Final Report
from the
Independent Investigation
of the
Vermont Gas Systems
Addison Natural Gas Project

Vermont Public Utilities Docket 17-3550-INV

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By

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Introduction

The Vermont Public Utilities Commission (PUC) issued a final order on 12/23/2013 in docket 7970 approving the Addison Natural Gas Project (ANGP) by Vermont Gas Systems (VGS). Subsequent to that approval, VGS submitted 6 non-substantial change (NSC) requests for the ANGP. NSCs #1 through 5 concerned changes to the route or location of facilities for the ANGP and were approved. NSC #6 addressed the construction technique and burial depth in the Clay Plains Swamp and is currently pending. Subsequent to NSC request #6, the Vermont Department of Public Service (DPS) issued a Notice of Probable Violation (NOPV) on February 13, 2018, dealing with topics such as bedding techniques and trench breaker types and locations (a.k.a. the Bedding/TB NOPV), which is also pending. In addition, other parties (collectively referred to as intervenors) have made a variety of claims related to construction of the ANGP that have been submitted to various PUC dockets related to ANGP and / or directly to me as the independent investigator. Further details about the events leading to this investigation are included in the Supplemental Discussion section of this report.

In response to these various claims and allegations, the PUC opened docket 17-3550-INV. Subsequent to opening that docket, the PUC hired me to serve as an independent investigator. My statement of qualifications is included as Attachment A#01.

My contract with the PUC listed several specific items and some general topics to be addressed, as summarized below. Some of the items listed in my scope of work are very narrow but the potential issues are broader. I have addressed both the specific items and the broader issues in this report. This report contains my[1] findings, conclusions, and recommendations from this investigation.

[1]I was assisted by various members of my staff with review, summarization, and organization of some of the documentation. I was also assisted by qualified VGS personnel when conducting inspections during my site visits. I occasionally use the term “we” or “us” in this report, which simply indicates that I did not personally do all the tasks performed during this investigation – but I have thoroughly reviewed or inspected their work. The final contents, opinions, and conclusions in this report are mine alone.

Scope of Work

The scope of work for this investigation is summarized as follows (quotes from the contract are in ***bold italics***):

1. **Compliance with Regulations and CPG Requirements / Commitments**
   The Contractor shall conduct a thorough review of Vermont Gas System's ("VGS") construction practices and construction-related documentation to assess VGS's compliance with the applicable pipeline safety regulations and the 2013 Final Order and CPG in Docket 7970.

2. **Depth of Cover**
   Contractor shall review and analyze VGS's August 11,2017, self-certification by conducting an independent on-site survey of the pipeline buried in a half-mile stretch of swampy ground in the VELCO right-of-way in New Haven and at pipeline stream crossings along the 4l-mile-long ANGP route, Contract will determine the pipeline burial depth in those locations and compare that information to the data provided in the VGS self-certification. Should the Contractor determine that the VGS failed to observe the burial depth requirements in the New Haven swamp, the Contractor will propose a survey method to assess the burial depth of the pipeline for the remainder of the 41-mile-long ANGP route.

3. **Specific Allegations**
   Contractor shall also conduct inquiries with all the parties to this investigation, including VGS's contractors and subcontractors as appropriate, to determine whether VGS failed to:
   (1) develop and comply with a QA program to oversee the pipeline contractor and subcontractor;
   (2) lay the pipeline in clean sand above the trench bottom;
   (3) test the compaction of backfill over the pipeline;
   (4) ensure that the pipeline was properly coated;
   (5) have an adequate cathodic protection system before gassing up;
   (6) install zinc ribbon corrosion protection in two high-risk areas, and
   (7) install bentonite trench breakers to protect wetlands and streams

4. **Professional Engineering**
   The scope of work was later amended by the PUC on 1-10-2019 to include making a factual conclusion as to ***whether or not the Company used construction plans that were signed by a Vermont-licensed engineer in constructing the pipeline***.

5. **Other Issues**
   The intervenors have made a variety of claims concerning non-compliance and safety issues concerning ANGP, as mentioned in the "Intervenors' Summary of the Evidence for Independent Investigator William Byrd PE (annotated with attachments)", dated2/27/2019, and the "Intervenors' Motion to Broaden Scope of the Investigation (Corrected)", dated around 3/8/2018 (depending on which source is used). There are also several filings by interested parties in the PUC's online docket 17-3550 INV which mention potential issues. Even if these were not specifically listed in my scope of work, I attempted to address them during my investigation to

the extent that they are within my general scope of work – even if not explicitly stated. The intervenors have raised questions concerning blasting during the project, but that topic is not within my scope of work and is not addressed in this report.

References in this Report

All attachments to this report are pdf documents, and I frequently refer to them as "(Attachment A#XX, pdf page YY)". The "pdf page" refers to the page number within the attachment pdf file, which may be different than the page number shown in the original document. This report contains many excerpts from other documents, which I put in "quotation marks" and frequently include as separate indented paragraphs. Some of the excerpts contain quotation marks themselves. I have attempted to format these as needed to avoid confusion. Some of the excerpts are in ALL CAPS in the original, and I have retained that format in the excerpts.

The pipeline safety regulations refer to the "operator" as the company that operates a jurisdictional pipeline. In this situation, the operator is VGS.

The energy pipeline industry uses "station numbers" to refer to locations along the pipeline ROW. These are in 100 foot increments, starting at 0+00 and going along the length of the PL to the termination point. As an example, a point that is 23,465 feet from the beginning of the pipeline would be referred to as station 234+65. The station number for any given location along a pipeline may change during construction due to changes in route that make the pipeline longer or shorter than anticipated. I use station information provided by VGS when referring to specific points along the pipeline, which should correspond to the as-built length along the existing pipeline. These may be slightly different than station numbers referenced during construction.

The area between stations 1641+00 to 1666+00 is referred to by various names, including the New Haven swamp, the Clay Plains swamp, the Red Maple / Green Ash swamp, and Cisco's swamp. During my investigation all parties referred to this area as the Clay Plains swamp, and I do so in this report to maintain consistency.

Investigation Activities

I received a final contract for this assignment on January 11, 2019. The hearing officer for this investigation, Mr. Michael Tousley, Esq., gave me wide discretion to perform this investigation using my best personal and professional judgment to address the scope of work, and I have done so. Our communications since that time have been limited to administrative matters concerning the contract and other communications that typically involve several Level 5 interested parties (see below).

VGS committed to assist with this investigation and they have since provided me with every document or record that I have requested that is in their possession, responded to every question, and assisted with site inspections by me and others (primarily through their legal representative, Ms. Debra Bouffard, Esq.). I haven't attempted to do an exact count, but they have provided tens of thousands of pages of documentation. They have also dedicated a significant amount of internal and external resources to assist the investigation and site visits and to respond to my requests. The intervenors responded in a similar fashion, dedicating many hours of their personal time to participate

in the investigation activities and to respond to my requests. They have also provided a copious amount of information regarding their concerns through their legal representative, Mr. James Dumont, Esq. These are primarily the Intervenor's Motion to Broaden Scope of the Investigation (with multiple attachments) of 3-1-2018 (Attachment A#07 – excluding the original attachments) and the Intervenor's Summary of the Evidence for Independent Investigator William Byrd, PE (annotated with attachments) [annotated version dated 5-21-2019], my Attachment A#08 (excluding the original attachments). The attachments associated with Mr. Dumont's filings are already in the PUC's dockets and are not included in their entirety as attachments to this report. Mr. Dumont has also provided some supplemental expert reports as described below.

In accordance with my commitment to conduct this investigation in an open and transparent manner, with participation from all interested parties, I sent an email on January 16, 2019 to all parties identified in previous proceedings requesting participation from interested parties with 5 possible participation levels:

1. I can be dropped from this list.
2. Copy me only on status reports.
3. Invite me to all physical meetings and site visits (presumably in Vermont)
4. Copy me on all correspondence and invite me to all meetings (virtual and physical).
5. I plan to participate to the maximum extent possible. Please try to accommodate my schedule for all calls and meetings.

As of the date of this report there were 16 parties at Level 5, 10 parties at Level 4, 5 parties at Level 3, and 17 parties at Level 2, for a total of 48 interested parties. This list has remained fairly static during the course of my investigation, with a few changes mostly due to job re-assignments and replacements of personnel. My most frequent communications have been with Ms. Bouffard and Mr. Dumont. My practice has been to involve all interested parties according to their desired level of interest whenever group participation is appropriate.

I held a kickoff meeting with several of the interested parties at Mr. Dumont's office on February 27, 2019, to hear personally about their concerns and understand their issues. Mr. Dumont provided me with "Intervenors' Summary of the Evidence for Independent Investigator William Byrd, PE", recapping the issues in this investigation from their perspective. This was amended on May 21, 2019, to include citations to reference materials and a supplemental appendix which referenced previous filings and attachments by Mr. Dumont in the docket – easily in excess of a thousand pages. After the kickoff meeting I compiled and circulated a summary of issues and questions to be addressed during my investigation to the intervenors, other interested parties, and VGS, but received no suggestions for additional topics.

As indicated above, this investigation required the review of a vast amount of information. I reviewed the CPG for ANGP and identified all the requirements and commitments related to pipeline safety. We reviewed all the documents in the PUC dockets for this case. I personally reviewed thousands of pages of inspection reports of all types that were made contemporaneously during the ANGP construction, to get a better understanding of the types of things that were noted during the construction project by the people that were inspecting it, including hundreds of photographs. A summary listing of most of these reports is given in Attachment A#03, which does not include

inspections conducted by VTrans personnel or DPS (which I address separately). We have reviewed all materials provided to me by VGS and the Intervenors. The vast majority[2] of the documentation provided to me by various parties (not already in the dockets) has been shared with and between Ms. Bouffard and Mr. Dumont when it was provided to me. A partial index of those documents[3] is included as Attachment A#02, which provides a good indication of the types and volume of information included in our review. The documents referenced in this index consume more than 20 gigabytes of storage space. A small fraction of that information is included as attachments to this report.

In addition to the kickoff meeting in Mr. Dumont's office, I conducted 2 site visit trips, from June 17-21, 2019, and August 26-29, 2019. In preparation for those site visits, I informed VGS that I wanted to physically access and inspect:

1. The entire VELCO ROW in the Clay Plains swamp, to both inspect surface conditions and to verify depths of cover by direct probing in a few areas, and using remote sensing methods along the remainder of that ROW.
2. Hurlbert's property adjacent to the Clay Plains Swamp, including probing of DOC.
3. Each "non-jurisdictional" stream crossing (< 1 sq mile in headwaters), to inspect the crossing location in general, and to probe directly the depths of the pipeline at Sucker Brook in Williston.
4. Every crossing of the pipeline under / over a public road or a railroad.
5. Various locations along the ROW that required re-contouring of the surface to achieve the required DOC (exact locations TBD).
6. Various locations along the ROW where sand or bentonite trench breakers were designed to be installed, but were not, as well as locations where they were installed but not designed (exact locations TBD).
7. Every location that was excavated after pipeline construction and burial (i.e. the "dig sites").
8. Every cathodic protection rectifier and test station along the ROW, including any accessible facilities installed for AC mitigation.
9. Every above-ground pipeline facility along the ROW, including the beginning and final gas pipeline tie in facilities and intermediate tie-ins and valve stations – specifically including every main line valve site.
10. Every section of the ROW that is Class 2 or above.
11. Any remaining pipe from this project that may exist in VGS's inventory (presumably in a pipe yard), including any concrete-coated pipe.
12. Any remaining samples of pipe coating or pipe coating test specimens from this project.

[2] As the state's investigator, I have also been provided with a small amount of information by various parties that is privileged, confidential, or security-sensitive that has not been shared with others and is not attached to this report, such as GIS files (a.k.a. kmz files) containing detailed information concerning the pipeline location and related information, which is security-sensitive per the Department of Homeland Security and should not be shared publicly.

[3] The index represents most of the documents received but is for illustrative purposes only. I have not attempted to do a comprehensive summary of every document received from every party.

In response to my request, VGS prepared a summary by station number of the locations mentioned above, in an excel spreadsheet. Several of the intervenors, VGS personnel, and I reviewed that spreadsheet in detail on June 17, during the first day of my first site visit, at which time we agreed on the actual locations to be visited (i.e. the "various locations" mentioned above) and laid out a general schedule by day. The schedule was updated each morning and changed depending on circumstances. Various parties, including the intervenors, participated in the planning meetings and site selection for these site visits and were able to personally participate in these visits[4]. Some sites were visited during the first trip, some on the second trip, and some on both trips (to confirm / compare conditions from time to time).

To ensure I had a complete collection of all photos and videos taken during the site visits (and to simplify the tracking of that information), I instructed all parties not to take their own photos or videos but to ask me to do so if they had any specific requests. I used a camera that sequentially numbered each photo and video, and geo-coded each photograph with its location. I can easily reference them to the site where they were taken. The photo and videos taken during my site visits were provided on USB drives to Mr. Dumont and Ms. Bouffard shortly after each visit. These are several gigabytes and are too large to post to the PUC docket. I am providing them via USB drive to the PUC's hearing officer in conjunction with this report.

I was able to visit every site on my original list, with the exception of visiting every test station in item #8 (I inspected the most important ones), every dig location in item #7 (but I did visit several), and every section of the ROW in Class 2 and above areas in item #10 (but I did visit much of it). There were no remaining samples of pipe coating or pipe coating test specimens for me to inspect in item #12, other than a short piece of pipe with factory-applied coating. A printout of the spreadsheet, containing site-specific information from my visits and inspections including photo and video numbers, is included as Attachment A#09. The spreadsheet is color-coded to show which sites were visited on each trip.

I have visited and witnessed readings at every rectifier and at key cathodic protection locations and SSDs throughout the ANGP. I have also visited every jurisdictional stream crossing that was not directionally drilled, as well as many non-jurisdictional stream crossings. I have witnessed depth of cover measurements (both indirectly and by physically probing the pipeline) at dozens of locations along the length of ANGP. I have walked several miles of the pipeline ROW to inspect its condition. I have visited some locations twice, to compare conditions / readings from time to time. I took photographs and videos at all locations, and can reference them to their physical location, date, and time. My findings and conclusions from those visits are contained in the relevant sections of this report.

In addition to the people I talked to during the site visits and misc. phone calls, I interviewed the following people who had personal experience with ANGP during construction. I sent the topics of discussion for each interview to Mr. Dumont and Ms. Bouffard at least 1 week prior to each interview

[4] The second round of site visits was more difficult and physically challenging than the first, and I limited public participation to 1 participant (with one other participant from DPS). I set no limit to the number of participants in my first round of site visits and we typically had several each day.

for their review and comment, but I conducted each interview without direct participation from any other party. I sent a summary of the discussion to all Level 5 parties after each interview.

Interviewee	Employer	Role
Bill Jordan	VT DPS	Supervised GC Morris, DPS Gas Engineer (now retired), and John McCauley, DPS Consultant, who inspected ANGP for the state
Jeff Nelson	VHB	Did environmental permitting for ANGP; managed EPSC Specialists who did weekly inspections and reports to the VT DEC, xc ACOE, during construction
Jason Gorman	CHA	Engineering manager during construction
Donald Johnston	CHA	Lead surveyor during construction
Joey Wilson	WCE	Performed and supervised inspections and did bi-weekly reports to the ACOE during construction; participated in ANR inspections.
Dustin McDaniel; Randy Miller; Ron Hickman	McDaniel Tech. Serv	Provided construction inspectors in 2015; Respectively: CEO and President; VP Field Services; Sr. VP during ANGP (now retired)
John St. Hilaire; Chris LeForce	VGS	Project Executive Lead and Project Engineering Lead, respectively

I have prepared 6 status reports which have been copied to all interested parties, as well as a multitude of e-mails and phone calls between a subset of the parties as appropriate.

Discussion by Topic

Compliance with Pipeline Safety Regulations and CPG Commitments

The CPG for ANGP requires compliance with regulations, permits, etc., as well as additional requirements and commitments that are not part of the normal regulatory scheme. I refer to these extra requirements and commitments as the CPG commitments. In this report I generally address the basic regulatory requirements first, then the extra CPG commitments.

Regulations

Natural gas pipelines in the United States are regulated by the federal Pipelines and Hazardous Materials Safety Administration (PHMSA) through its Office of Pipeline Safety (OPS). States can become certified by OPS to regulated their intra-state pipelines, and the state of Vermont has developed its own pipeline safety regulations and is certified by the federal Office of Pipeline Safety to regulate intra-state gas pipelines. The Vermont pipeline safety rule PSB Rule 6.100 Pipeline Safety states (emphasis added):

> 6.154 Compliance With Federal Regulations
> Every gas transmission or distribution system shall be constructed, tested, and operated, except as otherwise provided in these Rules, in compliance with the provisions of the presently effective Federal Regulations and any future revisions of that code. When the regulations stated in these Rules are more stringent than the Federal Regulations, provisions in these Rules shall apply; if the provisions as stated in these Rules are less stringent than the Federal Regulations, the Federal Regulations shall take precedence.

The State of Vermont largely relies upon the federal pipeline safety regulations by incorporation "except as otherwise provided in these Rules". Vermont's additional regulations for pipeline safety are not relevant to the issues in this case, so I will refer to the federal gas pipeline safety regulations in 49 CFR Part 192. Some industry standards are incorporated by reference into the pipeline safety regulations and have the same effect as the regulation itself. Other industry standards have not been incorporated but still provide a useful reference when determining compliance with general-duty requirements (such as not to operate an "unsafe" pipeline).

The pipeline operator must have "comprehensive written specifications or standards" that are "consistent with this part" (i.e. the pipeline regulations) – and then they must comply with them. Non-compliance with a procedure or specification made by a pipeline operator pursuant to the regulations is considered non-compliance with the regulation that required that procedure or specification in the first place. Most of the non-compliance issues alleged by the DPS inspectors and the intervenors concerning ANGP are related to non-compliance with a specification or plan developed by VGS or its contractors – not non-compliance with a direct rule requirement.

A pipeline operator's operations and maintenance (O&M) manual (required by 49 CFR 192.605) is arguably the most important and highest-level pipeline safety document maintained by an operator. It is an over-arching document that applies to all types of routine activities, and operators are normally very familiar with the contents of their O&M manual. The operator must review and update their

O&M manual at least annually, and it is routinely inspected by PHMSA or the relevant state agency. It frequently is not limited to operations and maintenance activities and may contain many of the operator's other programs and procedures to comply with a variety of PHMSA requirements. In this case, VGS's O&M manual addressed construction activities. The construction requirements in VGS's O&M manual apply to all VGS pipeline construction activities, including the ANGP project – in addition to any project-specific specifications.

The general procedures in an O&M manual need to be supplemented with more details specifications and procedures when performing a significant project such as ANGP. 49 CFR 192 Subpart G - General Construction Requirements for Transmission Lines and Mains states:

> §303. Compliance with specifications or standards
>
> Each transmission line or main must be constructed in accordance with comprehensive written specifications or standards that are consistent with this part.

This report notes items where ANGP exceeded normal industry specifications and standards as well as failures to comply with ANGP written specifications and standards and attempts to put both into context.

The state of Vermont DPS conducted extensive inspections of ANGP during construction. The DPS inspectors were Mr. G.C. Morris, Gas Utility Engineer, and Mr. John McCauley, retired gas engineer with the NY PUC who assisted Mr. Morris on a contract basis. One or both of them inspected the ANGP most days during construction. In my experience, this level of inspection by a pipeline regulatory agency was extraordinary. In an industry that builds several thousand miles of new transmission pipelines each year in the US, pipeline construction projects of only 41 miles receive very few if any agency inspections at the state or federal level during construction. In fact, the pipeline safety regulations don't even require advance notification to PHMSA of projects of less than 10 miles (making their likelihood of being inspected during construction extremely low… because the agency personnel don't know about the new pipe until after it is put into service).

Regarding compliance with the pipeline safety regulations (aside from the items mentioned in my scope of work, which were examined in depth), I relied primarily upon the inspection reports created by the state of Vermont DPS inspectors - who inspected all aspects of the project from 2014 through 2017. DPS's inspection reports[5] from 2014 through 2017 are included as Attachments A#39 – A#42. We also did an independent review of DOT compliance records for the construction project to confirm that appropriate records have been retained.

[5] The inspection report for 2016 has a DRAFT watermark, but DPS has informed me that it is in fact the final report for that year.

The DPS inspection reports cite both the VGS ANGP Project Scope of Work and Specifications (in narrative form, by topic) and the engineering specifications prepared by CHA. For example, the DPS inspection reports for 2014 (Attachment A#39) contain this citation[6] regarding non-compliance with the VGS narrative specification:

ATTACHMENT A

PIPELINE CONSTRUCTION ISSUES

ISSUE#15 **PROCEDURES/ SUPPORT**	11/3/2014	Observed installation of pipe in ditch at station 120+00 in area where shot rock in ditch, supported by sandbags spaced between 23' and 35' on center. ANGP Scope of Work and Narrative Specification PAGE 22 OF 49 paragraph I requires " The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe. Structured pipe pillows shall be installed in the bottom of the trench at maximum intervals of every 16ft to protect the pipe from lying on rocks, sharp objects and/or debris which may cause damage to the pipe or pipeline coating. The COMPANY may require the CONTRACTOR to use select fill trench bottom padding material. Select fill base material for rock trench areas and areas with cobbles/boulders, shall provide a minimum of nine (9) inches of padding below and twelve (12) inches of padding on the sides and top of the pipe. Select fill material and/or padding material shall be sand in accordance with VTrans Standard Specification 703.03 or shall be screened native material containing silts, sands and gravels with the largest material being no larger than 1-inch on the longest dimension. Topsoil from the RIGHT-OF-WAY shall not be used for padding material.	§ 192.303 Compliance with specifications or standards. Each transmission line or main must be constructed in accordance with comprehensive written specifications or standards that are consistent with this part.	Y	Contractor went back and put in sandbags at 16' on center. Company has rewritten procedure for pipe support. Awaiting detail drawings for placement of sandbags.

Other DPS comments refer to the CHA specifications. Some of these resulted in a Notice of Probable Violation (NOPV).

The NOPVs issued by DPS were[7]:

- 12-22-2014 regarding welding procedures. These concerns were subsequently addressed by VGS, and there was no formal proceeding as a result.
- 8-5-2016 regarding mitigation of induced AC electrical voltage during construction in the VELCO ROW. These violations were related to failures to strictly comply[8] with CHA procedure 130000 – Minimum requirements for pipeline construction paralleling overhead electrical lines. These were not pipeline-safety related issues per-se, but rather worker safety issues (to prevent electrical shock from AC current induced on the pipe during unloading and assembly). There were no worker injuries as a result of these violations. VGS made changes

[6] Apologies for the poor quality of this screenshot. The relevant text reads "ANGP Scope of Work and Narrative Specification PAGE 22 of 45 paragraph I requires…":

[7] There was another NOPV from the Agency of Natural Resources concerning Harsh Sunflower impacts, but that was unrelated to pipeline safety and is not in my scope of work - and at any rate has already been resolved.

[8] The violation cites details down to using a ½" diameter ground rod instead of a 5/8" ground rod as called for in the specification, for example.

to its training and procedures and paid a $95,000 fine. The case was closed in December 2016.

- 2-16-2018 regarding burial and trench breakers (a.k.a. the "Bedding / TB NOPV" as cited elsewhere in this report). It also mentioned an "Additional Subject of Concern" regarding pipe coatings, but with no alleged violation of the regulations. This NOPV is currently open, pending the results of this investigation.

In response to a complaint filed by the public, PHMSA assigned two State Evaluators / Liaisons to review the construction inspections conducted by the DPS. Their report notes: "PHMSA found the DPS inspectors to be knowledgeable regarding pipeline construction, able to both identify issues and note problems requiring corrective actions." (Attachment A#43). Thus, I believe the DPS inspection reports to be a credible source of compliance (and non-compliance) information.

CPG Commitments

The PUC final order of 12/23/2013 "approves, with conditions…" the ANGP project. We developed a list of conditions in the CPG related to safety of the transmission pipeline starting in paragraph 258 and investigated each. A summary table of these commitments and my findings is included in the Conclusions section. Compliance with most of these commitments is not currently in dispute. Items that are in dispute are discussed in detail below.

Section VI FINDINGS of the final order states: "Based on the petition, accompanying documents, and testimony, the Board makes the following findings in this matter" (emphasis added). Intervenors have questioned whether VGS lived up to the commitments made in their various filings that formed the basis of the CPG – including commitments that were not explicitly mentioned the PUC's final order. Thus, I investigated not only the regulatory compliance requirements, compliance with internal plans and specifications, and normal industry practices, but also any additional commitments made by VGS to the PUC as part of the petition, accompanying documents, and testimony. These are addressed in the relevant topical discussion sections below.

Design and Engineering

Design Basis

As explained below, ANGP was designed using a very conservative engineering design basis. The ANGP was constructed with pipe with the following specifications:

- Outer diameter: 12.75”
- Wall thickness: 0.312”
- Pipe grade: API-5L Gr X-65 (i.e. a specified minimum yield strength of 65,000 pounds per square inch)
- Maximum Allowable Operating Pressure (MAOP): 1440 psi

I will attempt to put this design basis into context. A typical gas transmission pipe specification is “API 5L Grade B”, which has a specified minimum yield strength of 35,000 psi. At 65,000 psi, the steel used in ANGP is almost twice as strong as typical pipeline steel.

ANGP is also relatively thick for its diameter. One design metric for a transmission pipeline is its diameter to wall thickness ratio (the d over t, or d/t ratio). As the d/t ratio increases, the pipeline becomes more difficult to weld in the field and more susceptible to external loads (such as road crossings). A common design limit[9] for d/t ratio is 100. The d/t for ANGP is 40.8, which is less than half the commonly accepted limit.

Another measure of a pipeline is the allowable unsupported span distance (i.e. the length of pipe that can be suspended in air between pipe supports on a permanent basis). This can be calculated using several different methods. A generic piping guideline[10] for 12” diameter steel pipe filled with water (to make the calculation more conservative) for Grade B pipe indicates a safe span distance of about 42 feet between pipe supports. This same guideline notes that additional analysis should be performed for spans over 25’. A more detailed analysis using the piping handbook[11] indicates that for a 37’ span the deflection in this pipe filled with water would only be an eighth of an inch with a 100# weight suspended halfway between the supports, resulting in a maximum bending stress of 3,640 psi (and this steel can handle 65,000 psi of stress). This is well within normal design limits and indicates this pipe does not need to be firmly supported at closely spaced intervals. It can be suspended for dozens of feet at a time with no support whatsoever and still be within design requirements. The construction specifications for ANGP required support every 15 feet during backfilling – less than half the acceptable span distance.

It is also important to note that VGS committed to build the ANGP to “Class 3” requirements. The gas pipeline regulations define 4 “class” locations – each with their own set of requirements. Class 1 is the least populated and has the least strict requirements. Class 2 is more densely populated than Class 1 and has more strict requirements. Class 3 is for highly populated areas and for pipelines close

[9] https://allaboutpipelines.com/article/Largediameterpipelines
[10] www.piping-designer.com
[11] Crocker and King, 5th edition, McGraw-Hill

to populated and / or sensitive sites such as playgrounds and schools and has very strict requirements. Class 4 is for pipelines close to multiple high rise buildings and has the most restrictive requirements.

Nationwide[12], about 79% of gas transmission pipeline mileage is considered Class 1, 10% is considered Class 2, 11% is considered Class 3, and less than 1% is considered Class 4. By committing to build the ANGP to Class 3 requirements (regardless of the actual Class designation[13] in each area), VGS committed to meeting or exceeding the regulatory requirements of more than 99% of all gas transmission pipelines in the US. Less than 1% of the gas pipeline mileage has more restrictive requirements than ANGP was built to.

There are several design requirements for Class 3 that are important from a pipeline safety standpoint. Perhaps the most important is the "design factor" that is used to calculate the pipeline's working pressure limits. In simple terms, a Class 1 pipeline can operate up to 72% of its theoretical strength limit (giving a 28% margin for safety), while a Class 3 pipeline can only operate up the 50% of its theoretical strength limit (giving a 50% margin for safety). From an engineering standpoint, a Class 3 pipeline can only operate at half its theoretical design limit and will have twice the strength required to prevent failure due to internal pressure. A Class 3 pipeline has a high capacity to withstand any un-anticipated loads or unusual operating conditions.

In summary, ANGP was constructed with steel that is about twice as strong as normal, with a thickness twice that which causes concern in most design codes, with twice as many supports during construction and backfilling as might have been necessary, and will operate at pressures no more than 50% of the theoretical maximum. This conservative engineering design basis is relevant to several of the issues raised about its construction.

Specifications and Standards

The pipeline safety regulations in 49 CFR 192 contain general requirements about pipeline construction specifications and standards.

> Subpart G - General Construction Requirements for Transmission Lines and Mains
>
> §301. Scope
>
> This subpart prescribes minimum requirements for constructing transmission lines and mains.
>
> §303. Compliance with specifications or standards
>
> Each transmission line or main must be constructed in accordance with comprehensive written specifications or standards that are consistent with this part.

VGS hired a professional engineering firm, CHA, licensed in Vermont, and various other contractors and subcontractors to develop the design drawings and specifications for ANGP. Some of these were

[12] https://www.aga.org/sites/default/files/legacy-assets/our-issues/safety/pipleinesafety/TransmissionPipelines/MAOP-Verification-and-Pressure-Testing-for-Transmission-Pipelines/legislation/Documents/Blaine_Keener.pdf data as of 7-1-2013

[13] Class locations are based on population density and can change with time. As of this report ANGP has 7.5 miles of Class 3 locations and 4.5 miles of Class 2 locations, with the remainder (29.2 miles) being Class 1.

submitted to the PUC as part of the application for the CPG, including a submittal to the PUC on 2/28/13 and a supplemental submittal on 6/28/13. The submittals to the PUC contained project plan drawings showing the route and typical design and construction information but did not include the detailed engineering and other specifications.

There were many plans, specifications, and reports created for construction of ANGP. During the early stages of the ANGP design process, a geotechnical report was prepared by CHA on 6/13/13 under the direction of Ronald K. Burns, PE, a licensed civil engineer in Vermont since 2/27/1991. This 527-page report addressed, in detail, geotechnical conditions along the entire route of ANGP as planned at that time.

One example of the scope of the specifications for ANGP is the bid specifications of May, 2014 (after issuance of the CPG), which included:

- 35 pages of General Conditions,
- 10 pages of Supplemental Conditions,
- digital attachments for all local, state, and federal permits, MOUs, and memorandums (including the VELCO technical memorandum of 10/1/2012),
- 4 Addendums,
- 4 Post Bid Bulletins,
- an abridged version of the VGS O&M manual for construction contractors,
- the Vermont Gas ANGP Project Scope of Work and Specifications (a.k.a. the VGS narrative specification),
- engineering specifications prepared by CHA,
- Alignment Sheets,
- EPSC Sheets,
- Mechanical, Civil, and Electrical drawings for the Colchester launcher and tie in site, the mainline valves, and the Williston, Plank Road, and Middlebury meter and regulating stations, and
- the AC mitigation system drawings and the cathodic protection system design drawings prepared by ARK engineering.

I prepared a detailed index of these bid specifications in Attachment A#16. The full package is given in Attachment A#17.

Special conditions in the CPG regarding pipeline construction were incorporated into the various project plans and specifications. The ANGP project specifications incorporated relevant parts of the VGS O&M manual, and contain the following note (italics in the original):

> *"*NOTE: The VGS Operating and Maintenance Manual (the Manual) is a working document and is continually updated and improved. This Manual is controlled only by VGS. The included sections are for reference and bidding purposes only. If awarded the Transmission Phase Contract, the selected Contractor is required to contact VGS for the most current release of the Manual prior to beginning construction."*

Thus, the ANGP project-specific specifications existed in parallel with the O&M manual that VGS normally used. Sometimes these documents referenced each other. For example, section 13 BACKFILLING of the VGS narrative specification, paragraph t states: "Refer to the following specifications for additional requirements: A. 312333 Trenching and Backfilling" (i.e. the CHA specification).

In addition, contractors were required to develop their own site-specific plans for some activities (such as pressure testing) and submit them to VGS for approval.

The contractor was expected to comply with the requirements of the entire bid package, including the engineering specifications prepared by CHA, the VGS O&M manual, the Vermont Gas ANGP Project Scope of Work and Specifications (a.k.a. the narrative specification), and any other site-specific plans for that activity. The design drawings contain only part of the requirements and were never intended to convey all the necessary detailed information. This is mentioned in Addendum 2 of the bid specifications (Attachment A#17, pdf page 88):

> "20. Q: "*Are all of the EPSC requirements on the EPSC drawings or does the contractor need to reference other documents?*"
> A: No, all EPSC requirements are not on the EPSC drawings. The anticipated EPSC requirements on the EPSC Plan are shown to the best of our ability prior to issuance of the Individual Construction Stormwater Discharge Permit (INDC). Once the INDC is issued, it will also serve as a reference for EPSC requirements. The contractor shall review all components of the EPSC plans (notes, details, typicals), as not all requirements are shown just on the plan view sheets. The contractor shall comply with all EPSC measures defined in the Contract Documents."

For projects of this type, with extensive specifications and requirements from multiple sources, there may be inconsistencies between these documents. There may also be situations encountered in the field that are not clearly addressed in the specifications or for which the specification is unnecessary or even inappropriate. This can lead to confusion or disagreement as to the appropriate course of action during construction, which the CMT is called upon to resolve.

Changes to the specifications were made during the project, as anticipated in the specifications themselves, to address site-specific issues and to clarify or reconcile inconsistencies within the specifications. These changes generally took 3 forms:

- Project Directives were issued directly from VGS to the field, normally to clarify or add requirements.
- Modification Bulletins were official modifications to the CHA specifications and plans.
- Requests For Specific Information (RFSI) were routed through VGS to CHA for final decisions from the engineer of record.

Construction Management Team

The project organization charts describe the Construction Management Team (CMT) (Attachment A#06). The project management organization evolved over time, although core members of the team were consistent. Chris LeForce was the Engineering manager, and per the standard form agreement (SC-1) CHA was the "Engineer" (CHA didn't list individual engineers within its firm). The project organization chart dated October 15, 2014, shows Chris LeForce as the Project Engineering Manager and Tyler Billingsley as the Project Engineer, reporting to Mr. LeForce. A subsequent organization chart on April 27, 2015, showed Chris LeForce as the Project Engineering Lead, with a "Third Party Technical Engineer" being HMM and an "Engineer of Record" being CHA – both reporting to Mr. LeForce. This was shown again in an organization chart dated April 18, 2016. Engineer's Consultants were listed as VHB, ARK, and Northern Energy Consulting. Per the project bid specifications (Attachment A#17), General Conditions 6.7, the Engineer could approve alternative materials or methods. Article 9 of the General Conditions explains the Engineer's role and responsibilities during construction, including issuing clarifications and interpretations and authorizing minor variations.

The specifications called for the CMT to exercise oversight and provide direction during construction of the ANGP. Section 312333 of the CHA specifications states that the CMT can make final decisions concerning:

- the suitability of materials that are to be used, specifically for select backfill / pipe padding; and general backfill
- the suitability of the trench bottom "for properly placing select backfill/padding material and laying pipe"
- the point of discharge for de-watering operations
- the bracing / protection system for pipe prior to completion
- pipe supports prior to backfilling
- methods of bedding the trench bottom
- the skids and protective padding materials to be used during pipe stringing
- the pipe bending machine and methods; and suitability of pipe after bending
- equipment spacing used for pipe lowering-in operations
- additional jeeping of the pipe coating prior to lowering-in
- location and type of rock shield
- suitability of drain tile repairs
- placement of backfill against structures
- additional testing on backfill

Professional Engineering

The pipeline safety regulations in Vermont and at the federal level do not contain any requirements for professional engineering certification of plans and specifications. This matter is left up to the state professional engineering regulatory bodies (in this case, the Vermont Secretary of State, Office of Professional Regulation). The Vermont professional engineering requirements are intended to safeguard "public health, safety, and welfare" by, among other things, requiring that professional engineers, licensed by the state, be in "responsible charge" of engineering activities, and that they provide their personal PE stamp and signature to indicate their review and approval of engineering

plans. The persons and firms with a license carry the responsibility to ensure that their work, including stamping / certifying that work, complies with the applicable regulations.

A complaint was filed on March 15, 2013, with the OPR concerning professional engineering requirements and oversight for the ANGP project. The OPR investigated the issues alleged in the complaint and closed their investigation with no adverse findings on January 30, 2014. The closing report[14] states:

> *"Investigation confirmed that the Vermont-licensed respondent served as Principal-in-Charge of the Vermont project and remained meaningfully in responsible charge of those activities undertaken by other design-team members. Both unlicensed respondents under the Vermont Licensee's supervision were highly qualified by training, experience, and education; and each had attained licensure in a foreign jurisdiction. The Vermont licensee was actively engaged in the project and verified the subordinates' work; he did not act as a rubber stamp. The Vermont licensee directly supervised the preparation of design progress drawings and application materials."* (emphasis added).

CHA has stated in writing to VGS that the plans were prepared under the responsible charge of engineers licensed in Vermont (Michael E. Hollowood, civil, Joseph J. Thomson, mechanical, and James B. Fuller, electrical). However, these plans and drawings had not been sealed and signed when the ANGP was being constructed. Mr. Hollowood received his PE in Vermont on Sept 5, 2013, after the construction drawings were issued in June 28, 2013. Some state PE boards allow the practice of professional engineering in the state by a licensee of another state while their state-specific application is pending – so I do not know if would have been acceptable for Mr. Hollowood to stamp these plans on June 28, 2013 or not (given the dates it would be likely that his Vermont license was pending at that time). That fact is that he was accepted and did become licensed by the State of Vermont shortly after June 28, 2013, so there does not appear to a lack of competence.

Mr. Gregory Liebert, PE, prepared a report for Mr. Dumont on September 12, 2019, which was provided to me, VGS, and others by Mr. Dumont on the same day. It noted that the plans issued for construction (IFC) had not been stamped by a professional engineer at the time, and that the plans stamped after construction had been stamped only by a civil engineer, not mechanical or electrical – as would be appropriate for the metering and regulating stations and the Colchester launcher and tie-in site. Subsequent to that report, VGS did a further investigation of their records and located plans for the mainline valves, the Colchester launching facility, and the Middlebury, Williston, and Plank Road gate stations that were stamped by mechanical, electrical and civil professional engineers, and which had been provided to VGS in January 2019 in paper form only. These plans were inadvertently omitted from the electronic file. VGS subsequently obtained electronic copies of those plans noted above as missing and they were provided to me on 9/23/2019, and to Mr. Dumont and others shortly thereafter.

CHA replied to Mr. Liebert's memo in their own memo dated November 6, 2019, claiming that Mr. Colantonio was the Vermont-licensed PE in charge until Michael Hollowood took over in October

[14] The OPR report is marked as Confidential and is not included in my attachments.

2013. CHA also re-iterated its earlier position that the IFC drawings were prepared under the supervision of the 3 persons mentioned in their earlier letter. Mr. Dumont replied in a memo on November 7, 2019, questioning some of CHA's statements and requesting detailed timesheets for the engineers involved.

Mr. Liebert prepared another report dated November 7, 2019, pointing out that the Cathodic Protection System Design and the AC Interference Analysis and Mitigation System Design, both prepared by ARK Engineering and Technical Services, Inc., had likewise not been stamped by a Vermont-licensed PE prior to being issued for construction. Mr. Dumont transmitted that report to me on November 12, 2019.

Intervenors have noted that the National Transportation Safety Board (NTSB) has recommended that PEs stamp utility design plans. The NTSB report was made in late 2018 - after the ANGP had been designed, built, and put into service. At the time of the NTSB's report, 31 states had blanket exemptions from PE stamp requirements for gas utility work. Further discussion concerning the NTSB report is given in the Supplemental Discussion section of this report.

Corrosion Control

The pipeline safety regulations dedicate an entire subpart to corrosion control (49 CFR 192 SubPart I). The corrosion control topics of concern to this investigation are primarily related to pipeline coatings and cathodic protection.

> *49 CFR 192. 455. External corrosion control: Buried or submerged pipelines installed after July 31, 1971*
> *(a) Except as provided in paragraphs (b), (c), and (f) of this section, each buried or submerged pipeline installed after July 31, 1971, must be protected against external corrosion, including the following:*
> > *(1) It must have an external protective coating meeting the requirements of §192.461.*
> > *(2) It must have a cathodic protection system designed to protect the pipeline in accordance with this subpart, installed and placed in operation within 1 year after completion of construction.*

Coating

Much like the paint on a car, the external coating of a pipeline is the first line of defense against external corrosion for a steel pipeline. It physically isolates the steel from its environment, stopping most corrosion mechanisms before they start. The regulation for external coating states:

> *§461. External corrosion control: Protective coating*
> *(a) Each external protective coating, whether conductive or insulating, applied for the purpose of external corrosion control must-*
> *(1) Be applied on a properly prepared surface;*
> *(2) Have sufficient adhesion to the metal surface to effectively resist underfilm migration of moisture;*
> *(3) Be sufficiently ductile to resist cracking;*
> *(4) Have sufficient strength to resist damage due to handling and soil stress; and*
> *(5) Have properties compatible with any supplemental cathodic protection.*
> *(b) Each external protective coating which is an electrically insulating type must also have low moisture absorption and high electrical resistance.*
> *(c) Each external protective coating must be inspected just prior to lowering the pipe into the ditch and backfilling, and any damage detrimental to effective corrosion control must be repaired.*
> *(d) Each external protective coating must be protected from damage resulting from adverse ditch conditions or damage from supporting blocks.*
> *(e) If coated pipe is installed by boring, driving, or other similar method, precautions must be taken to minimize damage to the coating during installation.*

Items (a)(1) and (a)(2) are related, because proper surface preparation is required for the coating to sufficiently adhere to the pipe. Surface preparation is typically done by scraping off impurities with a wire brush or sandblasting. Items (a)(3) and (a)(4) concern the physical properties of the coating to ensure it won't crack or fail during handling. Item (a)(5) ensures that the coating will effectively support the cathodic protection system (explained below).

Steel pipelines normally have shop / factory-applied coatings covering most of the pipe length except the ends (installed in some facility away from the job site), as well as field-applied coatings covering the welded joints and any other areas that need repair (installed in the field after the pipe joints are welded together). The ANGP followed this pattern.

The shop-applied corrosion control coating for ANGP was either Pritek or fusion-bonded epoxy (FBE). The specifications for and application of the shop applied coatings have been reported in detail to DPS per DPS's request of May 19, 2014 (Attachment A#18). The full set of information referenced in CHA's report is voluminous and not attached to my report, but our review of the information found it to be typical for new pipeline construction with no problems noted.

An abrasion-resistant overlay (ARO) was applied over the shop applied coating for pipe that was to be installed by HDD, to provide an additional layer of physical protection to the underlying corrosion control coating for pipe to be pulled through a drilled wellbore. Likewise, a concrete coating was installed over the underlying corrosion control coating for pipe to be laid in areas requiring buoyancy control (the concrete makes the pipe heavier). The ARO and concrete, where they exist, are not part of the corrosion control system.

The types of field-applied coatings used for ANGP changed over time, in response to coating inspection concerns. The personnel applying field coatings were qualified under VGS's operator qualification (OQ) program, as noted in DPS's inspection reports (Attachments A#39 – A#42).

In its NOPV dated February 16, 2018 (the Bedding / TB NOPV), DPS noted an "Additional Subject of Concern: Pipe Coating (No Allegation of Probable Violation)" (Attachment A#65). The stated DPS concerns were:

- Some patches to the shop-applied Pritek coating were discovered to not be bonding adequately to the base coating.
- Some manufactured lots of Canusa Sleeves (field wraps) exhibited adhesion failure. Most of these sleeves were replaced prior to installation, but 67 Canusa sleeves from these lots are still in place because the pipe had already been buried when the problem was discovered.
- Some pipe exiting HDDs had damage to the external coating, down to bare metal.

The DPS noted that the remedial actions proposed for other items in the NOPV (additional ILI and corrosion prevention activities) would also apply to the potential coating issues.

VGS responded to those concerns in detail in their response of February 28, 2018 (Attachment A#66). VGS noted[15]:

- The specification for trenching and backfilling requires a minimum of 2 comprehensive coating inspections (a.k.a. jeeping) (attachment 1, page 8 of 10)
- Project Directive 2015-010 dated 9/29/2015 eliminated the option to use wire brushing for surface preparation of shrink sleeves and required sandblasting (attachment 2, tab 7).

[15] The attachments, tabs, and page numbers in the following list are all internal to my report's Attachment A#66

- Adhesion issues were discovered with 2 different types of Pritek patches applied by the coating yard. VGS switched to Canusa sleeve wraps as a solution (attachment 2, tab 7).
- The Canusa Sleeve failures from certain early batches were due to adhesive separating from the outer layer. The manufacturer states that this is a destructive test (i.e. failure is the only option), with the only question being how the failure occurs. In every test the adhesive stayed adhered to the pipe surface – which is evidence of "proper surface preparation and preheat", and is an acceptable result of the test (attachment 12).
- Different adhesion testing percentages were specified for application of epoxy coatings in winter months versus summer months (attachment 2, tab 7).
- A special ARO was specified for welds inside HDDs (attachment 2, tab 7).
- VGS hired EN Engineering in 2015 to do a subsequent evaluation of the Route 2A/Rail Crossing HDD which had some evidence of coating damage to bare metal. EN used 4 different (and complimentary) techniques to evaluate the effectiveness of the pipe coating as-installed. Their readings indicated one minor coating defect in the HDD, but then noted that the cathodic protection system should adequately address this "as long as coating damage does not exist anywhere else along the pipe that would raise the necessary cathodic protection levels" beyond the design criteria[16] (attachment 2, tab 9).
- The Monkton Swamp HDD that had coating damage down to bare steel in some locations was pulled through until a 15' section had no defects in the corrosion control coating (although the ARO still had damage – which is acceptable) (attachment 13).

Cathodic Protection

A cathodic protection (cp) system imposes a weak direct electrical current on the buried pipeline steel that causes the pipeline to become a "cathode" (which acts like a noble metal and does not corrode as opposed to an "anode", which does). The voltages involved are about the same as a AA battery, creating no electrical shock threat to workers or the public. There are several criteria that can be used to determine if a cathodic protection system is working as required, with the most common being a "pipe-to-soil" (p/s) reading that compares the difference in voltage between the steel and the surrounding earth. A voltage of negative 850 mv (-0.85 volts) or more negative is generally adequate. Cathodic protection p/s readings are typically spaced a few thousand feet apart along the length of the PL ROW. Operators may also conduct "close-interval surveys" (CIS), which provide readings every few feet along the length of a pipeline segment. There are other techniques, such as Direct Current Voltage Gradient (DCVG) surveys, which provide complimentary information to the p/s readings and can be used to identify problem areas in a cathodic protection system. VGS used all of these techniques.

The PHMSA regulations require that a cathodic protection system be functional within 1 year of construction. The 1 year allowance after completion of construction does not mean that the operator can wait one year before worrying about cathodic protection. Rather, it acknowledges that cathodic protection systems are typically installed as a final step in the construction process and that cp requirements for pipelines change gradually over time after construction, as the pipeline adjusts to its new environment. The operator has a year to finalize and fine-tune the cathodic protection system to ensure that the entire pipeline meets the regulatory requirements.

[16] The cathodic protection system currently operates at a small fraction of its design criteria, as described below.

ARK specified 3 rectifiers, roughly evenly spaced along the length of the pipeline system, to provide cathodic protection current. Per the design package for the cathodic protection system prepared by ARK engineering (Attachment A#29): "The pipeline's DC current requirements for each of the cathodic protection systems have been determined using the pipeline dimensions and the cathodic protection design requirements. This design is based upon a current density of 1 mA/square foot and a maximum of 1.0 % bare surface area. An allowance of 50 % has been made to account for future coating deterioration of the pipeline." Per ARK's calculations, the 3 rectifiers would need to put out a total of 12 amps of electrical current – although they were designed to provide a total of 60 amps of current if needed.

Per the report from ARK CP Testing & Commissioning Report, Addison Natural Gas Project (first 11 miles), issued February 18, 2016, the first rectifier is located on Route 17 in Essex (known as the Williston Rectifier Bed) and was commissioned January 28-29, 2016 (Attachment A#31). The first 11-mile northern of pipeline were gassed up on February 9, 2016 and protected by this rectifier.

Per the report from ARK Testing and Commissioning Addison Natural Gas Project (30 Mile Section), issued May 1, 2017, the next 8-mile section of pipe was tied into the northern 11 mile section and gassed up on October 7, 2016 (Attachment A#32). These two sections were both being protected by the Williston Rectifier Bed. The second and third rectifiers, on Rotax Road in Monkton (or known as the Monkton Rectifier Bed) and on Route 7 in New Haven (or known as the Middlebury Rectifier Bed), were commissioned March 16-17, 2017. The final 22-mile section of pipe was tied into the northern 19-mile section and gassed up on 4/11/2017. At this point, all three rectifiers were on and protecting the entire 41-mile pipeline.

I inspected all 3 rectifiers during my site visits and witnessed readings of each. These rectifiers can be adjusted to change the voltage and current output. Two are set at the lowest possible settings, and the third is set slightly higher than the lowest possible setting. Although they are capable of putting out up to 60 amps of current, all 3 rectifiers combined only put out less than 1 amp of current. They are essentially running on idle – because that is all that is required to achieve desired cathodic protection levels. The internals of rectifier #1 are shown in Attachment A#10 image 2440.

I also witnessed p/s readings at 9 locations from the start to end of ANGP, including locations midway between rectifiers (which would be expected to have the least amount of cathodic protection) and locations adjacent to each rectifier (which might have too much cathodic protection). All of these locations were well into the acceptable range of cathodic protection. I witnessed p/s readings at two of these locations on both visits, to compare readings from time to time. Both locations were within 10% of the previous reading, indicating a very stable cathodic protection system. A typical cp reading is shown in Attachment A#10 image 2411.

CIS and DCVG surveys were conducted over the entire length of ANGP in late 2016 – 2017. ARK Engineering did a subsequent study of these surveys, aligning the information from both, and found no problems. Per the executive summary (Attachment A#33): "There were only three gradable DCVG indications found for the whole pipeline. Two were located at test station locations and the third was located in a series of bends in the pipeline. Since there were only three found over the entire

length of the pipeline of approximately 41 miles, cathodic protection was relatively easy to establish with a minimum of current. The small number of DCVG indications is also a compliment to the attention to detail maintained during the installation and construction phase of the installation."

A "gradable" indication simply denotes an area for further study, to determine the cause of the aberration in the reading. The test stations would cause an aberration in the readings, as would a series of bends. None of these "gradable DCVG indications" indicated problems with the pipeline coating or cathodic protection system.

Several miles of ANGP are in or adjacent to a VELCO or Green Mountain Power ROW containing high voltage overhead electrical transmission lines. These types of electrical transmission lines can create stray electrical currents in the ground surrounding the pipeline that interfere with the cathodic protection current protecting the pipeline from corrosion. Fortunately, electrical transmission systems use alternating current (AC) while cathodic protection systems use direct current (DC), and it is possible to isolate the beneficial DC current from the potentially harmful stray AC current. This is called AC mitigation.

The AC mitigation system was thoroughly designed by ARK Engineering and Technical Services, as described in their report of May 20, 2016 (Attachment A#30), considering both normal and abnormal operating conditions[17]. The design called for zinc ribbon to be buried between the ANGP pipeline and the VELCO electrical transmission lines in specified locations, connected to ANGP using Solid State Decouplers (SSDs). Per the report (page 36) "These devices allow AC current to flow from the pipeline to the grounding system while blocking any DC cathodic protection current from flowing off the pipeline to the ground conductors." I witnessed readings at several SSDs and noticed them at locations as required. The SSDs are all listed on the site visit spreadsheet, Attachment A#09, and are normally easy to spot because they stick out of the ground a couple of feet in a box. Each SSD box indicates at least one zinc ribbon connection (in some locations an SSD connects to zinc ribbon running in 2 directions). An SSD box and internals are shown in Attachment A#10 images 2414 and 2415.

The zinc ribbon, being electrically connected to the pipeline, interferes with the line locating equipment in the areas of the ROW where it was located. This can be avoided by physically disconnecting the zinc ribbon from the pipeline – which allows the line locator to track both the pipeline and the zinc ribbon independently. I did this from stations 888+00 and 892+75 (Section #8 on the ARK plans) to confirm the zinc ribbon installation in that area. I encountered an issue when attempting to use the line locating instrument to determine DOC in the Clay Plains Swamp, because the technician was originally unable to locate and disconnect one of the SSDs in the swamp vegetation. We physically probed the pipeline DOC in those locations. My activities to confirm the zinc ribbon in the Clay Plains Swamp are described in more detail in an e-mail of 9/4/2019 (Attachment A#34).

[17] In this instance, the normal and abnormal operating conditions refer to the electrical transmission lines, not ANGP.

Quality Assurance

The pipeline safety regulations in 49 CFR 192 contain the following requirements for inspection during pipeline construction:

> Subpart G - General Construction Requirements for Transmission Lines and Mains
> §301. Scope
> This subpart prescribes minimum requirements for constructing transmission lines and mains.
> …
> §305. Inspection: General
> Each transmission line or main must be inspected to ensure that it is constructed in accordance with this part.
> §307. Inspection of materials
> Each length of pipe and each other component must be visually inspected at the site of installation to ensure that it has not sustained any visually determinable damage that could impair its serviceability.

Additional guidance is contained in an industry standard publication: Guide for Gas Transmission, Distribution, and Gathering Piping Systems (ANSI Z380.1)[18] (a.k.a. the "GPTC Guide), which states: "Each operator should provide inspection by personnel who are knowledgeable by training or experience. Inspection should ensure that all work conforms to the operator's specifications and to the applicable federal, state, and local requirements. The inspector should have the authority to order the repair or the removal and replacement of any component that fails to meet the above requirements."

In July 2013, the American Petroleum Institute (API) issued API RP 1169: Recommended Practice for Basic Inspection Requirements – New Pipeline Construction[19]. While it has not been incorporated into the pipeline safety regulations, this RP provides a useful reference to recommended practices for inspection during construction of new energy pipelines (such as ANGP). It defines "inspector" as: "An individual qualified to monitor, assess, evaluate, verify, discuss, decide, resolve, report, and document pipeline construction activities to ensure the requirements of the design, drawings, specifications, regulations, and industry practices are being met safely, efficiently, and in an environmentally sound manner." It does not require that inspectors personally inspect every activity every day during construction. On November 1, 2017, API issued the first edition of API RP 1177: Recommended Practice for Steel Pipeline Construction Quality Management Systems, First Edition. That RP did not exist during the construction of ANGP.

A quality assurance plan was incorporated into the ANGP project specifications prior to construction. Section 014000-QUALITY REQUIREMENTS, in the Project Manual / Bid Specifications of May

[18] https://www.techstreet.com/standards/aga-z380118?gclid=EAIaIQobChMI2sjnqof85QIVDNvACh1j2AsHEAAYASAAEgIvMvD_BwE&sid=goog&product_id=2016421

[19] https://www.techstreet.com/standards/api-rp-1169?gclid=EAIaIQobChMIzdTWyaip5gIVB77ACh2miwbyEAAYASAAEgKNSvD_BwE&sid=goog&product_id=1861898

24, 2014, described the general requirements for Quality Assurance, Quality Control, Inspection, and Testing for the construction project (Attachment A#17, pdf pages 384 - 392).

VGS prepared Inspection Manuals for construction activities in 2014, 2015, 2016, and 2017. These manuals contained inspection forms and other reference materials for inspectors. The manual for 2014 is included at Attachment A#35. It is 462 pages and contains sections dealing with:

1. Hospitals and Emergency Contacts
2. Acronyms & Abbreviations
3. Report and Picture numbering Protocol
4. Weld Numbering Procedures; Radiographic Numbering Procedure; Tie-in Reports
5. Coating Reports
6. Pipe Tally
7. Hydrotest
8. Gate Inspector Reports
9. HDD Inspector Reports
10. Main Line Inspector Reports
11. Specifications
12. Gate – Contractor Scope
13. HDD – Design Build – Contractor Scope
14. Main Line – Contractor Scope
15. VGS Safety Manual.

The Inspection Manuals for 2015, 2016, and 2017 were similar in size, contents, and scope as the 2014 Manual and have not been attached.

VGS hired a variety of inspectors to ensure the pipeline was constructed safely and in accordance with the plans and specifications. Many inspectors were multi-skilled and could perform several types of inspection (such as welding and coating inspections). Some inspectors were individually issued field notebooks to document things that are more generalized than would be documented on an individual inspection form or report.

Many of the inspectors were provided by third party firms. Per VGS, construction inspection personnel were provided by:

- AK Environmental LLC in 2014
- McDaniel Technical Services in 2015
- Hatch Mott McDonald in 2016

Some of these personnel simply changed from one employer to another from year to year and continued their inspection duties for ANGP as before (which is common in the industry).

The inspectors were provided with the inspection manual as noted by inspector Eric Curtis on 7/12/2014 “Insp. Book issued, meeting w/ insp. Team was held at 7:30 am” (Attachment A#36 pdf page 21).

Inspectors were also responsible for tracking "Pay items", which are paid on a per-unit basis under the contract. For example, boring through rock might be a pay item that is reimbursed to the contractor at $x / foot. The inspector would record how many feet of rock was bored each day, to ensure the contractor billed the owner for the appropriate amount of rock boring. Inspector Eric Curtis's field notes from 7/8/2014 note "Agree on pay item footages with foreman daily." (Attachment A#36 pdf page 21).

Wilson Consulting Engineers, PLC, of Montpelier, VT, was engaged for the duration of the construction project, and submitted bi-weekly reports to the Army Corps of Engineers (ACOE) regarding compliance with the discharge permit for this project. These reports (72 in all) contain a general description of work activities during the report period as well as color photographs (focused primarily on water crossings, wetlands, and sediment control structures, but also providing photos of associated activities). These reports were very helpful in assisting me in understanding the typical work activities and conditions throughout the project. They also recorded any significant rainfall, by date – which is relevant to some construction issues encountered during the project.

VHB provided the "EPSC Specialist", as required by the Vermont Department of Environmental Conservation (DEC), Watershed Management Division, NPDES Number VTS00000146, Permit Number 6949-INDC. The permit required that the EPSC Specialist be approved in advance by the DEC. Among other things the permit required:

> *"The EPSC Specialist shall notify the contractor when changes in practice are necessary to comply with the EPSC Plan and the terms and conditions of this permit. The EPSC Specialist shall be responsible for inspections, photo documentation, and record keeping and shall, weekly during earth disturbance activities, file with DEC a report outlining:*
> *a. Construction status;*
> *b. EPSC practices installed and removed since last report;*
> *c. New measures undertaken subsequent to the prior report;*
> *d. Erosion problems encountered and how and when resolved;*
> *e. Status of the project in terms of consistency with the planned construction sequence;*
> *f. Description, including location and total area (acres), of disturbed land at the time of the inspection;*
> *g. Description of areas temporarily or permanently stabilized since the last inspection record;*
> *h. Changes in the EPSC Plan that are required (including submission for authorization from DEC, when necessary);*
> *i. When dewatering is underway, discussion and photographs of measures being utilized for treatment, and turbidity monitoring results in conformance with Part III.H of this permit;*
> *j. Photographs of areas stabilized since the prior report;*
> *k. Photographs of all disturbed areas;*
> *l. Photographs of receiving water(s) at turbidity monitoring location(s); and*
> *m. All turbidity monitoring results collected since prior report in accordance with Subpart III.B of this permit."*

The EPSC Specialist filed weekly reports in a format approved by the DEC directly to the DEC including pictures and descriptions of construction work activities. These reports were copied to about 10 people outside of the DEC, including the USACE, VGS, and other contractors. There are 156 EPSC reports in the materials I received, and I reviewed them all.

As described in the Compliance section of this report, the Vermont DPS also had personnel who observed the complete spectrum of field construction materials, personnel, and activities, as documented in their inspection reports (Attachments A#39-A#42).

Mr. Randy Snelling from VTrans also did periodic inspection when pipeline construction activities were in or adjacent to highways.

I personally reviewed 701 pages of field notes and 14,506 pages of other construction-related inspection reports, including ditching, coating, jeeping, gate station, mainline, welding, HDD, and others. This included more than 4,000 pages of Mainline and Welding inspection records and more than 2,000 pages of general inspection reports. Those topics are not currently at issue so I will not delve more deeply into them. Coating inspection is currently at issue and I deal with it in more detail below. VGS also provided me with 57 documents containing qualifications for the inspection personnel, which I spot-checked.

Coating Inspections

As mentioned earlier, pipelines have both factory-applied coatings and field-applied coatings. The application of factory-applied coatings was addressed by VGS's "Specification for Application of Pipeline External Coatings" (Revision 4 dated April 18, 2014, is Attachment A#19). Inspection of the application of those coatings was done in the factory. The ultimate integrity of these coatings and any repairs was determined during the final comprehensive coating inspection process described below.

The inspection of field-applied coatings falls under the general construction inspection regulations described above. As noted by the Intervenors from inspector Kelch's reports, VGS did not conduct inspection of the application of all field coating locations in 2014. Instead, VGS conducted and documented detailed inspections of a sampling of locations during field coating application. That was consistent with industry practice and the regulatory requirements. These inspections were comprehensive and detailed, noting the dates, locations, contractor & supervisor, ambient conditions (in detail), steel temperature, Testex[20] tape results (to confirm adequate surface preparation), type of coating (in detail), applied thicknesses, and inspector's notes. Different forms were used for "below ground" and "HDD" coating inspections. The VGS response to the Bedding / TB NOPV mentions that there are 340 welds for which they have no corresponding installation inspection report (A#66, attachment 2, tab 1, page 3 of 6). A 41 mile pipeline with pipe joints every 40 feet would have more than 5,400 welds – indicating that ANGP had an application inspection rate of about 94%, which far exceeds the typical "spot check" inspection process for field-applied coatings during application. Nevertheless, VGS changed their inspection practices after 2014 and conducted detailed inspection of

[20] http://www.testextape.com

the application of all field coatings. This went beyond the requirements of the regulations and typical industry practices.

Other inspections of coatings took place during construction. From my review of field inspection reports, James Haney apparently managed field fabrication and material storage yards, and he was also actively looking for coating defects (Attachment A#37). On 8/9/15 he notes: "take a look at bending machine – may have an issue with it tearing coating *Fixed This*". On 8/21/15 he notes: "found a few bad patches on pipe. Told NACE inspector and showed them the pipe", on 8/22/15 "Mark all pipe with bad patches with pink tape. Notified all inspectors.", and on 8/24/15 "found a new coating damage on Pritec pipe". On 9/9/15 he noted "Recommended putting padding on side boom in yard. Was cutting into coating every so often."

One of the inspections performed on field applied coatings was an adhesion test, which determined if the coating was properly adhering or sticking to the pipeline. Project Directive 2015-008 Adhesion Testing – Field Coating dated 8/31/2015 clarified that "An adhesion test shall be performed on an average of 1 in every 50 coated welds, as well as on a minimum of one coated weld in the string for each HDD installation." (Attachment A#28).

The DPS inspectors also inspected the factory-applied coatings (FBE, Pritek, and ARO). Their inspection report from 2016 was especially detailed, describing a statistically-based sampling program of individual pipe joints using a random-number generator. In every case they determined that "All records in this audit were found compliant" (Attachment A#41).

In addition to routine inspections during the application of field-applied coatings, the pipeline safety regulations require (as does API RP 1169) a final comprehensive inspection of all coated pipe with a holiday detector (a.k.a. "jeeping") immediately before lowering in (i.e. placing the pipe in the ditch). VGS has stated that most of the pipeline, including the field coatings, was jeeped at least twice prior to burial to ensure that there were no voids in the coating (with the first jeeping to identify any coating defects, and the second jeeping to inspect the repaired coatings[21] and to look for any further defects). This was done to avoid delays that might be caused by finding a coating defect during the final lowering-in process.

[21] The field coating application inspection reports frequently documented jeeping of the coating immediately after field installation.

Burial (Including Installation in Swamps)

Several issues in this investigation relate to burial of the pipeline, including the burial technique used in the Clay Plains Swamp, the depth of cover achieved in the swamp and elsewhere, the types of material used in the burial process (quality, quantity, type, and strata), the compaction of the backfill materials, and the location and type of trench breakers in the ditch. Many of these issues are also described in the Bedding / TB NOPV of 2-13-2018 (Attachment A#65) which includes the following items:

- Finding Number 1: Pipe Support
  This finding mentions 3 locations where the pipe was not bedded as described in CHA specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING, part 3.5B, dated 4-29-2015 (Attachment A#21) and May 2016 (actually effective 7-1-2016) (Attachment A#22); and Design drawing sheet ANGP-T-G-015 (Attachment A#23). Two of these locations involved direct burial in swamp locations (which Mr. Dumont refers to as the "sink in swamp" method… which is as good a description as any). The other location was where the pipeline was intentionally installed directly on the trench bottom without bedding.

- Finding Number 2: Trench Breakers
  The finding also refers to CHA specification 312333, specifically part 3.5C which states "Trench breakers shall be installed per construction plan details prior to backfilling operations begin." The issue related to trench breaker locations during construction in 2014, when trench breaker locations were determined in the field and not strictly according to the nomograph included in the design drawings.

VGS made an extensive reply to the Bedding / TB NOPV on 2/28/2018 (Attachment A#66). As of the date of this report, this NOPV is still open.

The ANR provided comments on 05-04-2018 (Attachment A#69) stating: "the Agency believes that the expert's review should include both the stream crossing and trench breaker items discussed in the Agency's letters of October 12, 2017 and March 22, 2018.". An ANR letter of March 22, 2018 (Attachment A#68) states: "At this time, the Agency has identified one item which it believes has the potential for significant impact to natural resources, and thus warrants further investigation. The referenced item concerns the issue of whether permanent bentonite trench breakers were not installed in areas where they should have been installed." It goes on to cite various attachments to the Intervenor's Motion to Broaden Scope of the investigation regarding trench breaker locations.

The burial issues are closely related to one another and frequently overlap, but I will deal with them individually for ease of reference and clarity. The burial issues are organized under the following sub-topics:

- Backfill Materials
- Pipe Support and Protection (Bedding and Backfill)
- Compaction and Surface Loads
- Trench Breakers

- Depth of Cover (DOC)
- Burial in Swamps

Backfill Materials

Backfill is the material used to fill up the trench. Backfill may consist of several distinct layers within the trench[22].

- Select backfill is the material intended to be in closest proximity to the pipe and is specified such that it won't damage the pipe or coating. This would include the "bedding", which is the bottom layer of material underneath and which supports the pipe, and "padding" which is the material closest to the pipe (perhaps on all sides, including the bottom). The CHA specifications refer to this as "pipe zone bedding" and "pipe zone backfill". It is normally composed of smaller-grained materials, such as sand.
- General backfill is used to fill the remainder of the trench and is not intended to be in close proximity to the pipe. Specifications for general backfill are less strict than for select backfill, allowing larger rocks and other items that would not be appropriate in contact with the pipe, but not so large that they might interfere with future maintenance or inspection. The CHA specifications refer to this as "trench backfill".
- Topsoils are commonly treated differently than the rest of the trench materials by segregating them during the start of the excavation process and returning them only to the top layer of the trench at the end of backfilling. For example, WCE report of 8-18-2015 shows in photograph #2 "Michels Pipeline Construction stripping topsoil between stations 393+00 to 396+00" (Attachment A#51).

Backfills may be either native materials (i.e. the material that was excavated from that location during digging of the trench) or "borrow" materials (which come from some other location). In some locations, all of the excavated material will meet the requirements for select backfill and the contractor need not make distinctions during the backfill process. In other locations, borrow materials (such as sand) may be needed for padding but native materials can be used for general backfill. Even if the excavated native material is unsuitable for backfill, it may be processed after excavation to make it suitable for use as backfill material.

The pipeline safety regulations mention backfill materials used during construction (emphasis added):

> 49 CFR 192.319. Installation of pipe in a ditch
>
> …
>
> (b) When a ditch for a transmission line or main is backfilled, it must be backfilled in a manner that:
>
> …
>
> (2) Prevents damage to the pipe and pipe coating from equipment or from the backfill material.

[22] Paragraph #68 of the CPG refers to these as "soil horizons".

This is a performance-based requirement and allows all types of backfill materials as long as they don't damage the pipe or the pipe coating.

Backfill operations during ANGP construction were subject to continuous inspection by the CMT, as contained in CHA Specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING (Attachment A#22): (emphasis added)

> SECTION 312333
> 3.10 FIELD QUALITY CONTROL
> A. Notify the Construction Management Team at least three (3) working days in advance of all phases of excavation and backfilling operations. The contractor shall not conduct backfilling operations unless the Construction Management Team is present for inspections. Backfilling operations shall commence as soon as possible after the pipe has been lowered into trench. The amount of lowered pipe that is not backfilled shall be kept at a minimum at all times. Contractor shall not backfill trench until the Owner's as-built survey crew has completed their necessary tasks

At the start of construction in 2014, inspector Eric Curtis noted "Rock from trencher can be put back in trench after viewing for approval" (Attachment A#36, pdf page 48). WCE report of 6-23-2015 shows in photo #1 "J. A. McDonald, Inc. setting up their rock crushing plant to process the blasted material so that it's suitable for general pipe backfill." (Attachment A#52). The excavated materials were screened to segregate larger rocks and debris – with the screened material being used as select backfill and the remaining material being used as general backfill (or discarded), as evidenced by a photograph #2 of WCE report of 9-27-2016 "Utilizing shaker bucket to sift out material being placed in the backfill" (Attachment A#53).

There was an inconsistency between the VGS and CHA specifications concerning the size of acceptable rocks / clods in general backfill. The VGS Operating Procedures (included in the Project Manual / Bid Specification package Attachment A#17) for Excavation, Trenching, and Backfilling states: "Trench spoil material should be utilized for backfill material above the padding layer, whenever possible, within the confines of the project. The material is acceptable provided rocks with a maximum diameter in excess of 6" are removed." Project Directive 2015-007 dated 8/31/2015 (Attachment A#27) reconciled an inconsistency between the VGS O&M manual and the CHA specifications Section 312333 paragraph 2.1(B) concerning the acceptable size of stones or clods in general backfill. It clarified that "native materials containing no stones or clods larger than 6" in the longest dimensions are acceptable for general backfill", to be consistent with the VGS O&M manual requirements. This was subsequently confirmed in Modification Bulletin Trans-09 (Attachment A#20)[23], dated 5/13/2016, which contains a modified CHA specification 312000 that says "Common fill shall be clean material not containing contaminants, large amounts of organic materials, trash or stones greater than 6" in any one dimension." Section 312333 of this modified specification contains the following revisions as of 5/13/16:

[23] This modification bulletin contains re-issued drawings and specifications. At 108 MB it is too large to post as an attachment but has been shared from Ms. Bouffard to Mr. Dumont and will be included in the USB drive I send to the PUC to accompany this report.

- 2.1 B “General Backfill: Native materials containing no stones or clods larger than 6” in the longest dimension are acceptable.”
- 3.5 B “Pipe supports may be installed in all locations prior to backfilling as an alternative to continuous pipe bedding for the entire width of the trench. However, areas around pipe shall still be padded with select backfill as shown on the contract drawings and explained in paragraph 3.3.b. above. Stacked sandbags, pipe pillows, or owner approved equal are acceptable methods. Spacing shall be per manufacturer recommendations, if a commercial product, or 15' maximum separation if sandbags.”
- 3.5 D.1. “Typical Cross-country areas: Thoroughly compacted by mechanical means to avoid any future trench settlement. Use of excavator buckets and equipment tracks is acceptable for compaction in these areas only.”

Note that general backfill is not placed adjacent to the pipe, and there is no pipeline safety or integrity concern from having rocks or clods up to 6” in general backfill.

Certain load-bearing areas may require “structural backfill” or “engineered backfill”. The specifications for these backfill materials are based on their suitability to resist movement and settlement during extended periods of loading and / or high levels of external loading – such as the base of a road or the foundation of a building. Requirements for structural backfill or engineered backfill do not apply to normal pipeline backfill materials but could apply where an open-cut trench crosses a road.

Pipe Support and Protection (Bedding and Backfilling)

High pressure welded steel pipelines such as ANGP almost never fail due to axial tension (aside from defective welds and landslides) because the steel strength required to contain the internal pressure of the pipeline is about twice the axial stress requirements. A steel pipeline that can handle a 1,440 psi internal pressure (like ANGP) can handle any reasonable axial load. This is different than low pressure pipeline systems, such as water and sewer pipelines, that may have much weaker, non-welded joints that have little ability to resist axial loads and must be carefully protected from trench settlement.

Likely for that reason, the pipeline safety regulations have little to say about pipeline support other than it be firm and not damage the pipe or coating. The pipeline safety regulations in 49 CFR 192.319. Installation of pipe in a ditch state:

> (a) When installed in a ditch, each transmission line that is to be operated at a pressure producing a hoop stress of 20 percent or more of SMYS must be installed so that the pipe fits the ditch so as to minimize stresses and protect the pipe coating from damage.
> (b) When a ditch for a transmission line or main is backfilled, it must be backfilled in a manner that:
> (1) Provides firm support under the pipe; and
> (2) Prevents damage to the pipe and pipe coating from equipment or from the backfill material.

The regulation requires "firm support under the pipe" but does not require any type of bedding. It also requires that the backfill prevent damage to the pipe and pipe coating but does not require any particular backfill quality or specification. The regulations do not mention compaction for transmission pipelines. The regulations for bedding and backfill of gas transmission pipelines are performance-based, and any approach that provides firm support and protects the pipe is acceptable.

From a pipeline engineering and regulatory compliance standpoint, laying a pipeline on clean dirt is fine with no additional bedding but laying a pipeline on rock is unacceptable and would require bedding material.

The Vermont Gas ANGP Project Scope of Work and Specifications are what is known as the narrative specification, prepared originally by VGS, as suitable for welded-steel pipeline construction. The VGS specification section 13.i states "The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and / or debris that may cause damage to the pipe."

The Project Manual / Bid Specifications (Attachment A#17) contained requirements associated with padding and backfill, as described in ENGINEER'S ADDENDUM #1 dated 10-18-2013. Part II – PERTAINING TO TECHNICAL SPECIFICATIONS, paragraph 9 states (as shown in the original document without revision or emphasis by me):

> 9. Division VGS – Special Construction (Gas Pipeline)
> a. Vermont Gas ANGP Project Scope of Work and Specifications Item 13.i.
> REPLACE with the following: "i. The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe. Structured pipe pillows shall be installed in the bottom of the trench at maximum intervals of every 16ft to protect the pipe from lying on rocks, sharp objects and/or debris which may cause damage to the pipe or pipeline coating. The COMPANY may require the CONTRACTOR to use select fill trench bottom padding material. ~~Select fill base material for rock trench, shall provide a minimum of twelve (12) inches of padding around the entire circumference of the pipe. Select fill material and/or padding material shall not exceed 1-1/2 inches diameter and shall be placed completely around the pipe.~~
> *Select fill base material for rock trench areas and areas with cobbles/boulders, shall provide a minimum of nine (9) inches of padding below and twelve (12) inches of padding on the sides and top of the pipe. Select fill material and/or padding material shall be sand in accordance with VTrans Standard Specification 703.03 or shall be screened native material containing silts, sands and gravels with the largest material being no larger than 1-inch on the longest dimension.* Topsoil from the RIGHT-OF-WAY shall not be used for padding material. ~~All select fill padding shall be procured from existing commercial facilities and shall be of sand.~~"

This specification, at that point in time, clearly allowed for the pipe to "rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe." This was consistent with the pipeline safety regulations and the VGS narrative

specification. It required select fill base material for "rock trench areas and areas with cobbles/boulders". In those areas it allowed sand or "screened native material".

CHA specification Section 312333 also concerns Trenching and Backfilling. It was revised several times during the project. Paragraph 3.3 B addresses bedding beneath the bottom of all structures and barrels, bells or couplings:

> "Excavation shall be made to such a depth and to the width indicated on the Contract Drawings so as to allow a minimum of six (6) inches of pipe zone bedding in earth (9 inches in ledge) to be placed beneath the bottom of all structures and barrels, bells or couplings of all pipes installed unless otherwise specified in the drawings."

Paragraph 3.3 C addresses bedding beneath the pipe itself (emphasis added):

> "The bottom of the trench shall be accurately graded to provide a uniform layer of bedding material, as required, for each section of pipe.".

Strictly speaking, paragraphs 3.3.B and 3.3.C do not require bedding of the pipe – only that the trench be capable of accommodating bedding "as required". CHA specification Section 312333 only requires 6" of bedding in areas where "structures and barrels, bells or couplings" would be installed, or "as required" for each section of pipe.

Some would read the VGS narrative specification and the CHA specification, which existed in the same bid package at the same time, to contradict each other. However, it is important to note that ENGINEER'S ADDENDUM #1, explained above, was issued by CHA (the "Engineer") – who also issued the CHA specifications. Thus it is not unreasonable to believe that those 2 specifications were intended to be compatible with one another. This is confirmed by an e-mail from CHA on 6-22-2016 (Attachment A#59, pdf page 5), which explained the CHA specification as being compatible with the VGS narrative specification "If the material 6" below the bottom of the trench is deemed to be suitable material".

Bedding of a pipeline can occur in 2 ways. The bedding materials could be placed in the bottom of the trench before the pipe is laid in the trench, or the pipe can be installed on supports such as sandbags or "pillows" and the bedding material be placed over and around the suspended pipe. ANGP bedding was installed using the second method. Modification Bulletin TRANS-07 dated 11/12/2014 allows the use of sandbags as an alternative to pipe pillows under specification 13i.

Pipe was installed directly on the trench bottom without bedding from station 240+26 to 279+75 on 8/31/2015. Project Directive 2015-005 dated 9/1/2015 documented the justification for doing so. It states:

> "In 3.5(B) — Bedding and Backfilling of Section 312333 — Trenching, Pipe Laying, and Backfilling of the Technical Specifications: pipe supports shall be installed in all locations prior to backfilling, unless otherwise directed by the Construction Management Team. This document serves to direct the construction without pipe supports in the sand area from station

> 240+26 to station 279+75, as the uniform sand in the trench meets requirements for select backfill."

Modification Bulletin Trans-09, dated 5/13/2016 (Attachment A#20), contains CHA specification 312000. Section 312333 contains the following revisions:

> 3.5 B "Pipe supports may be installed in all locations prior to backfilling as an alternative to continuous pipe bedding for the entire width of the trench. However, areas around pipe shall still be padded with select backfill as shown on the contract drawings and explained in paragraph 3.3.b. above. Stacked sandbags, pipe pillows, or owner approved equal are acceptable methods. Spacing shall be per manufacturer recommendations, if a commercial product, or 15' maximum separation if sandbags."

Intervenors have noted that DPS inspector's notes mention pipe being laid directly on trench bottom in June and July, 2016 (Attachment A#41, pdf page 7):

- "6/16/16 observed mill defect on pipe, refered to CWI D. Love At kick off Williston station observed pipe being laid directly on trench bottom in non compliance with VGS Specification 312333 3.5(B). Referred to M. Reagan and D. Crandall."
- "7/8/16 Observed backfilling at Williston Sbstation. Once again noted pipe directly on bottom of ditch. Notified D. Crandall who advised that pipe was lowered in before directive from CHA engineering."

Williston gate station is located at station 551+00. VGS has stated that pipe was installed directly on the trench bottom from station 564+24 to 567+84. The locations cited by VGS as being directly buried on trench bottom are within a few hundred feet of the Williston gate station mentioned in the DPS report – and I believe they are talking about the same locations. Per VGS, all other locations were either directionally drilled, bored, or installed by open cut trenches with bedding.

VGS received an email from Brendan Kearns, CHA, on 6-22-16 stating "The intent of the trenching and backfilling specification is to have suitable native material (described in the specification) around the pipe" and that it was acceptable to lay directly on trench bottom "as long as it is sufficiently supported as stated in 3.3.C" (Attachment A#59). Note that this e-mail from CHA on June 22 was sent after the Modification Bulletin Trans-09 dated May 13.

Modification Bulletin Trans-14 dated 6/30/16 added detail to CHA specification 312333 concerning pipe support, padding, and compaction and deleted the requirement to complete the ditch before stringing pipe (Attachment A#22).

Clearly the issue of whether the specifications allowed the pipe to be buried directly on trench bottom without bedding was being discussed in the June – July 2016 timeframe. An email from John St. Hilaire to GC Morris on 7-1-2016 summarized pipe bedding discussions from their weekly meetings of 6/21 and 6/28 (Attachment A#59). The 6/21 discussion resulted in the e-mail from CHA approving burial without bedding in certain areas. In the 6/28 discussion "we learned the issue was not the mechanical aspects of placing the pipe at the bottom of a trench, it is the corrosion potential

due to oxygen differentials in the soil layers." As I explain below, I believe the corrosion concern is misplaced - but it was a concern at the time.

After the CHA e-mail of 6-22-2016, there must still have been some question concerning the acceptability of laying the pipe directly on the trench bottom because VGS sent an official Request for Information[24] (RFI) to CHA on 7-1-2016, stating: "VGS is requesting clarification with respect to the methods the pipeline can be placed in the trench and backfilled under Section 312333 Trenching, Pipe Laying, And Backfilling Specification. Please provide intent and clarification on the various methods the trench bottom can be prepared under the specification." CHA's reply quoted their specification and said that "LAYING THE PIPE DIRECTLY ON IN-SITU NATIVE MATERIAL ON BOTTOM OF TRENCH IS NOT ACCEPTABLE". After that time, all pipe installed in a trench was installed with bedding.

An e-mail from Chris LeForce to GC Morris on 7-7-16 states: "It was our intention to allow the pipe to be installed on the trench bottom if the soil conditions were shown to be rock free." It then refers to CHA's response to the RFI, claiming that was not acceptable under the current specs (Attachment A#59). VGS committed to pad all trenches in the future until the specification was edited and updated, unless an alternative was approved by the CMT.

Attachment A#66, pdf page 204-205 contains a memo to file from Adam Gero dated 6-6-2017 (about a year later) explaining the series of events related to installation of the pipe directly on the trench bottom without additional bedding. It quotes CHA Specification 312333 part 3.5B as of 4/29/2015 and 5/2016, both of which allow pipe supports as an alternative to continuous pipe bedding and allow "owner approved equal" supports. The memo also cites the email from Brendan Kearns, CHA, on 6-22-16, which indicated that burial without bedding was acceptable in some areas.

Corrosion Concerns from Burial Conditions

A white paper produced internally by James Bushman, principal corrosion engineer of Bushman and Associates, Inc., has been introduced in this case (Attachment A#66 pdf pages 220-229). While this paper provides a good introduction to basic corrosion and cathodic protection concepts, this is not a peer reviewed paper and is hardly authoritative[25], nor has it been published to my knowledge by anyone other than Bushman itself (indeed, it is copyrighted by Bushman).

The white paper mentions a potential corrosion issue that can occur when a pipeline is directly placed on "oxygen-starved compacted clay soil" when surrounded by "oxygen rich sand backfill". The concept of corrosion caused by differential oxygen concentrations is well-established, and is the reason that the gas pipeline safety regulations in 49 CFR 192.481 (b) require that "During inspections the operator must give particular attention to pipe at soil-to-air interfaces," when monitoring for external corrosion.

[24] RFI #: ANGP-VGS-RFI-025

[25] I have been a member of the National Association of Corrosion Engineers for almost 40 years, and I had never seen this paper prior to this investigation.

Compaction and Surface Loads

Compaction is a measure of the density of the soil, with the compaction generally increasing with time (loose soils become dense and hard over time). Each soil type is composed of many different particles with different physical properties and will have its own maximum level of compaction (i.e. its maximum density). After excavation, soils are generally loose and with relatively low compaction. The compaction can be increased by either adding or removing water from the soil, and by physically compressing the soil (as done by a steamroller). Insufficient compaction of backfill around the pipeline can result in settling of soils within the trench (leading to an uneven surface and/or potholes), and paradoxically, frost heave (if the backfill contains too much water – which expands when frozen). These can affect the surface of the ROW and are important in areas which require a smooth surface over the pipeline (such as roads).

The Transportation Research Board (TRB) published a report[26] on Compaction Concepts. It notes (emphasis added):

- "Compaction and stabilization are very important when soil is used as an engineering material; that is, when the structure itself is constructed of soil."
- "Considerable compaction can also be obtained by proper routing of the hauling equipment over the embankment during construction."
- "There are basically two types of earthwork specifications: (a) method specifications, and (b) end-product specifications."

Surface loads imposed on a buried pipeline are caused by the interaction of some external weight (such as a truck or rail car) transmitted through the soil to the buried pipe. Multiple variables are used when calculating the effects of these external loads on a pipe, including the DOC and the soil type.

Regulations

There is no section of the pipeline safety regulations that mentions compaction around transmission pipelines[27]. This is probably because settling of backfill materials due to sub-optimal compaction doesn't pose a threat to high strength welded steel pipelines such as ANGP. The steel and welded joints have more than adequate strength to resist earth settlement[28]. The settling soils will yield and conform to the pipe, not the other way around.

The pipeline safety regulations state this about consideration of external loads (including surface loads):

§103. General

[26] http://onlinepubs.trb.org/Onlinepubs/state-of-the-art/8/8-003.pdf

[27] There is a mention of compaction for distribution pipelines – which are typically made from plastic and have much less capacity to resist trench settlement than steel pipelines.

[28] Certain areas of the country are susceptible to sink holes – such as in Florida where they can be large enough to swallow a house. Other areas may be subject to subsidence – such as when long-wall mining occurs underground – causing the ground to sink by a dozen feet or more over a long distance. These situations can cause a threat to a welded steel pipeline, but neither of these situations exist along ANGP.

> Pipe must be designed with sufficient wall thickness, or must be installed with adequate protection, to withstand anticipated external pressures and loads that will be imposed on the pipe after installation.
>
> §105. Design formula for steel pipe
> (a)….
> t = Nominal wall thickness…. Additional wall thickness required for concurrent external loads in accordance with §192.103 may not be included in computing design pressure.
>
> §327. Cover
> …
> (c) Where an underground structure prevents the installation of a transmission line or main with the minimum cover, the transmission line or main may be installed with less cover if it is provided with additional protection to withstand anticipated external loads.

The design and the cover sections of the regulations for steel gas transmission pipelines require that pipe be installed with adequate "protection to withstand anticipated external loads". This protection could come from additional burial depth, through additional wall thickness / strength, or some other method (such as a casing). The regulations also cite no specific loading standard. The strength requirements for modern steel transmission pipelines are typically governed by the ability to contain internal pressure (i.e. the MAOP) not by external surface loads (which are much smaller) – but both must be considered.

Industry Standards / Recommended Practices

There is an industry recommended practice that addresses external loads for transmission pipelines: API RP 1102 Steel Pipelines Crossing Railroads and Highways. While it is widely used in the industry, it has not been incorporated into the pipeline safety regulations and its use is optional. It was developed specifically for situations where pipelines cross under active roads and railroads. It is not intended for use in areas where the pipeline is crossed only occasionally, nor where crossed by tracked vehicles or other vehicles that do not have high wheel / axle loads. Its use for the VELCO ROW, which is rarely traversed, is very conservative.

Concerning bedding, backfill, and compaction, the RP has common-sense requirements (emphasis added):

- Section 4.2 General, 4.2.1 "The carrier pipe[29] should be as straight as practicable and should have uniform soil support for the entire length of the crossing".
- Section 6.2.1.3: "The bottom of the trench should be prepared to provide the pipe with uniform bedding throughout the length of the crossing. In addition to being properly compactable, padding and backfill must be of the appropriate quality to prevent damage to pipeline and /or casing coatings."

[29] ANGP did not use casings (a pipe outside the pipe). All ANGP crossings are uncased crossings, and the ANGP is considered "carrier pipe".

- Section 6.2.2 "Backfill should be compacted sufficiently to prevent settlement detrimental to the facility being crossed", and to "densities consistent with that of the surrounding soil".

The pipe in the VELCO ROW was installed using open cut trench excavation, as described in section 6.2 of the RP. The RP requires uniform soil support and uniform bedding (which would be provided by the bottom of the trench, if properly prepared). The backfill itself should be of appropriate quality not to damage the pipe or its coating. The RP provides no requirement for % soil compaction, simply requiring that backfill density be consistent with the surrounding soil and compacted "sufficiently to prevent settlement detrimental to the facility being crossed". The methods used in the RP to calculate acceptable loads consider soil type but not soil compaction levels.

Intervenor's submittal of 2-28-2018 included an attachment that is a report done for the Canadian Energy Pipeline Association (CEPA) titled: "Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods" by David J. Warman, James D. Hart & Robert B. Francini of Kiefner & Associates, dated October 16, 2009 (Attachment A#49). The introduction discusses API RP 1102, which has been cited elsewhere in this case, stating (emphasis added):

> "A survey by CEPA of member companies indicates that they employ a variety of techniques to evaluate and mitigate surface loading effects on their buried pipelines. One widely used practice, embodied in API ll02 (1993, reaffirmed 2002), is limited to cover depths greater than or equal to 3 feet and has been specifically developed based on AASHTO H20 truck loads with small footprints associated with tire pressures typically in-excess of 550 kPa (80 psig). Several important limitations are inherent to this method. The method cannot be effectively extrapolated to shallow cover situations. It also may not scale correctly to different types of equipment that ride on floatation tires or caterpillar tracks where ground surface pressures are less than 350 kPa (50 psig). Further, it determines pipeline stresses in a non-traditional manner. These conditions create a barrier to uniform adoption of the method."

and in Section 2.2:

> It is our observation and experience that the vast majority of pipeline crossing scenarios require little in the way of special measures to protect the pipeline provided the pipeline is in sound condition and has sufficient amounts of competent soil protection. Exceptions exist such as where muskeg soils or exceptionally heavy equipment or very shallow cover might he involved. We are aware of only one pipeline incident associated with a ground surface vehicle. The line was either a cast iron or old steel gas main with very shallow one-foot cover that ruptured under a cement mixer on a car/boat dealer's parking lot.

In addition to pointing out various limitations to API RP 1102, the CEPA report noted that energy pipelines almost never fail due to surface loading and recommended the use of simplified screening methods to determine if a more detailed analysis was required for each situation. It then went on to develop a simplified screening method which it notes (page 32) is "very conservative". Figure 3.7 gives a graph of the results of that screening method based on a 4' DOC, showing acceptable wheel / axle loading at various pipe MAOPs and pipe steel yield strength. The report, being for a Canadian

client, uses metric units. The ANGP has an MAOP of 10,000 kPa and a pipe grade of 448, indicating a maximum permissible wheel load of 33,000 kg and an axle load of 66,000 kg (145,000 pounds).

VELCO Agreement

The MOU between VGS and VELCO of June 2013 (Attachment A#44) says this concerning loading (emphasis added):

> 5. Loading. VGS will design the Project in VELCO's ROW and access roads into VELCO's ROW to meet an HS-20+15% standard which VGS plans to meet by using Class 3 pipe interred at a depth of 4 feet.

In this MOU, VGS agreed to what the TRB report on compaction concepts (discussed above) refers to as a "method specification", not an "end-product specification".

VGS received an e-mail from VELCO on 9-21-2016 concerning the Clay Plains Swamp DOC agreeing to the reduced DOC if the HS20+15% loading criteria was still met, along with other requirements (Attachment A#55).

The HS-20 loading requirements are explained in simple terms in a diagram at this website[30], showing that HS20 loading assumes 16,000 pounds of loading per wheel, or 32,000 pounds of loading per axle. Adding 15% to that number would yield 36,800 pounds per axle. VGS planned to meet this requirement "by using Class 3 pipe interred at a depth of 4 feet", with no other conditions. This begs the question as to whether simply burying this pipe at a depth of 4 feet is sufficient to meet an HS-20+15% loading requirement.

Analyses of ANGP Acceptable Loading

Permissible loading requirements were analyzed at least three times for ANGP (not counting my own analysis). A memo from CHA on 11-7-2014 (Attachment A#47) conveyed the results of their analyses per API RP 1102 (using GasCalc 5.0 version 007 software from Bradley Bean) and the "Guideline for Design of Buried Steel Pipe" from the American Lifelines Alliance. Both analyses determined that the pipe in the VELCO ROW should meet AASHTO HS-20+15% truck loading requirements. Mott MacDonald did additional analyses on 5/25/2016 to "ensure the pipeline's integrity under loading without compaction of backfill. The stress calculations were performed per API 1102, using various combinations of soil type and depth of cover to confirm that 90% compaction will not be necessary." (Attachment A#48). These calculations were performed using the Pipeline Toolbox software from Technical Toolbox.

ANGP Specifications

The ANGP specifications for compaction were internally inconsistent and changed over time.

Section 13. BACKFILLING in the VGS narrative specification of the bid specifications of May 24, 2014 (Attachment A#17, pdf page 317) states this concerning compaction:

[30] https://www.iwconsultingservice.com/post/understanding-cover-load-ratings

f. At all locations where the pipeline crosses roadways, walkways, and proposed roadways where the open trench method of crossing is utilized, backfill shall be placed in lifts and mechanically compacted within the limits of the existing or proposed pavements and to the satisfaction of the governing agency. The CONTRACTOR shall hold the COMPANY harmless from any and all damages resulting from open trench Construction. Unless specified otherwise, backfill compaction shall achieve at least ninety five percent (95%) Modified Proctor density by wetting and tamping at all levels in the backfill material. Approval shall be received from the COMPANY to operate compaction equipment within thirty-six (36) inches of the pipeline.
g. Attention shall be given in backfilling the pipeline near roads to ensure that proper pad dirt is place in such a manner as to completely fill the voids around and under the pipe and to prevent damage to electrolysis test site leads.
h. The CONTRACTOR shall compact, subject to COMPANY approval, ditches crossing residential and industrial yards and bell holes around all above ground pipeline appurtenances at the CONTRACTOR'S expense.

CHA Specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING, in that same bid package contained the following requirements for compaction (pdf page 493):

3.4 BEDDING AND BACKFILLING

A. All pipe trenches backfill (pipe zone bedding, pipe zone backfill and trench backfill) shall be compacted by tamping or rolling to achieve a minimum dry density of 90 percent of the modified Proctor maximum dry density of the material used (ASTM D1557). Backfill in pipe trenches to be covered with pavement or in roadways shall be compacted to a minimum of 95 percent of modified Proctor maximum dry density. Backfill materials shall be placed with water content within plus or minus three (3) percent of optimum moisture content per the modified Proctor method (ASTM D1557). Any water used for compaction shall be provided by the Contractor at his own expense. The Contractor is responsible for the repair of any trench settlement at no expense to the owner.

These specifications changed subsequent to the bid package. A later version of CHA Specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING described 3 compaction methods / requirements:

D. All pipe trenches backfill (select backfill/padding, general backfill, subbase) shall be thoroughly compacted by mechanical means as follows:
   1. Typical Cross-country areas: Thoroughly compacted by mechanical means to avoid any future trench settlement.
   2. VELCO corridor: All backfill in pipe trenches in the VELCO corridor shall be compacted to a minimum of 90 percent of modified Proctor maximum dry density by installing 12- inch (maximum) loose lifts.
   3. Existing and Proposed Road Areas (unpaved and paved): All backfill in pipe trenches in, or directly adjacent to (with 10' of edge of road surfaces – existing or proposed) road surfaces, shall be compacted to a minimum of 95 percent of modified Proctor maximum dry density. Backfill materials shall be placed with water content within plus or minus 3

> percent of optimum moisture content per the modified Proctor method (ASTM D1557). Any water used for compaction shall be provided by the Contractor at their own expense. The Contractor is responsible for the repair of any trench settlement at no expense to the Owner for the period of one year after substantial completion of the project.

VGS Project Directive Number 2015-006 on 8-31-2015 (Attachment A#26) provided further clarification of CHA specification Section 312333, part 3.5(D)(1). The Directive reads:

> "In 3.5(D)(1) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications, it states that the pipe trench in typical cross-country areas shall be thoroughly compacted by mechanical means to avoid any future trench settlement. In these cross-country areas, the trench can be compacted by mechanical means using an excavator bucket.
>
> Compaction shall occur when there is at least 12" of sand padding and 12" of general backfill above the pipe and at a maximum of 24" lifts thereafter. Final compaction at grade can be completed using either an excavator bucket or the tracks of a piece of excavating equipment.
>
> The use of an excavator for mechanical means of compaction in cross-country areas is typical in transmission pipeline construction."

Modification Bulletin Trans-09, dated 5/13/2016 (Attachment A#20), contains a variety of plan sets issued for construction (IFC), including CHA specification 312000. Updated Section 312333 (pdf page 426) contains the following revision / clarification to the prior specification:

- 3.5 D.1. "Typical Cross-country areas: Thoroughly compacted by mechanical means to avoid any future trench settlement. *Use of excavator buckets and equipment tracks is acceptable for compaction in these areas only.*"

Modification Bulletin Trans-14 dated 6/30/16 (effective as of 7/1/16) deleted the compaction requirement in the VELCO ROW (Attachment A#22 pdf page 7).

Compaction for Roads

In load bearing areas (such as roads and building foundations), it is common to require "Structural Fill" or "Engineered Fill". These types of fills have the most restrictive requirements concerning type of material, moisture content, and compaction requirements.

The VTrans permit for ANGP was issued 5/27/2014, and contained typical language concerning compaction of backfills in and immediately adjacent to the road (Attachment A#46). It requires compaction to 95% of dry density using air or mechanical tampers "Where a trench is excavated within the roadbed…" (emphasis added). This same 95% requirement in roads is included in CHA project specification Section 312333, paragraph 3.4A. The VTrans permit for ANGP also requires "Backfilling within the highway structural prism…" (emphasis added) to comply with Agency of Transportation Backfilling Specification 601.08. These requirements for structural or engineered fill

at 95% of dry density were to protect the road from settling, not to protect the pipeline from external loads.

It is important to note that the VTrans permit anticipated that NO state highways would be crossed by open-cut trenching. The compaction requirements were included as "**a contingency condition in the event the "open cut method" is approved during construction**" (bold in the original). ANGP did not cross any permitted highways with open cut trenching, so the compaction requirements in that permit were irrelevant.

Vermont's Agency of Transportation normal practice is to hold the permittee responsible for follow-up road maintenance for a period of 18 months following construction completion and inspection, to correct any subsequent issues. After 18 months the State resumes responsibility for those areas. Per a memo from VTrans to VGS on January 8, 2019, they will release VGS of that responsibility on July 8, 2020.

ANGP crossed 15 roads using an open-cut trench installation method, listed below. These are dirt roads, not state highways, and they were not included in the VTrans permit. Several of them only serve a few houses - but they would be considered load-bearing areas from the pipeline's standpoint (due to routine vehicle traffic). Being roads, these crossings also need to maintain a reasonably flat surface, without settling or frost heave.

ROADS CROSSED BY OPEN-TRENCH EXCAVATION

#	Street/Road Name	City/Town	Approx. Construction Station	Area Served By Road
1	Lincoln Road	Williston	755+95	Several residences; shortcut between Hwy 116 and 2A
2	Breezy Valley Lane	St. George	788+10	Several residences
3	Hickory Place	Hinesburg	947+95	A few residences
4	Charlotte Road	Hinesburg	1048+25	Multiple residences and other roads west of Hinesburg
5	Baldwin Road	Hinesburg	1114+40	Multiple residences and other roads southwest of Hinesburg
6	Rotax Road	Monkton	1293+85	Multiple residences and other roads northwest of Monkton. Close to Palmer residence.
7	Stillson Road/Cedar Lane	Monkton	1379+10	A couple of buildings
8	Post Road	Monkton	1424+25	A couple of residences
9	Old Stage Road	Monkton	1547+60	Multiple residences and other roads southwest of Monkton.
10	Old Stage Road	Monkton	1553+55	Ditto
11	Old Stage Road	Monkton	1565+50	Ditto
12	Parks Hurlburt	Monkton	1588+45	Ditto

13	Quarry Road	New Haven	1768+45	Several residences; shortcut between Lime Kiln Rd and North St.
14	Hunt Road	New Haven	2011+60	Several residences; shortcut between US Hwy 7 and South St.
15	Belden Falls Road	New Haven	2129+45	Several residences and a waterfall

Trench breakers

The pipeline safety regulations make no mention of trench breakers. The only regulatory requirement for an operator is that they follow their own plans, procedures, and specifications – and these frequently include details about trench breaker types and location. The CPG (Attachment A#05) has the following statements regarding trench breakers:

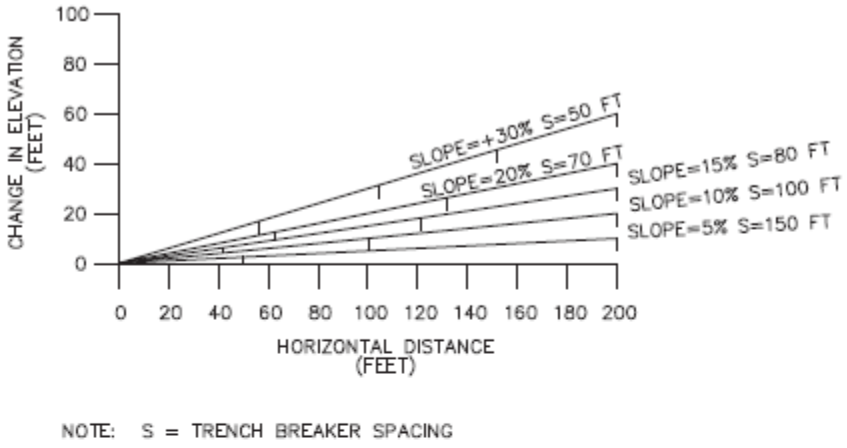
31. The design calls for the installation of trench breakers at specified intervals along the pipeline, based on surface topography. The trench breakers will be filled with bentonite and will reduce the trench's overall transmissibility of water while still allowing some water to pass. Heintz pf. reb. at 22; see sheet ANGP-T-G-015 of exh. Pet. Supp. JH-3.
32. In addition, the design calls for bentonite trench breakers at the limits of each wetland. The bentonite trench breakers act as a plug in the trench to inhibit the migration of water from wetland areas. Heintz pf. at 22.
33. The installation of these mitigation devices will minimize impacts associated with the installation of the pipeline trench. Heintz pf. at 22.

Sandbag trench breakers are to prevent erosion of the trench <u>during construction</u>, isolate trench segments <u>during construction</u>, and physically stabilize the trench <u>during construction</u>. The drawings refer to these as "Permanent Trench Break" (and they are in fact permanent, since they are never removed), but their presence <u>after</u> construction is of little importance. They neither impede nor facilitate the flow of water along the trench and do not provide long term stability to the trench (although they do provide some physical stability for a while – at least until the sandbags degrade).

Bentonite trench breakers are a special type of trench breakers, with sandbags forming 2 walls across the trench with the space between being filled with impermeable bentonite clay up to a certain height. They create a plug in the trench that prevents future water flow down the trench, even after construction. Bentonite is required when non-native backfills (such as clean sand) are used along the trench as backfill that might have much higher capacity to transmit water than the surrounding soils. Without the bentonite barrier, the trench could form an underground conduit for water flow. This type of situation can occur where rock is blasted to form the trench and then the trench is backfilled with non-native soils that have much higher permeability than the surrounding rock. This was mentioned explicitly in an MOU between VGS and ANR in September 2013 (Attachment A#45, pdf page 7) (emphasis added):

3. Where <u>bedrock</u> is encountered during construction of the Project within Class Two wetlands, buffers or vernal pools, VGS will install a bentonite plug at the base of the trench, through the <u>blasted segment</u> of the wetland.

Trench breaker locations in 2014 were determined using a nomograph in design drawing ANGP-T-G-015 (Attachment A#23), which gave "recommended minimum" spacing depending on the slope of the trench. This gave the personnel in the field guidance on spacing while providing some discretion in determining the location of trench breakers as needed for site conditions. A screenshot of the nomograph is given below:



NOTE: S = TRENCH BREAKER SPACING

NOTES:

1. PERMANENT TRENCH BREAKER SANDBAGS SHALL NOT BE FILLED WITH TOPSOIL.
2. SPACINGS SHOWN ARE RECOMMENDED MINIMUM GUIDELINES. OSPC REPRESENTATIVE MAY ADJUST SPACING IN THE FIELD WITH PRIOR WRITTEN APPROVAL OF OWNER.
3. ONE TRENCH BREAKER IS REQUIRED AT ALL STREAM BANKS AND AT WETLAND BOUNDARIES.

2 **Permanent Trench Break Spacing Guideline** 12/12

N.T.S. Source: CHA LD_

The drawing refers to bentonite trench breakers as "Trench Breaker With Bentonite". The drawings call for bentonite 6" higher than the non-native backfill used on either side of the trench breaker (with the implication being that bentonite isn't needed at all if native backfills are used). This is logical because native backfills should have the same water transmissibility as the adjacent soils and would not provide an underground conduit for water flow along the trench. The bentonite seal should be irrelevant in that situation.

That drawing includes notes for detail #5 "Permanent Trench Break or Sandbags":

1. PERMANENT TRENCH BREAKER WITH BENTONITE SEAL IS INTENDED TO PROHIBIT WATER FLOW THROUGH THE BREAKER
2. PERMANENT TRENCH BREAKER WITH BENTONITE SEAL TO BE INSTALLED AT EDGE OF WETLANDS AND STREAMS
3. SAND BAG BARRIER WIDTH SHALL BE MINIMUM 1 BAG WIDE AND/OR AS FIELD DETERMINED TO PROVIDE STABILITY
4. BENTONITE IS TO BE INSTALLED IN THE VOID SPACE BETWEEN THE SANDBAG BARRIER "FORMWORK" IN SUCH A MANNER TO COMPLETELY SURROUND THE PIPE AND FILL THE VOID FROM THE BOTTOM OF THE TRENCH TO A HEIGHT 6" ABOVE THE LEVEL OF IMPORTED PADDING MATERIAL WHICH IS INSTALLED ON THE EXTERIOR SIDE OF THE SANDBAG BARRIER IN THE WETLAND ZONE.
5. AFTER BENTONITE PLACEMENT, INSTALL SAND BAGS ON TOP OF THE PERMANENT TRENCH BREAKER AND BENTONITE SEAL TO THE REQUIRED HEIGHT PER DETAIL 2 AND BACKFILL EXTERIOR SIDES OF SAND BAG BARRIERS.

That drawing had several revisions including 6-11-2015 (Attachment A#24) and 5-2016 (Attachment A#25).

Trench breaker locations were determined in the field in 2014 in consultation with the on-site environmental inspectors from VHB. Inspector JR Kelch's daily inspection reports (Attachment A#38) contain the following notes:

- 9/5/2014 "Eds crew built a trench plug at sta#546+57 area. Doug Mabee with VHB agreed with location."
- 9/10/2015 "They also built trench plug (bentonite) at sta#553+00 approved by Doug Mabee with VHB."[31]

VGS prepared a CPAR on 12-11-15 (Attachment A#54) regarding trench breaker types and locations installed in 2014. It states "trench breakers were not installed as designed in numerous locations", and provides a table comparing the actual trench breaker types and locations versus the design requirements. My notes concerning each location with a missing trench breaker are in red in that attachment.

Some might argue that personnel in the field are be in the best position to determine the exact location of each trench breaker and that the nomograph in Attachment A#23 was merely a guideline (and not to be strictly followed). Reasonable people might also disagree as to the exact location of the edge of a wetland along a ROW, and so forth. To avoid further ambiguity, in 2016 VGS modified that drawing and added additional pages that spelled out the exact location by station number of every trench breaker by type (Attachment A#25).

[31] VGS has informed me that VHB's inspectors did not officially "approve" trench breaker locations – rather that they confirmed the location per the plans.

On 2/16/2018 DPS issued an NOPV re bedding and trench breakers alleging that VGS did not comply with its own standards by not installing trench breakers in each location called for in the plans and specifications (Attachment A#65). VGS replied on 2/28/18 (Attachment A#66) and submitted a Remedial Action Compliance Plan (Attachment A#67) on 3/30/18. This proceeding is stayed pending my investigation.

A letter from the ANR dated 5-4-2018 (Attachment A#69) stated: "the Agency believes that the expert's review should include both the stream crossing and trench breaker items discussed in the Agency's letters of October 12, 2017 and March 22, 2018." The ANR letter of 3-22-2018 (Attachment A#68) stated: "The lack of a permanent bentonite trench breaker in a location that necessitates a trench breaker has the potential to result in a significant impact to a wetland or stream resource. Further investigation is necessary to determine whether such trench breakers are lacking in areas where they are necessary and, if so, whether natural resources have been significantly and adversely impacted as a result." (emphasis added).

At my request, VGS provided a summary of their interactions with ANR regarding trench breaker issues (Attachment A#70). Excerpts from the summary are provided below (emphasis added):

- September 2018 – Conversation between ANR (Laura LaPierre) and VHB (Carla Fenner). Based on this conversation, VGS understands that no further action/review is needed in wetland areas where no blasting occurred, and ANR is awaiting VGS follow up on trench breakers in wetland areas that were blasted.
- September 2018 – Based on VGS review, all wetlands in proximity to blasting areas have documented bentonite TBs. Two individual TBs of unknown type (based on prior review) located at different wetland locations were confirmed bentonite. VGS used ground penetrating radar to locate the trench breaker at Wetland 2012-CM-91 and confirm that it is bentonite. Second, later review of construction photographs in the vicinity of wetland 2012-JB-12 show evidence of bentonite storage proximate to the location where the unspecified type of trench breaker was installed indicating that it is likely a bentonite trench breaker.
- July 11, 2019 – ANR email to VHB\VGS confirming request for Condition J documentation
- August 20, 2019 – VHB submits Condition J memo to ANR concluding that, as required under the VWP, a bentonite plug was installed at all Class II wetland and Class II wetland buffer locations where blasting occurred.
- November 5, 2019 – ANR acknowledges receipt of the memo to "support compliance of Condition J of the Vermont Wetlands Permit #2012-184 and subsequent amendments."
- November 2019 – Based on the detailed review of ANGP bentonite trench breakers, including the regulatory basis, their presence/absence, and the field visit conducted in April 2018, VHB has reached the conclusion that the potential absence of 10 trench breakers located at 5 wetlands did not observably or significantly alter the wetland hydrology to the extent that any Class II wetland boundaries or functions were impacted beyond what was permitted. VHB also concludes that bentonite trench breakers were installed at all stream locations as specified.

Depth of Cover

Regulatory Requirements

The pipeline safety regulations do not require pipes to be buried but do contain requirements[32] for pipes that are buried, including minimum depth of cover (DOC) – which is measured from the top of the pipe to the surface of the ground, as buried. For a gas pipeline such as ANGP, the depth of cover requirements vary by class location (i.e. population density), ranging from 30" in the least populated areas to 36" in highly populated or sensitive areas, and 48" in river and stream crossings[33]. Less cover is required in consolidated rock. The rules also state: "*Where an underground structure prevents the installation of a transmission line or main with the minimum cover, the transmission line or main may be installed with less cover if it is provided with additional protection to withstand anticipated external loads.*".

There is no dispute that VGS met these minimum regulatory requirements (aside from the shallow areas in swamps).

VGS Commitments

VGS committed to exceed the minimum regulatory requirements for DOC and these commitments were incorporated into the PUC's final order of 12-23-2013 (Attachment A#05) which states (emphasis added):

> Project Construction (page 40)
>
> 62. The process of pipeline construction involves a series of sequential steps that **generally proceed** in the following sequence:
>
> ….
>
> e. Pipe lengths will be welded together, inspected, laid in the trench and warning tape will be laid over the line, and then the trench will be backfilled. The pipe will be covered by **at least 36 inches of soil**. The pipeline will have **four feet of cover in agricultural areas and within the VELCO ROW**, generally **five feet of cover at road crossings**, and **seven feet of cover at open cut streams**.
>
> f. The **landscape will be restored** as close as possible to pre-construction conditions in accordance with applicable permit requirements.
>
> Heintz pf. supp. at 31-32; exh. Pet. Supp. JH-3.

VGS also made other commitments regarding DOC that are not contained in the CPG. For example, VGS agreed to install the pipeline with 5' DOC for the Hurlburt property – which extends for about 2 miles of the ANGP ROW.

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[32] PHMSA has clarified through letters of interpretation issued 8-3-1979; 1-2-1973; and 8-1-1975; among other references, that its depth of cover requirements are for new construction, not for ongoing maintenance. A pipeline operator is required to maintain a safe pipeline once it is constructed, including a safe depth of cover or some other method of ensuring pipeline safety if the pipeline is no longer buried at the initially required depth.

[33] PHMSA issued a letter of interpretation for 49 CFR 192.327 on July 26, 1983 which clarified that the extra depth requirement only applies to rivers, streams, and harbors that are navigable in fact. "Only those streams, rivers, and harbors which support large vessel (ships, barges, etc.) traffic would require 48" of cover for a buried pipeline crossing. Less cover depth would be required for smaller or shallower streams, rivers, and harbors that do not support large vessel traffic."

There are disputes concerning VGS's commitments to exceed these regulatory requirements in residential areas and for non-jurisdictional streams. Specifically:

- Did VGS commit to bury the pipe at least 4' in all residential areas?
- Should VGS have buried the pipe at least 7' deep under non-jurisdictional open-cut streams?

A VGS filing of 8-4-17 (Attachment A#60) gives their view that there is no 4' DOC requirement in residential areas and that a 7' DOC is only required for jurisdictional streams. Intervenors disagree as stated in several filings.

Intervenor's claim that a 4' DOC is required in all residential areas is based on the following statement in pre-filed testimony by Mr. Heintz on 2-28-2013 (Attachment A#04). The relevant part reads (emphasis added):

> 3. Project Construction
> Q15. Please describe the pipeline construction process.
> A15. The process involves a series of sequential steps, as graphically illustrated on Exhibit JH-13, previously provided. The pipeline construction process, which is essentially unchanged from the December 20 Proposal, will generally proceed in the following sequence:
> …
> 5. Pipe lengths will be welded together, inspected, laid in the trench and warning tape will be laid over the line, and then the trench will be backfilled. The pipe will be covered by at least 36 inches of soil. The pipeline will have four-feet of cover in agricultural areas, within the VELCO ROW and residential areas, and generally five-feet of cover at road crossings and seven of feet cover at open cut streams.

The PUC's final order for ANGP (Attachment A#05) states:

> Project Construction
> 62. The process of pipeline construction involves a series of sequential steps that generally proceed in the following sequence:
> …
> e. Pipe lengths will be welded together, inspected, laid in the trench and warning tape will be laid over the line, and then the trench will be backfilled. The pipe will be covered by at least 36 inches of soil. The pipeline will have four feet of cover in agricultural areas and within the VELCO ROW, generally five feet of cover at road crossings, and seven feet of cover at open cut streams.

The PUC's final order contained the same language, verbatim, as the pre-filed testimony, with the exception of making no mention of DOC in residential areas.

Both the pre-filed testimony and the final order mention seven feet of cover at open-cut streams. The question of what qualifies as a "stream" under this requirement was addressed by Jeffrey A. Nelson

of VHB in an affidavit of 8-4-2017 (Attachment A#61). Mr. Nelson handled stream and wetland permitting for ANGP, among other duties. He notes (emphasis added):

> "the Project involved a total of 47 perennial or intermittent stream crossings. Of these, 21 occurred at larger streams or rivers with greater than one square mile of upstream drainage area, the jurisdictional threshold at which a Stream Alteration Permit would typically be required by VT DEC pursuant to 10 V.S.A. Chapter 41."

He goes on to explain his belief that the 7' DOC requirement only applied to jurisdictional stream crossings. The ANR criteria for a "jurisdictional" stream is one with more than 1 square mile of drainage area. A typical jurisdictional stream crossing is shown in image 2447, Alder Brook, at station 349+00. A typical non-jurisdictional stream crossing is shown in image 2465 at station 469+00.

DOC Compliance

The ultimate question, after consideration of the DOC commitments in dispute, is if ANGP is in compliance with the applicable requirements and commitments for depth of cover. My scope of work requires that:

> ***Contractor shall review and analyze VGS's August 11,2017, self-certification by conducting an independent on-site survey of the pipeline buried in a half-mile stretch of swampy ground in the VELCO right-of-way in New Haven and at pipeline stream crossings along the 4l-mile-long ANGP route, Contract will determine the pipeline burial depth in those locations and compare that information to the data provided in the VGS self-certification. Should the Contractor determine that the VGS failed to observe the burial depth requirements in the New Haven swamp, the Contractor will propose a survey method to assess the burial depth of the pipeline for the remainder of the 41-mile-long ANGP route.***

Per John St. Hilaire's affidavit of 8-11-2017, (Attachment A#62):

> "18. On behalf of VGS, I certify that, other than the 18 welds in the Clay Plains Swamp, based on the information compiled by the CHA and VGS survey teams as shown in the Depth Table attached here as Exhibit 1, the pipeline's installed depth complies with the Project's permits, agreements, and the 2013 Final Order."

The Depth Table (his Exhibit 1) is Attachment A#63 in my report.

My scope of work specifically mentions depth of cover in the New Haven[34] swamp and at stream crossings, but I also addressed this topic in general for the entire ANGP. I have surveyed the length of the Clay Plains Swamp, every jurisdictional stream crossing not installed by HDD, and most of the non-jurisdictional stream crossings. I have also surveyed numerous random locations along ANGP and compared the measured DOC to the self-certification from VGS, as shown on my site survey

[34] In this report I refer to this location as the Clay Plains swamp, as is consistent with my notes and much of the project documentation, not the New Haven swamp – but these are the same location.

spreadsheet (Attachment A#09), to confirm the accuracy of VGS's submittal. My DOC readings are given in the DOC Reading column of that spreadsheet.

Pipeline depth of cover can be determined in a variety of ways – using direct methods such as probing or excavating, or indirect methods using instruments. I used both methods during my site visits.

To physically probe the depth of the pipe, VGS used a 5' long fiberglass probe rod with a rubber tip (to avoid damage to the pipe coating). The probe rod is pushed into the ground until it has contact with the pipe, then withdrawn and measured to determine the depth to the top of the pipe. This method is hard to perform in areas with stiff soils, and can't provide an exact DOC when the pipe is buried deeper than 5'. A typical depth of cover reading from probing is shown in Attachment A#10 image 2860.

To indirectly determine the depth of the pipe, VGS used a model 7000+ radio detection line locating unit from SPX, with a matching 3 watt transmitter, to both locate the pipe and to estimate its depth during my site visits. This is a typical type of pipe detection unit used in the industry and is designed specifically for this purpose. At my request it had been calibrated on June 11, 2019, shortly before my first visit, and I reviewed the calibration records on Monday June 17, 2019. This unit provides a real-time indication of line depths with an accuracy specification of +/- 5% for line depths between 4" and 10'. For a pipeline buried at 5', the accuracy should be +/- 3". Early in my site visits, VGS physically probed the line to determine the depth in 2 locations and I compared those measurements to the line locator reading. The DOC determined by both methods was within less than 1", which confirmed that the line locator was performing within its stated specifications for depth indications.

My practice was to photograph the instrument reading and the measurement of the probe rod to document the DOC indication. The instrument measures the distance to the geometric center of the pipe, not the top. For a 12" diameter pipe like ANGP, the radius of the pipe (in this case, 6") must be subtracted from the instrument reading to find the distance to the top of the pipe. I made that adjustment to all indirect DOC readings when populating my site visit summary spreadsheet (thus, there is a uniform 6" difference between the photographed reading and the spreadsheet). A typical depth of cover reading determined by the line locating instrument is shown in Attachment A#10 image 2417.

During my site visits I witnessed DOC readings at 59 locations along ANGP. One additional DOC reading for the water crossing at Old Stage Road was taken after my visits by VGS[35] on 9/25/2019, when the waters had receded sufficiently for them to take a reading, for a total of 60 locations:

- 23 locations were in the Clay Plains Swamp
- 37 locations were outside the swamp.

During the site visit planning process, I targeted locations that had previously been determined to not have adequate depth of cover (and which had been re-graded after initial burial), as well as all 8

[35] VGS used the same instrument that was used during my site visits and provided photographic documentation of the location and readings to me.

jurisdictional steams that were not crossed by HDD. One of these locations was spontaneously requested by Mr. Dumont during our site visits (the DOC in that location was acceptable).

Concerning measurement technique:

- 28 locations were determined solely by indirect methods (all outside the Clay Plains Swamp)
- 32 were probed or were probed and compared to indirect readings (23 in the Clay Plains Swamp; 9 outside the swamp)

I also compared the DOC readings obtained during my site visits to the data provided to me by VGS in a kmz file, to confirm the accuracy of that information. The kmz dataset was the basis for VGS's submittal to DPS concerning DOC on 8-11-17, and is based on survey measurements of weld elevations after construction compared to survey measurements of ground elevations after burial (i.e. comparing top of pipe surveys immediately prior to burial to ground elevation surveys after burial).

VGS excavated 4 locations at the end of July 2019 for integrity management inspections. At my request, they used a tight line and tape measure to determine the DOC of the pipe at these locations after the pipe was exposed. The dig reports, with photographs, are included as Attachments A#11 – A#14. Relevant DOC information is summarized below:

Location	**Station**	**~kmz DOC**	**Required DOC**	**Measured DOC**
Breezy Valley	823+09	4'1"	4'	4'2"
Baldwin Rd	1120+31	4'8"	4'	5'2"
Chicken Farm	1926+81	5'	4'	4'5"
Route 7	2156+91	5'9"	5'	5'8"

In every case the measured DOC was in excess of the requirements in that location, and within a few inches of the nearest data point in the kmz file[36].

I measured DOC at 15 locations on the Hurlburt property (outside the Clay Plains Swamp), looking specifically for DOC at low spots. DOC at 13 of these locations was in excess of the 5' (sometimes much more), with the exception of 2 areas. DOC at one location in an open field was 4'7" (station 1602+80), and at station 1612+10 it was 4'10". These are agricultural areas that are tilled, and it is possible that a few inches of cover have been displaced from those locations after construction.

We measured DOC at every jurisdictional stream crossing and at many non-jurisdictional stream crossings. My site visit spreadsheet lists all types of stream crossings in the Description column, and has a "Y" in the Stream JD not HDD? column for every jurisdictional stream crossing that was crossed by open-cut trenching (i.e. requiring a 7' DOC).

[36] The kmz file data is in decimal feet, which I have converted to the nearest foot and inch for ease of comparison

The PL ROW extends about 2,500' through the Clay Plains Swamp, where the original VELCO ROW agreement calls for a 4' DOC. We took DOC readings in 23 locations, all by probing[37]. About 500' of the ROW was less than 4' depth, plus one other isolated location at 3'9" of depth. It is relevant to note that the location indicated in the intervenor's photo and video (a.k.a. "Cisco's video") was around station 1641+75, where the pipe is currently buried 4'7" (in excess of the requirements for that area). The shallow depth of cover areas are towards the middle of the swamp. None of these shallow locations are close to the edge of the swamp.

During my site visits I walked several miles of the ROW. I did not see any indication that the surface contours were substantially altered along the ROW nor any drainage or erosion issues (with the exception of one drainage location on the Hurlburt property, which was already being addressed between Mr. Hurlburt and VGS).

HDD

Some sections of pipe are installed by horizontal directional drilling (HDD). This method is especially popular for crossing large rivers or environmentally sensitive areas where open ditching can be problematic. Pipes installed by HDD are normally much deeper than trenched pipe, frequently 20 feet or more below the surface of the ground (or the bottom of the river) – although obviously the HDD returns to normal trench level on each end so it can be tied in to the other pipe.

Concerning HDD, the final order states:

> Horizontal Directional Drilling (pages 42 - 44)
>
> 71. To avoid or minimize impacts to certain streams, rivers, wetlands, and other sensitive resources, VGS **will employ HDD** at a **minimum of 15 locations**….

ANGP was installed by HDD in a total of 23 locations, including all 15 locations cited in the final order.

Burial in Swamps

The pipeline safety regulations have no special requirements for construction in swamps. The normal regulations apply as well as any operator specifications, etc.

The wetlands permit from the ACOE for ANGP was premised on VGS using no permanent foreign materials in a wetland, as explained in the application (Attachment A#57) (emphasis added):

> Block 21. Types of Material Being Discharged and the Amount of Each Type in Cubic Yards
>
> Project construction would require the temporary placement of fill material within wetlands and below stream OHW. There would be no permanent placement of fill within wetlands or streams as a result of Project construction. Temporary fill materials which would be placed in wetlands include construction mats and EPSC measures (i.e., silt fencing), as well as

[37] I compared my field notes with the DPS representative's notes and we have identical DOC measurements but with minor variations (+/- 10 to 20 feet) in station numbering because we used different methods to determine the station number of each reading.

discharges due to trenching for pipe installation. Temporary fill within streams could include temporary bridging, or flow diversion materials. Since the proposed fill impacts are temporary in nature and would not result in permanent displacement of wetland soil or fill below stream OHW, fill volumes have not been calculated.

The PUC's final order of 12-23-2013 (Attachment A#05, pdf page 41) states (emphasis added):

Project Construction

62. The process of pipeline construction involves a series of sequential steps that generally proceed in the following sequence:

….

d. In the elements of the Project that do not involve horizontal directional drilling, a trenching process will be used. For the Transmission Mainline, a four to five-foot wide trench will be excavated to a depth of approximately five feet, and soil from the trench will be stockpiled adjacent to the trench within the construction corridor. There will be different construction configurations for each of the different types of areas to be crossed, including wetlands, agricultural areas and within the public highway ROW. Smaller trenches of approximately four feet by five feet will be used for the Distribution Mainlines.

….

Heintz pf. supp. at 31-32; exh. Pet. Supp. JH-3.

Concerning HDD, the final order states (pdf page 43):

Horizontal Directional Drilling

71. To avoid or minimize impacts to certain streams, rivers, wetlands, and other sensitive resources, VGS will employ HDD at a minimum of 15 locations….

The order goes on to list the locations for HDD and concludes (pdf page 45):

On balance, the Project planners, stakeholders, and regulators appear to have engaged in a reasoned dialog resulting in the use of the most cost-effective method, either HDD or trenching, given the varying site characteristics along the Project route. We therefore condition our approval of this Order and CPG upon the use of HDD as articulated in VGS's February 2013 Project plan (as amended to reflect the use of HDD to cross the entire route through the Palmer property) and the VGS-ANR and VGS-Monkton MOUs.

The issues in this investigation aren't related to construction in a swamp per se, but the method used to bury the pipe in the swamp, referred in this investigation as the "sink in swamp" method. This method involved excavation of an initial trench shallower than ultimately required but not so deep that it would collapse in the muck, installing the pipe in that ditch, and then excavating adjacent to the pipe to allow the pipe to sink deeper into the excavation. As Mr. Dumont has noted in multiple filings, this technique was not described in the project plans and specifications.

Per an e-mail[38] from GC Morris to James Porter dated 8-7-2017 (among other sources), there were 2 areas installed by the sink in swamp method: New Haven and Monkton. It also refers to pipe being buried "on the ground" around station 1635+00 and station 1642+00 to 1666+00 – both referred to as "swamp". These are the same locations.

By all accounts, construction conditions in the New Haven (a.k.a. Clay Plains) swamp and the Monkton swamp were challenging. Per Mr. Bubolz' deposition[39] of December 19, 2017, page 105, concerning excavation in the Clay Plains Swamp: "It wasn't even that wet. It wasn't like we were digging in water. The material was - - it was just like an ooze." Typical trench excavation to final depth before laying the pipe in the ditch was unsuccessful in that area, and the sink in swamp method was used instead.

To get a better understanding of the activities and site conditions, I conducted a detailed review of the construction inspection reports for the Clay Plains Swamp area, including:

- ACOE Bi-Weekly reports
- Ditching Daily reports
- Lowering, Padding Backfilling Daily reports
- Trenching, Lowering, Backfilling QA Checklists
- Grading Daily reports

I prepared a graphic summarizing the inspections by source[40], inspector, day, date, and description by Station number in that area (Attachment A#58). The ACOE Bi-Weekly reports record the amount of rainfall in the area each day, based off nearby weather stations. They record the following amount of rain:

Date	**Day**	**Rain**
8/12/16	Fri	0.24"
8/13/16	Sat	0.32"
8/16/16	Tue	0.93"
8/21/16	Sun	0.28"
8/31/16	Weds	0.16"

The inspection reports state on 8/7/16 "Construction and timber mat installation has commenced in the New Haven Swamp", and on 8/10 and 8/11 "Setting timber mats". Significant rains began the following day, totaling almost 2" of rain in less than 3 weeks. During this 3 week period, the inspection reports show very little construction activity in the swamp. The ACOE Bi-Weekly report of 9/4-9/17 states: "Pipe installation leading into the Red Maple/Green Ash[41] swamp; Conditions were extremely challenging; work off timber mats". At some point in mid-September, the sink in swamp method was used to install the pipe.

[38] This is included in the Intervenor's Motion to Broaden Scope of the Investigation, as their attachment #19.
[39] This deposition and attachments are already in the docket for this case.
[40] The Source in this graphic refers to an internal worksheet listing all the inspection files by file folder and file name.
[41] As noted earlier, this is also known as the Clay Plains Swamp.

Intervenors have stated that a video of pipe taken on September 19, 2016, prior to burial in the Clay Plains Swamp, indicate that the pipe was lying in a very shallow trench and couldn't have been buried as deep as required or claimed by the following day. I inspected the Clay Plains Swamp with the person who took that video (Mr. Cisco Shelton), and he agreed that we inspected and took DOC readings in the area depicted in his video.

Regardless of the time required to perform additional excavation, the intervenor's claim that the pipe was in a very shallow trench presumes that the pipe as photographed was laying on a firm trench bottom – but that did not exist in the swamp. The pipe in the Clay Plains Swamp was not laying in on a firm trench bottom but in mud (perhaps pure mud from the walls of the trench sloughing into the ditch after excavation). It is possible that the pipe as depicted in Mr. Shelton's video was sitting not on the trench bottom but was floating in muck.

The depth of cover ultimately achieved in this area was measured during my site visit and is shown by station number on my site visit summary spreadsheet (Attachment A#09). VGS has admitted that portions of the pipeline are not buried as deep as required in the Clay Plains Swamp area – and that was confirmed by my readings. However, VGS obtained agreement from VELCO that the shallow DOC in that area was acceptable (under terms and conditions) (Attachment A#56).

Mr. Dumont has cited an email[42] from GC Morris on 9-8-2017 as an indication that there were "several" areas where the sink-in-swamp method was used – and those additional locations are unknown. Mr. Morris's e-mail states: "the pipeline, in several swampy areas, was installed by via excavation of soft material adjacent to pipeline allowing pipe to sink-in to position by displacement of ground beneath it." I'll note that the topic of Mr. Morris's e-mail on 9-8-2017 was coating concerns, not burial techniques, and it offers no additional information concerning the reference to "several" swampy areas – which could be referring to several areas within the Clay Plains Swamp.

[42] This is included in the Intervenor's Motion to Broaden Scope of the Investigation, as their attachment #8.

Conclusions

Most of the compliance and performance issues cited regarding ANGP are based in alleged non-compliance with a specification, plan, or procedure developed for ANGP – not with a regulation or applicable industry standard. While the rule requirement for an operator to develop and comply with a comprehensive set of plans and specifications for a project like ANGP is clear, the questions remain: How comprehensive do the written plans and specifications need to be? How perfect must compliance be? Because there is no such thing as a perfect set of written plans and specifications, nor perfect compliance with those specifications and standards, my standard was not perfection. I wanted to know if the ANGP project complied with generally accepted practices for gas pipeline construction and had developed and followed typical plans and specifications. But I did not stop there, because VGS had committed to perform this project at a higher standard than generally accepted practices and basic rule compliance.

My performance expectation when determining if VGS complied with the requirements and their commitments was to look at the plain language of the requirement or commitment as it would be reasonably interpreted by a knowledgeable and competent person, without bias toward or against VGS and its contractors and without reading the requirements "narrowly and with unnecessary technicality"[43].

Any non-compliance is non-compliance, but I differentiated (as does PHMSA) between non-compliance that impacts pipeline safety versus non-compliance that does not when formulating my conclusions and recommendations, including non-compliance with specifications that were unnecessary or inappropriate to that situation.

Compliance

I have reviewed the DPS inspection reports for each year and found any critical comments (aside from those that resulted in NOPVs), to be minor deficiencies that are routinely found and corrected on a daily basis during a project of this type. They caused no overall compliance concerns. The compliance issues that resulted in NOPVs have been resolved appropriately (except the Bedding / TB NOPV which is still open). I address both Findings from that NOPV in the appropriate sections below.

Most of the discussion concerning non-compliance by VGS and its contractors is based on non-compliance with regard to plans and specifications – not some explicit rule requirement. In fact, both Findings from the Bedding / TB NOPV are related to non-compliance with a specification developed by CHA for ANGP. As noted earlier, these plans and specifications were occasionally incomplete, inappropriate for the situation at hand, or internally inconsistent.

Our independent review of DOT compliance records (post construction) for ANGP did not note any deficiencies.

[43] In a different pipeline case, Michigan Court of Claims Judge Michael Kelly said requirements "should be construed reasonably, not narrowly and with unnecessary technicality." https://www.mlive.com/news/2019/10/court-rules-in-favor-of-enbridge-in-line-5-dispute-with-gov-whitmer.html

My conclusions concerning compliance with CPG Special Pipeline Safety Commitments are given in the table below, organized by topic. P# refers to paragraph number in the CPG.

Commitment / Requirement	P #	In Compliance?
GENERAL		
meet or exceed all applicable state and federal codes and standards	259	Yes, except as noted in this report.
have a variety of permits before starting construction	408	Yes
meet a number of industry standards	263	Yes
quality assurance plan addressing a number of topics.	264	Yes
DESIGN / MATERIALS		
meet Class 3 design requirements	262	Yes
2 types of over pressure protection at all gate stations	262	Yes
mainline valves spaced per Class 3 requirements	59	Yes[44]
8 mainline valves / more valves than req'd by code	56; 262	Yes
valves inside locked fence enclosures	60	Yes
valves will be remotely operated	61; 262	Yes
certification records for flanges, etc.	266	Yes
seams will be UT inspected after cold expansion and hydrostatic testing	262	Yes
use non-shielding cp coating	262	Yes
use abrasion resistant coating for trenchless installation	262	Yes
CONSTRUCTION		
x-ray welds	262	Yes
QA inspection and testing program for pipe coating, addressing a number of topics	265	Yes
at least 36" of cover or equivalent means of protection from outside force damage	267	Yes, with the exception of swamp installations noted elsewhere.
installed at least 1' below the deepest expected penetration of the soil	267	Yes
buried at least 4' in agricultural areas	268; 423	Yes, with minor exceptions as noted elsewhere.
only use suitable backfill	270	Yes[45]
bentonite trench breakers based on topography	31; 429	Yes
bentonite trench breakers at the limits of each wetland	32	Yes

[44] Per Class 3 design criteria, no point on the pipeline can be farther than 4 miles from a mainline valve. The mainline valve locations are shown by station on my site visit spreadsheet and meet this requirement.

[45] Allegations of unsuitable backfill were investigated, but no problems were found.

bentonite trench breakers bedrock and wetlands	406; 430	Yes
HDDs installed in locations specified	71 - 75	Yes
the landscape will be restored as closely as possible to pre-construction conditions	62(f)	Yes
various soil stability monitoring and mitigation commitments	273	Yes
not cause unreasonable soil erosion	410	Yes
pressure test for 8 hours at least 2,160 psi.	30	Yes
initial strength test will exceed code requirements	269	Yes
OPERATIONS		
various odorant commitments	271	Yes
ROW management plan	274	Yes
line of sight markers	274	Yes
various patrol commitments	272	Yes
review and update of damage prevention program to meet or exceed standards and practices	274	Yes
INTEGRITY MANAGEMENT		
TIMP data collection and integration for the entire pipeline, not just HCAs	276	Yes
use metal loss ILI	262	Yes
use geometry ILI	262	Yes
assess the entire project every 7 years, not just HCAs	278	too soon to verify this one

Concerning compliance with statements made by VGS and its representatives during the application process, I find that VGS did what they said they would do, as would reasonably be expected, with the realization that details of projects such as this evolve during the final engineering and construction process. As an example, Mr. St. Hilaires pre-filed testimony of 2-28-13, section 3, says the project will "generally proceed in the following sequence". This document and several others like it described the project in general terms and were not a definitive set of project specifications that would apply in every location at every point in time.

VGS was diligent in their efforts to comply with the pipeline safety regulations, their own plans and specifications, and the CPG commitments during construction of ANGP. While they did not have perfect success in every instance, they resolved issues in a timely manner as they became aware of them. The answer to "Did VGS comply with pipeline safety regulations and the 2013 Final Order and CPG in Docket 7970?" is generally Yes.

Design and Engineering

Did VGS use construction plans that were signed by a Vermont-licensed professional engineer in constructing the pipeline?

The construction plans were not stamped by professional engineers in responsible charge of the engineering work at the time of construction, but the plans had been developed by engineering firms licensed in Vermont and under the supervision of engineers licensed in Vermont. After being requested to do so, Vermont-licensed professional engineers provided PE-stamped versions of the

"Issued for Construction" drawings with no additional modifications – indicating that the engineering work was complete for the earlier set even though it had not officially been sealed at the time of construction.

I agree with Mr. Liebert that inadequate engineering plans and specifications CAN put the public at risk and make no excuses for the lack of PE-stamped designs during construction, but do not share his conclusions that, as a result of not having PE-stamped drawings "ANGP was constructed in a manner that does not adequately protect the public". The engineering process and oversight was investigated by the Vermont OPR and found to be acceptable (although the Intervenors have noted that the Vermont OPR's decision regarding adequacy of the professional engineering for this project was rendered before the ANGP drawings were issued for construction – without being stamped).

I disagree with Mr. Liebert's opinion that the cathodic protection and AC mitigation system designs were required to have a PE stamp. The Vermont Office of Professional Regulation licenses engineers by discipline[46] (Chemical, Structural, etc.). The practice of corrosion engineering has been recognized at least since 1943 when the National Association of Corrosion Engineers[47] (NACE) was established, but Vermont has no classification for professional Corrosion engineers and does not license them.

The federal regulations require the use of a "person qualified" to handle these tasks:

> 49 CFR 192.453. General
> The corrosion control procedures required by §192.605(b)(2), including those for the design, installation, operation, and maintenance of cathodic protection systems, must be carried out by, or under the direction of, a person qualified in pipeline corrosion control methods.

I found the ARK designs to be thorough and technically sound and have seen no indication that they were inadequate for their intended purpose or prepared by a person who was not qualified to do so. Quite the opposite.

Lastly, Mr. Liebert's point that the corrosion protection system documents were issued after construction began is of little relevance, because corrosion protection systems are typically installed after most other construction activities are complete. In fact, the federal regulations allow these systems to be installed and placed in operation up to 1 year after completion of construction (emphasis added):

> 49 CFR 192.455. External corrosion control: Buried or submerged pipelines installed after July 31, 1971
> (a) Except as provided in paragraphs (b), (c), and (f) of this section, each buried or submerged pipeline installed after July 31, 1971, must be protected against external corrosion, including the following:
> (1) It must have an external protective coating meeting the requirements of §192.461.

[46] see 26 V.S.A. § 1182 (a) and (b)
[47] https://en.wikipedia.org/wiki/NACE_International

(2) It must have a cathodic protection system designed to protect the pipeline in accordance with this subpart, installed and placed in operation within 1 year after completion of construction.

I have not seen or heard of any specific reason that the relevant plans were not stamped by a Vermont PE prior to construction. The Vermont PE regulations allow for electronic stamps and signatures (not just physical stamps and signatures), so there may have simply been a misunderstanding about work products having been officially stamped or not.

While the letter of the professional engineering requirements in the State of Vermont was arguably not met in this instance, the spirit clearly was. I have seen no evidence that the engineering or design work for the ANGP was deficient, was not performed by competent engineers, or posed a risk to "public health, safety, and welfare.". The specifications also provided a comprehensive and technically sound basis for quality assurance during the project.

Quality Assurance

Although API RP 1169: Recommended Practice for Basic Inspection Requirements – New Pipeline Construction has not been incorporated by reference into the pipeline safety regulations and was issued for the first time after design of the ANGP had begun, the ANGP inspection process generally conformed with its requirements and recommendations, and met or exceeded other industry expectations for inspection.

Mr. Liebert prepared a memo on September 12, 2019 to Mr. Dumont that stated "Since there were no signed and stamped IFC plans, there was nothing that a QA plan could ensure conformity with." I disagree with that statement and similar opinions expressed by Mr. Liebert in that letter. The plans and specifications provided a strong basis for quality assurance, and I have seen no evidence that any person involved in the construction project felt that the specifications weren't required to be conformed with – whether they had a PE stamp or not.

Extensive specifications of all types were prepared in advance of construction, and extensive inspections were performed by multiple parties to ensure conformance with those specifications - with contemporaneous reporting up to the CMT. The CMT was well defined and actively involved in the oversight of the construction project. In every situation, VGS addressed issues as they were identified and non-compliance was corrected or properly managed in conjunction with the appropriate regulatory agency. ANGP did develop and comply with a QA program to oversee the pipeline contractor and subcontractors.

Burial

Backfill Materials

There was never any requirement for the pipeline to be laid in clean sand above the trench bottom, and that was not typically done. The VGS and CHA specifications agree on this point. Per VGS narrative specification Section 13.i "Select fill material and/or padding material shall be sand in accordance with VTrans Standard Specification 703.03 or shall be screened native material containing silts, sands and gravels with the largest material being no larger than 1-inch on the longest

dimension." CHA specification 312000 in the bid package, section 3.5 Fill, says "A. When native soil conditions are not acceptable for pipe bedding and pipe envelope backfill, "bank run sand" shall be utilized." Both specifications allowed the use of native soil for bedding and backfill, as long as it was acceptable.

ANGP used select backfill to bed and pad the pipe, and that backfill normally came from the excavated materials as is common in the industry. Clean sand was only imported and used when the native materials were unacceptable. I have seen no evidence that the backfill used for bedding and padding the pipe was of insufficient quality.

Pipe Support and Protection (Bedding and Backfill)

At the outset, I believe both VGS and CHA thought their specifications concerning bedding and backfill were in agreement with one another. The team and the inspectors (including the DPS inspectors) relied on the more appropriate VGS narrative specification in 2014 and 2015, not the CHA specification, concerning bedding and backfill. It was only in 2016 that the focus changed to the CHA specification, and future correspondence which focused **solely** on that specification did not appropriately consider the entire specification package (including the incorporated VGS narrative specification) and its development.

I note that CHA's e-mail of 6-22-2016 described the intent of their specification, which would allow direct burial on the trench bottom while their official reply to the RFI of 7-1-2016 cited the letter of their specification… with no mention of its intent. The response to the RFI also made no mention of the VGS narrative specification – which was also part of the official specification package and which explicitly allowed direct burial on the trench bottom. The VGS narrative specification was more appropriate in this instance than the CHA specification, and I think the appropriate response to the RFI would have been for CHA to cite both specifications and to reconcile them in favor of the VGS narrative specification.

VGS complied appropriately with the specifications for bedding and pipe support as they were understood at the time and responded in the most conservative fashion (bedding all the pipe regardless of soil type) after questions were raised.

Corrosion concerns from laying pipe directly on trench bottom:

The specific corrosion concern cited in Bushman's paper from burying pipe directly on the trench bottom would be unusual (significantly different oxygen concentrations in adjacent buried soils), and he may have mentioned it more as an interesting application of the concept than a typical problem. Mr. Hereth's report of 2/27/2018 (Attachment A#66 pdf pages 191-192) explains why he does not feel this phenomenon is an issue for ANGP, and I concur with his opinion[48]. Differential oxygen corrosion between 2 different soil types for a buried pipeline isn't impossible but is highly unlikely. As noted earlier, this phenomenon is normally limited to soil / air interface regions, such as where the pipe goes from above to below ground. I serve as the consultant to an industry data-mining team and have never seen it mentioned as a contributing factor to a corrosion failure.

[48] Mr. Hereth is well qualified to speak on gas transmission pipeline construction issues. Among many other accomplishments, he lead the development of the INGAA Foundation Primer on Construction of Natural Gas Pipelines.

Even if this phenomenon were a threat for a buried pipeline, various parties have misunderstood the specific situation described in Bushman's paper and its application for ANGP. There are no locations where the pipe was BOTH installed directly on the trench bottom AND backfilled on 3 sides with clean sand or non-native backfill. The only areas where ANGP was installed directly on the trench bottom were also areas that used native backfill – which eliminates the potential for this problem. The potentially corrosive situation described in Bushman's paper simply doesn't exist on ANGP. Even if it did, the coating and cathodic protection for ANGP is in excellent condition and should be more than adequate to address this relatively weak corrosion process. My opinion was apparently confirmed by Mr. Bob Allen, President and Owner of ARK engineering, NACE CP4 certified, in a conversation with Mr. St. Hilaire on 7/1/16, per Attachment A#66, pdf page 204-205.

In summary, this white paper has been misunderstood and misapplied, and the potentially corrosive environment explained by burying a pipeline directly on the trench bottom (while surrounded on 3, but not 4 sides, by clean sand on top of native trench materials) does not exist on the ANGP. All references to this phenomenon for this pipeline are incorrect. The burial techniques for ANGP, including burial directly on the trench bottom in some locations, had no deleterious effects on corrosion control and did not create a corrosive environment for the pipeline.

Compaction and Surface Loads

The intervenors have noted that there were very few compaction tests made during construction of ANGP and that many of these tests did not meet the specification (although it should be noted that some of these tests were of the same location, with the initial test failing the specification and a subsequent test passing). The test results given in Attachment A#50 are for 4 different locations where ANGP is in or crosses a VELCO ROW. Aerial images of all 4 crossings are included in Attachment A#10. Each of these locations shows well-established vehicle traffic patterns along the VELCO ROW, indicating that these locations were treated differently than "normal" VELCO ROW. In all the other areas VGS did not "Test the compaction of backfill over the pipeline". The VGS / VELCO MOU (Attachment A#44) mentions a loading standard but also states that VGS will meet that loading standard by building the pipeline to Class 3 requirements and burying it 4' deep. The MOU does not require testing of compaction in the VELCO ROW.

The initial compaction requirements of the CHA bedding and backfill specification were excessively conservative for non-load bearing areas – and for this pipeline. As explained earlier, small diameter, high yield strength steel pipelines such as the ANGP have joints have the same tensile strength as the pipe itself, if not more, and don't rely on the trench bottom for joint stability. Compaction of the trench bedding materials makes no difference from a pipeline integrity standpoint, and settlement of dirt within the ditch also poses no threat to the pipeline. I discussed this issue with Mr. Gennaro Marino (PhD, D.GE) on October 16 of this year at an ASME meeting where he made a presentation entitled: "Undermining Oil & Gas Pipeline Integrity Resulting from Subsidence". He specializes in the engineering analysis of pipelines undergoing earth movement – such as pipelines crossing areas undergoing long-wall mining. He is a PE licensed in 26 states and chairman of the American Bar Association's Expert Witness Civil Engineering subcommittee. Mr. Marino said that pipeline backfill is typically "very loose". He said this as a general observation and then noted that the lack of

compaction is beneficial in areas with subsidence because the earth can adjust itself around the pipeline.

Re-contouring the surface of the ROW to achieve DOC after construction does not prove settlement or lack of compaction.

The issue concerning compaction isn't non-compliance with the specifications, but rather that the specifications were excessively conservative and over-prescribed and should have been changed prior to construction.

Likewise, the HS20+15% loading criteria in the CHA bedding and backfill specification was excessively conservative for a pipeline ROW (i.e. not under a road or other load bearing area) – but it doesn't matter because ANGP can meet that loading standard at any reasonable burial depth or level of compaction. Per the CEPA surface loading report in Attachment A#49, ANGP would easily pass the "very conservative" screening analysis and require no further analysis, while greatly exceeding HS20+15% standards[49] - regardless of soil compaction. Surface loading under any anticipated scenarios isn't a concern for ANGP[50]. This has been confirmed by multiple analyses from different engineers using different software.

VGS should have monitored compaction levels and ensured sufficient compaction in open cut roads and I have seen no evidence that they did so (at least, not differently than in any other location). This would be to protect the road, not the pipe. During my field visits members of the public mentioned 2 dirt road crossing where they had noticed frost heave. This issue is addressed in the Recommendation section.

Trench Breakers

While I make no claims to be an expert in soils or hydrology, I have walked several miles of the ANGP ROW and noticed no areas with evidence of water migration along the subsurface ditch. The use of native materials as backfill, as was done for most ANGP ditches, helps to avoid that problem. I have also physically inspected and / or reviewed detailed aerial photography for every location noted in Attachment A#54 where bentonite trench breakers were called for but not installed in 2014. My notes concerning each location with a missing trench breaker are in red in that attachment. ANGP is parallel to major roads, a railroad, or a golf course which DO significantly impact hydrology, but none of these locations appear to be at risk of affecting hydrology due to water flow along the subsurface ditch. Any impact caused by a lack of a bentonite trench breaker in the ANGP ditch in these locations should be insignificant.

[49] The 145,000 pound limitation from the graph is almost 4 times greater than the required loading capacity of 36,800 pounds to meet HS20+15% requirements.

[50] A useful comparison is to culverts installed routinely under roads – which are designed only to withstand the loading imposed by the road. Image 2956 shows a road culvert buried under Vermont Highway 289 – a busy 4 lane road, in an area where ANGP parallels the highway. Its diameter is several times that of ANGP, and the wall thickness is less than half. It also is probably constructed of steel with normal yield strengths – not high strength steel such as ANGP. All of these factors would make the culvert much more likely to fail under the load of the road – but it doesn't. I have no doubt that it has been adequately engineered and is perfectly safe for that road crossing. ANGP would be many times safer.

The environmental consultant that handled wetlands permitting and day-to-day relations with the ANR was VHB – and VHB has been in communication with ANR on this issue. Per Attachment A#70: "VHB has reached the conclusion that the potential absence of 10 trench breakers located at 5 wetlands did not observably or significantly alter the wetland hydrology to the extent that any Class II wetland boundaries or functions were impacted beyond what was permitted. VHB also concludes that bentonite trench breakers were installed at all stream locations as specified." My field inspections support that opinion.

VGS did "install bentonite trench breakers to protect wetlands and streams". I have seen no evidence that trench breakers were not installed where personnel in the field thought they were required or appropriate to the situation. Any question concerning the installed trench breaker types and locations appears to be more a difference of opinion concerning the letter of the requirements, not a dispute that the intent of the requirements was met. VGS responded appropriately to these differences of opinion by modifying their specifications to give the precise station number for each trench barrier by type.

Depth of Cover

To determine if VGS's self-certification of 8-11-17 concerning DOC was correct, I first had to decide what DOC requirements applied in residential areas and for non-jurisdictional streams.

Residential DOC Commitments

The change in language between the pre-filed testimony and the PUC's final order concerning DOC in residential areas appears to have been an intentional deletion (as that was the only change to the language in that paragraph in the PFT), indicating that the PUC had decided not to include a 4' DOC requirement in residential areas.

Stream DOC Commitments

The ANR in a letter of 10-12-2017 (Attachment A#64) indicated that they believe the 7' DOC requirement was technically required per the project specifications and permits for the non-jurisdictional stream crossings, but that "non-compliance was a technical violation but not worthy of enforcement action." I disagree with their interpretation of the specifications as to the DOC requirement but agree that any violation would be purely of a technical nature with no impacts on pipeline safety or the environment.

I visited every jurisdictional stream crossing and most would meet my understanding of a stream (although some were very small). None of the non-jurisdictional streams would meet my understanding of a "stream". They are areas that might routinely contain some water runoff after a rain that are small enough to step across. Most of them wouldn't qualify as a ditch in my opinion – having no defined boundaries or channel. The non-jurisdictional streams have no erosion potential that would present pipeline safety concerns nor require additional depth of cover. I do not believe that a 7' DOC was ever intentionally claimed or expected for those areas, although there was some overlap in the use of the word "stream" in some of the design drawings for both jurisdictional and non-jurisdictional streams – leading to confusion about the requirements.

General DOC Findings

I agree with VGS's opinion that there was no requirement to bury ANGP with a 4' DOC in all residential areas, nor to bury it 7' below non-jurisdictional stream crossings. The question then became whether VGS's Depth Table (Attachment A#63) contained in its self-certification of 8-11-17 was accurate. As mentioned earlier, we took DOC measurements at 60 locations – 23 of which were in the Clay Plains Swamp and 37 that were not. These DOC measurements are recorded in my site visit spreadsheet in Attachment A#09 and compared to the data in the kmz file[51]. The DOC measured during my inspection was on average 2.4" greater than in VGS's records outside of the Clay Plains Swamp, and on average 2.1" less that in VGS's records inside the Clay Plains Swamp.

My field DOC readings had only minor variations as compared to the information submitted to DPS, as would be expected due to equipment accuracy or local changes over time (such as in a cultivated field). Within the swamp our feet would often sink 6" into the muck, so a 6" difference in DOC could result from measuring within a footprint or not. I found no bias in the data (consistently deeper or shallower) submitted by VGS and believe it to be accurate as of the date it was submitted. There is no need to re-survey DOC for the entire pipeline.

The 2 locations on the Hurlburt property that were less than 5' (as required in their site-specific agreement) may have been caused by subsequent farming activities – since adjacent readings were in excess of 5'. As explained earlier, there is no regulatory requirement to maintain an original DOC. These locations should be addressed between Mr. Hurlburt and VGS as normal for pipeline / landowner interactions, to prevent damage to the pipe from agricultural activities.

DOC in New Haven swamp

All parties agree that the pipeline does not have a 4' DOC in the New Haven (a.k.a. Clay Plains) Swamp. While the final order does not contain any particular DOC requirement in swamps, it does require a 4' DOC in the VELCO ROW – and ANGP is in a VELCO ROW through the Clay Plains Swamp. Not achieving that DOC was technically a change from the approved plans and specifications even though VELCO, based on engineering analyses for loading capacity, approved a variance to DOC in their ROW in the Clay Plains Swamp.

The CPG (Attachment A#05, page 12) was approved with the following statement (emphasis added):

> "The VGS-VELCO MOU does, however, commit the parties to certain safety and emergency standards and binds both parties to **negotiate in good faith in an iterative process as the final form of Project plan is resolved.**"

Thus, the PUC appears to have deferred to VGS and VELCO to determine the final requirements for safety and emergency standards for the co-located ROW. I find that VGS acted appropriately in working directly with VELCO concerning deviations to burial requirements along the Clay Plains Swamp ROW, and that these deviations were adequately analyzed from a technical standpoint and were committed to writing by both parties. In my opinion this did not constitute a "material

[51] I calculated the differences for those locations that I thought were close enough to a kmz reading to be relevant, but did not attempt comparisons when there was no kmz data close to our reading. These locations are shown as "no weld" in my spreadsheet because the kmz data was recorded at each weld.

deviation", "material change", or "substantial change" from the plans and specifications, and that it meets the requirements for a "non-substantial change".

The Final Order mention the relative costs / benefits of HDD versus open trenching and lists 15 locations where HDD would be required (see the Burial section, below). The record shows that VGS used HDD in 23 locations. In hindsight, HDD might have been preferable for this location as well, but that would have had greater impacts to adjacent properties that are agricultural. I find that VGS and its contractors addressed the constructability issues in this area in a reasonable fashion and with proper regard for environmental protection and public safety.

Burial in Swamps

The intervenors have claimed that since the specific construction configuration and technique used in the Clay Plains swamp was not depicted in the project plans, that this construction configuration and technique was in violation of the CPG. I disagree. The CPG mentions that "There will be different construction configurations for each of the different types of areas to be crossed, including wetlands…". As noted earlier, Addendum 2 of the bid specifications notes that the drawings do not contain all the requirements (Attachment A#17, pdf page 88):

> 20. Q: "*Are all of the EPSC requirements on the EPSC drawings or does the contractor need to reference other documents?*"
> A: No, all EPSC requirements are not on the EPSC drawings.

The project plans and specifications gave the CMT the authority and responsibility to address site-specific conditions, and they acted appropriately when addressing the conditions in the Clay Plains Swamp (and other swamps). I believe this was entirely consistent with the project plans and specifications and the CPG. This variation in construction technique was not in violation of the law nor applicable pipeline safety regulations.

The intervenors have also noted that the swamp trench was not bedded prior to installation of the pipeline. There was also no compaction. The bedding and compaction issues in the swamp are no different than elsewhere and have already been discussed. Lack of bedding or compaction cause no pipeline integrity concerns in this area.

The pipeline in the Clay Plains Swamp is not buried as deeply as required, but engineering analysis of the pipe as installed in the swamps indicates that it should meet the loading standard contained in the VELCO MOU – and VELCO has agreed in writing to its current location. I'll note that highway loading standards such as are contained in the VELCO MOU are of little relevance in areas that can't be traversed by wheeled (or perhaps even tracked) vehicles. I do not think any attempts should be made to increase the depth of cover for the pipeline in this area, barring unforeseen developments.

Coating

ANGP was constructed from pipe with modern factory applied coatings and applicable specifications. These coatings were inspected both in the factory and in the field and patched as needed. Field-applied coatings were applied by qualified personnel and under a comprehensive inspection program (although not every field coating was inspected during application, as noted elsewhere). The entire

length of ANGP was inspected at least twice by jeeping to ensure that there were no defects in the coating prior to burial. The issues with various coating patches detected during the inspection process were addressed effectively. I concur with the DPS that the coating issues identified during construction created a potential area of concern – but subsequent inspections of the cathodic protection system have effectively resolved those concerns. I do not believe that excavating the 67 Canusa sleeve locations from suspect manufactured lots would be worth the risk of excavation. Any remaining risk can be managed as part of VGS's normal inspection and integrity management activities, as noted in the Recommendations section.

The fact that the cathodic protection system requires less than 10% of its design current, and less than 2% of its capacity[52], is clear evidence that the coating of ANGP is in excellent condition[53]. ANGP was and is properly coated, as evidenced by subsequent inspections and the minimal amount of cathodic protection current required to meet acceptable cp levels.

Cathodic Protection

VGS did have an adequate cathodic protection system before gassing up, as described in the Discussion section. Comprehensive cathodic protection surveys indicate that the cathodic protection for ANGP is excellent. The p/s readings during my inspections were consistent with those findings.

My field inspections confirmed that VGS installed zinc ribbon corrosion protection in two high-risk areas: the Clay Plains Swamp and station 889 to 892 in St. George. I also noted many above-ground SSDs (used to connect zinc ribbon to the pipeline) along the PL ROW in the appropriate areas called for in the plans.

[52] The ARK Commissioning report for the first 11 mile segment (Attachment A#31) says: "The CP system was very easy to balance. In fact, output was so low that current measurements at the individual shunts were almost too small to measure."

[53] An analogy would be the amount of heat required to keep a house warm on a cold day. A well-insulated house requires little heating, while a poorly insulated house requires much more heating. From a cathodic protection standpoint, ANGP requires very little heating (cp current) to stay warm (have adequate cathodic protection).

Summary

I have thoroughly investigated the construction of the ANGP. It was thoroughly and competently designed and engineered using modern equipment and technology, and comprehensively inspected during construction by multiple parties. With a few noted exceptions, it was constructed in compliance with applicable rules and commitments, and in many important respects it significantly exceeds the typical requirements. In my opinion VGS met the letter of all requirements and commitments in almost every case, and the intent in every case.

ANGP was designed and built with modern materials according to sound specifications and with thorough inspection, which provides the foundation for safe pipeline operations. Inspections subsequent to construction confirm my opinion. The in-line-inspection (ILI) of July 9-18, 2018, found no actionable anomalies. The cathodic protection close-interval survey (CIS) and direct current voltage gradient (DCVG) surveys found no problems with the pipe or coating (Attachment A#33). Inspection digs subsequent to the ILI and cp surveys revealed no problems with the depth of burial or backfill.

Ongoing inspections and maintenance as well as periodic integrity management assessments and evaluations should identify and resolve any pipeline safety issues that arise in the future and provide assurance of continued safety. The Recommendations section contains 7 recommendations, above and beyond existing regulatory requirements and commitments, to ensure that ANGP operates at a higher level of safety than most similar pipelines in the future.

Recommendations

Additional Requirements

While I believe ANGP is safe, the following recommendations will provide additional assurance of safety in the future.

1. The zinc ribbon / SSD system should be routinely inspected and quickly repaired as necessary to ensure that AC interference currents do not cause corrosion of the pipeline. VGS should conduct and document detailed inspections of all SSDs twice a year (not to exceed 7.5 months between inspections) and correct any problems within 2 months of discovery.

2. VGS should conduct over-the-line (OTL) surveys every 3 ½ years (not to exceed 48 months between inspections), with the specific types of OTL survey to be determined by a competent corrosion consultant independent of VGS. All indications should be investigated and corrected as necessary within 6 months of discovery. The surveys should be able to detect AC interference / stray current issues.

3. VGS (or VELCO) should install large warning signs at each end of the ROW in the Clay Plains Swamp with the following (or similar) text "WARNING. SHALLOW HIGH PRESSURE GAS PIPELINE IN THIS AREA. NOTIFY VGS AT (phone number) BEFORE MOVING HEAVY EQUIPMENT INTO THIS AREA"

4. VGS should perform a DOC survey in all actively cultivated agricultural areas every 3 years, and address any DOC less than 4' (or landowner agreements – whichever is greater) to ensure agricultural activities will not impact the pipeline. This does not mean that DOC must be maintained at the original installation depth, but that any loss of cover must be managed in cooperation with the landowner / farmer to ensure agricultural activities do not interfere with pipeline safety.

5. VGS should ensure its line locating procedures, training, and qualification programs address the potential for zinc ribbon interference with line locating equipment. The procedures should require disconnection of the zinc ribbon prior to using an indirect line locator, probing the pipeline location, or hand digging / potholing to ensure the line is located accurately prior to any excavation near a pipe protected by zinc ribbon. These procedures, training programs, and qualification programs should be submitted for DPS review within 6 months of this report.

6. VGS should hire a Vermont-licensed professional civil engineer with expertise in dirt road construction and maintenance to inspect each of the 15 open cut road crossings for evidence of frost heave, settlement, and potholing, at times of the engineer's choosing but at least twice (once during cold weather to look for frost heave and once during warm weather to look for settlement and potholing), and have them develop and certify a remediation plan for any deficiencies that are discovered. VGS should inform the engineer in writing prior to the inspections of any complaints received concerning these crossing locations. VGS should report to DPS and any relevant local agency, municipality, or authority for each crossing within 18 months of my report

concerning the results of these inspections and any remedial actions taken or planned. VGS should provide periodic updates to these parties until all deficiencies (if any) have been corrected.

7. VGS should modify its pipeline integrity management plan to specifically mention the locations of the 67 Canusa sleeve repairs from the problematic[54] batches. These locations should be called out as a potential integrity concern during all subsequent integrity assessments and evaluations (such as close-interval surveys and in-line inspections). This does not mean that every assessment must be designed specifically to look for external corrosion threats at coating repairs. Rather, that the Canusa sleeve locations be considered when evaluating the results of every assessment (even assessments not designed to look for that threat), because of the potential for interacting threats.

In response to the Bedding / TB NOPV, VGS proposed a Stipulated Remedial Action Compliance Plan (Attachment A#67). The actions proposed in the Stipulated Remedial Action Compliance Plan reflect a very conservative approach to integrity management, going far above typical requirements. This plan (still DRAFT) contains the following commitments:

A. Conduct both metal loss and geometry ILI on a 5 year interval, not to exceed 63 months, and get a final report within 90 days
B. Conduct CIS and either DCVG or ACVG surveys within 6 months of the ILI
C. Use more conservative repair criteria than required by codes or industry standards for anomalies
D. Prepare a comprehensive report integrating these results within 120 days of their completion[55].

I support the comprehensive ILI surveys proposed in item A but believe that a 5 year inspection interval is unnecessary. The 7 year inspection interval required by regulation should be adequate for ANGP. I believe my Recommendation 2 should replace the surveys in item B. I agree with the more conservative repair criteria in item C. The comprehensive reports in item D should be prepared after the ILI's in item A.

[54] The manufacturer seems to disagree that these batches failed the peel test in a way that is problematic, but out of an abundance of caution I believe they should be considered to potentially be problematic in the future, until proven otherwise.

[55] The DRAFT document says "Within 120 days of the completion of the ILI runs", but it should read "Within 120 days of the completion of these surveys", since the other surveys to be integrated may be conducted up to 6 months after the ILI.

Proposed Penalties / Remedies

Earlier this year (and for the first time), PHMSA published a document providing for the public a general overview of their civil penalty calculation process (Attachment A#15). The factors listed in their guidance include:

- Nature
- Circumstances
- Gravity
- Culpability
- History of Prior Offenses
- Good Faith
- Other Matters as Justice May Require (Any and all appropriate factors will be applied to the violation)
- Economic Benefit
- Ability to Continue in Business

The Civil Penalty Range for each factor ranges from a credit of $25,920 (reducing a resultant penalty) to the Maximum penalty. The maximum penalty is adjusted each year for inflation and is currently more than $200k / violation / day, for up to 10 days for any single violation.

PHMSA's enforcement actions and penalties are public information and are posted on its website. My company maintains an internal database which allows us to analyze that information when dealing with enforcement actions. Penalties for violation of the pipeline safety regulations vary significantly based on the consequences of the non-compliance (the Gravity factor). Non-compliance leading to a fatality or significant environmental damage typically receives a much larger fine than non-compliance with no adverse consequences, all other things being equal.

Under "Other Matters as Justice May Require", PHMSA lists "Operator's written procedures exceeded a regulatory requirement and the non-compliance was against the requirements of the procedure that exceeded the regulation." – which could result in a CREDIT against a potential penalty. Virtually every claim of non-compliance during the construction of ANGP has been "against the requirements of the procedure that exceeded the regulation". PHMSA's guidance would not indicate that those are serious offences – even if they are technical ones.

In response to the Bedding / TB NOPV, VGS proposed a Stipulated Remedial Action Compliance Plan (Attachment A#67) that included a $25,000 fine. That fine amount is more than adequate given the nature of any non-compliance that may have been involved.

Acronyms / Initials

§ - Paragraph or Section
AGA – American Gas Association
ANGP – Addison Natural Gas Project
ANR – Vermont Agency of Natural Resources
ARO - Abrasion-Resistant Overlay
ASME – American Society of Mechanical Engineers
CPAR – Corrective/Preventative Action Request
CEPA – Canadian Energy Pipeline Association
CHA – CHA Consulting, Inc (aka Clough Harbour)
CIS – Close-Interval Survey
CMT – Construction Management Team
cp – Cathodic Protection
CPG – Certificate of Public Good
DCVG – Direct Current Voltage Gradient
DEC – Vermont Department of Environmental Conservation
DOC – Depth of Cover
DPS – Vermont Department of Public Service
EPSC - Erosion Prevention and Sediment Control
GPTC – Gas Piping Technology Committee
HDD - Horizontal Directional Drilling
ILI – In-Line Inspection (a.k.a. smart pigs)
INGAA – Interstate Natural Gas Association of America
JSH – John St. Hilaire
LOD – limits Of Disturbance
LL – Line List (numerical reference for easements / landowners)
NOPV - Notice of Probable Violation
NSC – Non-Substantial Change
NTSB – National Transportation Safety Board
O&M – Operations and Maintenance
OPR – Vermont Office of Professional Regulation
p/s – Pipe-to-Soil
PHMSA – Federal Pipeline and Hazardous Material Safety Administration
PUC – Vermont Public Utilities Commission
RFSI - Requests For Specific Information
SSD – Solid State Decoupler
USACE – US Army Corps of Engineers
VGS – Vermont Gas Systems
VTrans – Vermont Agency of Transportation
WRB – William R. Byrd

Supplemental Discussion

Summary of Events Leading to this Investigation

The PUC issued a Final Order and Certificate of Public Good (CGP) on 12-23-2013, approving the ANGP project "with conditions". VGS established a project management team and awarded work to multiple contractors. Construction of the ANGP began in the summer of 2014, after final permits had been received. Project oversight was provided by VGS and its direct inspection contractors as well as independent inspectors reporting to the Vermont Department of Public Service (DPS), Vermont Agency Natural Resources (ANR), Vermont Department of Environmental Conservation (DEC), and the US Army Corps of Engineers (ACOE).

During the project, numerous revisions were made to the construction specifications and other project plans and documentation, frequently accompanied by Project Directives or Modification Bulletins. VGS submitted a total of 6 Non-Substantial Change (NSC) requests to the PUC. The first 5 concerned changes to the pipeline route, relocation of mainline valves, changes to work space and access roads, and changes between open cut and direction drill installation techniques and were approved. The 6th, submitted on June 2, 2017, concerned burial techniques and depth of cover in the Clay Plains Swamp area.

On June 8, 2017, the PUC requested comments as to whether the 6th NSC request was a non-substantial change to the project. The ANR submitted a letter noting that the change did not change the disturbance footprint, did not raise any significant concerns about impacts to the environment, and did not require any Agency permit amendments. Attorney James Dumont, along with and on behalf of several parties (a.k.a. the Intevenors) opposed the NSC request, requested an evidentiary hearing, and petitioned the PUC to open an investigation. The DPS made a separate filing that stated "As discussed previously, the Department believes that the pipeline continues to conform to requisite safety requirements. However, the Department also believes that 'a material deviation from the approved plans' has likely occurred, and accordingly, the Department requests that the Board open an investigation into this issue."

The intervenors supplemented their petition on July 14, 2017, to expand the investigation to include burial depths to 7 feet in streams and 4 feet in residential areas. The PUC issued an order that same day opening an investigation to:

> "determine whether VGS's deviation from the Project plan is material or a substantial change to the Project plan, and, if so, whether it is appropriate to order any remedial action, impose a penalty, or take any other steps authorized by law. Additionally, the Commission hereby requires the Company to submit evidence by August 11,2017, to certify that the remainder of the pipeline has been buried at the depth required by the 2013 Final Order." and "'We will also require the Company to conduct a root-cause analysis of the Company's construction-related deviations from the 2013 Final Order that are the subjects of this investigation and Dockets 8791 and 8814."

On August 4, 2017, ANR requested that VGS provide detailed information about stream crossings that were and were not subject to VT DEC stream alteration permit jurisdiction. The DPS made a separate filing concurring with this request and asking for information about all other burial depth requirements and actual burial depths. VGS made filings agreeing to provide depth of burial information but disagreeing with the intervenors' interpretation of certain project requirements and commitments.

VGS filed their official response to the PUC's order on August 11, 2017, certifying that "the entire 41-mile Addison Natural Gas Project ("ANGP") has been buried at depths as required by its permits, agreements, and this Public Utility Commission's ("Commission") Final Order in Docket 7970, with the exception of the 18 discrete locations in the Clay Plains Swamp area that are the subject of this Docket."

On September 8, 2017, ANR filed that they had determined that the Stream Alteration Permit requirements had been met, but that they had not yet completed their review of other streams[56]. DPS filed that they believed there was "ample evidence that the depth of cover requirements for the 41-mile transmission pipeline have been met" (with the noted exceptions in the Clay Plains Swamp), and concurred with the recommendations that had previously been made to address that situation. They also indicated that they would discuss the materiality of the depth of cover in the Clay Plains Swamp at an upcoming status conference. The intervenors cited numerous issues and disagreements concerning compliance with burial requirements, stating that these were material deviations and substantial changes from the CPG sufficient to deny the NSC request, asking for an evidentiary hearing with opportunity for discovery if the NSC is not denied, and asking that "The Commission should order that inspection of the depth of burial of the pipeline, throughout the project, be conducted by an independent third party."

VGS responded to the intervenors' additional allegations concerning burial issues on September 22, 2017, asking that the investigation be closed and that the NSC be granted.

The PUC held a hearing on October 20, 2017, where the parties agreed to additional discovery, which then began, including a deposition of Mr. Carl Bubolz of Michels Corporation (the prime contractor in 2015 through completion) on December 19, 2017.

On December 6, 2017, the PUC issued an order stating that they planned to hire an independent expert to:

> "assess the VGS burial depth data by conducting an on-site survey of the ANGP pipeline buried in the half-mile stretch of swampy ground in the VELCO right-of-way in New Haven, which VGS reported on June 2,2017 , as deviating from the burial depth requirements of the Docket 7970 Certificate of Public Good, and at all pipeline stream crossings along the 41-milelong ANGP route. The expert will be required to determine the pipeline burial depths in those locations and compare that information to the data provided in VGS's self-certification. The expert will then inform the investigation by filing a written report of the expert's findings,

[56] ANR's subsequent filing of October 12, 2017, noted "immaterial" non-compliance for some streams due to a "technical detail" that was "not relevant", and that they did not plan to pursue enforcement action.

> preparing pre-filed testimony, and testifying as an independent witness at the evidentiary hearing. The expert's work product would not be subject to the pre-review of any party or the PUC."

On February 28, 2018 (corrected March 1, 2018), the intervenors filed a Motion to Broaden Scope of the Investigation, alleging numerous additional safety violations and stating: "Once the scope encompasses all of the violations, the Commission can properly exercise its authority". ANR filed on March 22, 2018, stating that further investigation should be conducted concerning installation of bentonite trench breakers in 2014 (related to environmental protection). DPS filed that, from a pipeline safety standpoint, they had already addressed the issues and that "there is little, if any, need to expand the scope of this Docket." VGS proposed that "the Commission order a State-led review by an independent expert in pipeline construction and compliance. Such an expert could conduct a thorough review of VGS' construction practices and construction-related documentation to assess VGS' compliance with the applicable pipeline safety regulations and the Final Order in Docket 7970. The expert could also review VGS' plans for ongoing testing and inspections of the pipeline's integrity. The State's expert could make a thorough report of findings and recommendations to the Commission and all parties." On April 5, 2018, the PUC ordered that the scope of the investigation be broadened.

On April 10, 2018, the intervenors filed a second set of discovery requests which was opposed by other parties. On May 22, 2018, the PUC issued an Order Granting Further Stay in Proceedings, to "suspend the schedule for this proceeding indefinitely in order that the schedule may accommodate the broadened filings of an independent third-party expert."

On November 20, 2018, intervenors filed to expand the scope of the investigation to include Professional Engineering issues. On December 4, 2018, DPS agreed that "this matter warrants further investigation". Intervenors supplemented their filing on this topic on December 18, 2018.

Contract #37512 between RCP Inc. and the PUC was finalized on January 7, 2019 to initiate this independent investigation. On January 10, 2019, the PUC ordered "as part of its review, the independent investigator make a factual conclusion in its investigation report as to whether the Company used documents with a Vermont-licensed professional engineer's signature and seal during the pipeline construction process."

NTSB Recommendations Concerning PE Certification of Utility Projects

Intervenors have cited an NTSB report[57] concerning an over-pressurization event in Merrimack Valley, Massachusetts on 9-13-2018, as regards the need for Professional Engineering of projects such as the ANGP. I have included excerpts from NTSB's report on that topic below (emphasis added):

> *2.1 NTSB Safety Recommendation to Commonwealth of Massachusetts*

[57] https://www.ntsb.gov/investigations/AccidentReports/Reports/PAR1902.pdf

At the time of the accident, a Massachusetts P.E. stamp was not required on any utility system construction, operations, or maintenance projects as local natural gas distribution companies in the state had a utility exemption from requiring a P.E.'s stamp. On November 14, 2018, the NTSB issued a safety recommendation report, Natural Gas Distribution System Project Development and Review, in response to this accident and the events that followed (NTSB 2018). According to the report:

> *The Commonwealth of Massachusetts' exemption for the requirement of registered Professional Engineer (P.E.) to perform industrial and public utility work limits the opportunities for competently trained and experienced engineers to uncover system design and work process deficiencies. By eliminating the exemption, especially for systems involving inherently dangerous materials such as natural gas distribution systems, companies, workers, and the public are provided* ***greater safety assurance*** *that competent and qualified engineers, who are ethically bound to work only on projects within the scope of their expertise, will review, assess, and execute the requisite work activities according to best engineering practices and with expected safeguards.*

As a result of this investigation, the NTSB issued Safety Recommendation P-18-5 to the Commonwealth of Massachusetts

> *Eliminate the professional engineer licensure exemption for public utility work and require a professional engineer's seal on public utility engineering drawings. (P-18-5)*

And

3.4 Professional Engineer Review and Approval
The NTSB recognizes that a P.E. license is a valued credential, especially for engineering projects affecting public safety. The P.E. license conveys that the holder maintains and demonstrates technical competency and imposes continuing education requirements in most states. Moreover, P.E. licensees are bound to a code of ethics for engineers, which creates a duty to hold public safety, health, and welfare paramount and to perform services only in the areas of their competence, among several other obligations. P.E. licensees are also personally accountable for the work they approve and stamp and must exercise responsible charge over all aspects of the work. As shown in table 4 of this report, ***31 states have an industrial exemption for P.E. licensure.*** *The NTSB concludes that requiring a licensed professional engineer to stamp plans would* ***illustrate*** *that the plans had been approved by an accredited professional with the requisite skills, knowledge, and experience to provide a comprehensive review. Therefore, the NTSB recommends that those 31 states with an industrial exemption for natural gas infrastructure projects remove the exemption so that all future natural gas infrastructure projects require licensed professional engineer approval and stamping.*

And

4.2 Probable Cause

> *The National Transportation Safety Board determines that the probable cause of the overpressurization of the natural gas distribution system and the resulting fires and explosions was Columbia Gas of Massachusetts' weak engineering management that did not adequately plan, review, sequence, and oversee the construction project that led to the abandonment of a cast iron main without first relocating regulator sensing lines to the new polyethylene main. Contributing to the accident was a low-pressure natural gas distribution system designed and operated without adequate overpressure protection.*

NTSB states that "weak engineering management" was the probable cause of the incident and notes that having a PE officially stamp engineering design documents provides "greater" safety assurance, and "illustrates" that the plans had been approved by a qualified individual. NTSB notes that 2 licensed PEs were in the management chain above the engineering intern who prepared the plans… but they didn't exercise appropriate oversight. The implication is that if these PEs had been required to officially stamp the plans they would have done a more thorough job of reviewing them – hopefully noticing and correcting the design oversight that lead directly to the incident.

List of Attachments

A#	GENERAL
01	W. R. Byrd Statement of Qualifications
02	Partial Index of Files Received
03	Listing of Construction Inspection Reports Reviewed by WRB
04	Mr. Heintz' 2-28-13 PFT
05	PUC Final Order of CPG for ANGP
06	ANGP Organization Charts
07	Intervenors Motion to Broaden Scope of Investigation 3-1-18
08	Intervenors Summary of the Evidence for WRB – annotated 5-21-19
09	WRB Site Visit Summary Findings Spreadsheet
10	Selected Images
11	Breezy Valley Dig Report 7-30-19
12	Baldwin Rd Dig Report 7-30-19
13	Chicken Farm Dig Report 7-31-19
14	Route 7 Dig Report 7-31-19
15	PHMSA Civil Penalty Guidance 02-25-2019
	DESIGN AND ENGINEERING SPECS
16	Bid Specification Index
17	Bid Specification Package, Project Manual May 24 2014
18	CHA Summary of Material Specifications and Quality Control Procedures
19	Specification for Application of Pipeline External Coatings
20	IFC plans 5-13-16 in Modification bulletin Trans-09 **
21	CHA Specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING dated 4-29-2015
22	CHA Specification 312333 TRENCHING, PIPE LAYING AND BACKFILLING 7-1-2016; in Modification Bulletin Trans-14
23	Design drawing sheet ANGP-T-G-015 as of 6-28-2013
24	Design drawing sheet ANGP-T-G-015 as of 6-11-2015
25	Design Drawing ANGP-T-G-015 as of 5-2016 w TB tables
26	Project Directive 2015-006 Backfill Compaction 8-31-15
27	Project Directive 2015-007 General Backfill Materials 8-31-15
28	Project Directive 2015-008 Adhesion Testing 8-31-15
	CORROSION CONTROL
29	ARK cp System Design IFC 5-20-2016
30	ARK Engineering AC Mitigation Design
31	ARK CP Commissioning – first 11 miles
32	ARK CP Commissioning – 30 miles
33	ARK DCVG & CIS Analysis
34	E-mail of 9/4/2019 concerning zinc ribbon in Clay Plains Swamp
	QUALITY ASSURANCE
35	ANGP Inspection Manual from 2014
36	Eric Curtis Field Notes May 30 - July 26, 2014

37	James Haney Field Notes July 27 - Nov. 4, 2015
38	JR Kelch ML Inspection Reports 9-5 and 9-10-14
39	DPS Inspection Report – 2014
40	DPS Inspection Report – 2015
41	DPS Inspection Report – 2016
42	DPS Inspection Report – 2017
43	PHMSA Review of VT DPS Inspectors
	BURIAL
44	VGS - VELCO MOU of 6-2013
45	VGS – ANR MOU of 9-2013
46	VTrans Permit of 5-27-2014
47	CHA Loading Calculations 11-7-2014
48	Mott MacDonald Loading Calculations 5-25-16
49	CEPA Report 10-16-2009 re Surface Loading
50	Compaction Testing Results and email of 5-24-2016
51	WCE Report of 9-27-16 - stripping topsoil.
52	WCE Report of 6-23-15 crushing rock for general backfill
53	WCE Report of 9-27-16 - using shaker bucket to sift backfill
54	CPAR of 12-11-15 re TB locations in 2014
55	VELCO email of 9-21-2016 re Clay Plains Swamp; includes 5-25-2016 loading analysis
56	VELCO letter of 4-25-2017 re Clay Plains Swamp
57	Wetlands Permit Supporting Narrative
58	Clay Plains Inspection Report Summaries - WRB
59	Summary Memo re Laying Pipe on Trench Bottom 6-6-17
60	VGS 8-4-17 Comments re DOC commitments
61	JAN Affidavit 8-4-2017 re Stream Crossings
62	JSH Affidavit 8-11-17 re DOC
63	JSH Affidavit 8-11-17 Exhibit 1 – DOC Table
64	ANR Comments 10-12-17 re DOC for Non-Jurisdictional Streams
65	Bedding / TB NOPV of 2-13-2018
66	VGS Response to DPS Bedding / TB NOPV 2-28-18
67	Stipulated Remedial Action Compliance Plan – DRAFT to Bedding TB NOPV
68	ANR Comments 3-22-18 re Trench Breakers
69	ANR Comments 5-4-18 re Scope of Investigation
70	VGS email re ANR TB Follow Up Activities 11-12-19

** TOO LARGE TO POST TO PUC'S WEBSITE