-specific evaluation during each blast. HMM is only aware of one Pennsylvania location at which blasting may be possible within 32 feet. Pursuant to regulations, any blasting within 200 feet of a natural gas pipeline will require the blaster to notify the natural gas utility company. Therefore, PennEast will almost certainly be consulted and involved in planning to maintain the pipeline's safety. At other locations along the current Project pipeline alignment, PennEast maintains this safe distance from blasting operations.

Considering the above, based on HMM's evaluation, PennEast should not anticipate that blasting at the Hunterdon County Trap Rock Quarry in Delaware Township, New Jersey will have any disruptive or damaging effect to the proposed PennEast pipeline Project. In addition, where noted, portions of this evaluation are applicable to other quarries within vicinity of the PennEast Pipeline Project. From this analysis and other studies conducted by and on behalf of PennEast, PennEast will not anticipate blasting will impact the safety of the proposed pipeline.

Vatsal A. Shah, Ph.D, PE
Senior Project Engineer

8. References

- 27 CFR Part 55. Commerce in Explosives.
- 29 CFR 1926.900(k). Occupational Safety and Health Administration blasting requirements.
- 49 CFR Parts 171 - 178. Hazardous Materials Regulations.
- Bender, W., 1981. "Blast Vibration Limits on Pipelines."
- Bender, Wesley L., 2007. "Understanding Blast Vibration and Airblast, their causes, and their damage potential." Presented at the Golden West Chapter of the International Society of Explosives Engineers.
- Church, Horace K. Excavation Handbook. New York: McGraw-Hill, 1981. Print.
- CIRIA/UEG, 1989, OTH 87 240. "The Assessment of Impact Damage Caused by Dropped Objects on Concrete Offshore Structures." Department of Defense Offshore Technology Report.
- Dowding, Charles H., 1996. "Construction Vibrations." Prentice Hall. ISBN 0-13-299108-X.
- Esparza, D. E., 1991. "Pipeline Response to Blasting in Rock."
- Esparza, D. E., et al., 1981. "Pipeline Response to Buried Explosive Detonations." Southwest Research Institute.
- Esteves, J.M. Control of Vibrations Caused by Blasting Laboratorio National De Engenharia Civil, Lisboa, Portugal, Memoria 498, 1978.
- Fuglem, M. K., et al., 2001. "Pipeline Design for Mechanical Damage." For the Pipeline Design Construction & Operations Technical Committee of Pipeline Research Council.
- Goodman, Richard E. Introduction to Rock Mechanics. 2d ed. New York: Wiley, 1989. Print.
- Hanson, Carl E., David A. Towers, and Lance D. Meister. "Transit Noise and Vibration Impact Assessment." Rep. No. FTA-VA-90-1003-06. Washington, DC: U.S. Department of Transportation, Federal Transit Administration, 2006. P. 12-12 Print. May 2016.
- Hopler, Robert, 1998. "ISEE Blasters' Handbook, 17th Edition." Pp. 618-625
- Husch, J.M., 1988. Significance of Major and Race Element Variation Trends in Mesozoic Diabase, West-Central New Jersey and Eastern Pennsylvania. Froelich, A.J. and Robinson, G.R., Jr., eds. Studies of the Early Mesozoic Basins in the Eastern United States. U.S. Geological Survey Bulletin. Pp.141 -150.
- J.F. Wiss. "Vibrations During Construction Operations." Journal of Construction Division, Proc. American Society of Civil Engineers, 10., No. CO3. Pp. 239 - 246. September 1974.

- Johnson, M.E., and McLaughlin, D.B., 1957. Field Trip No. 2, Triassic Formations of the Delaware Valley, in Dorf, E., ed. Guidebook for Field Trips, Atlantic City Meeting, 1957, Geological Society of America. Pp. 31 - 68.
- Katz, Kathy. "Trap Rock Lake – The 100 Year Plan." The Delaware Township Post. 22 July 2008. Accessed online at [http://www.delawaretownshipnj.org/2006/12/law-suit-settled-trap-rock-and-township-will-preserve-151-acres/].
- Konya, Calvin J. and Walter, E. J., 1991. "Rock Blasting and Overbreak Control." Federal Highway Administration/National Highway Institute. Original Pub. No. FHWA-HI-92-001.
- Langefors, U. and B.K. Kihlstrom. "The Modern Technique of Rock Blasting." John Wiley and Sons. New York, 1978.
- Natural Resources Conservation Service. 2015. Web Soil Survey.
- Oraid, L.L. (1994). "Vibration and Ground Rupture Criteria for Buried Pipelines." Proceedings of the Twentieth Annual Conference on Explosives and Blasting Technique, International Society of Explosive Engineers.
- Siskind, D, E., M. S. Staff, J. W. Kopp, and C. H. Dowding. "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting." Rep. No. RI 8507. Washington, DC: US Department of Interior, Bureau of Mines.
- Siskind, D. E., et al., 1980. "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting." Bureau of Mines Report of Investigations, RI 8507.
- Siskind, D.E. and Stagg, M. S., 1993. "Response of Pressurized Pipelines to Production-Size Mine Blasting." Proceedings of the Ninth Annual Symposium on Explosives and Blasting Research. International Society of Explosives Engineers.
- Siskind, David E., et al., 1994. Report of Investigations 9523, "Surface Mine Blasting Near Pressurized Transmission Pipelines". Bureau of Mines Report of Investigations, RI 9523.
- State of New Jersey Department of Labor & Workforce Development - Division of Safety and Health. Explosives Act. N.J.S.A. 21:1A-128 et seq.; N.J.A.C. 12:190.