



DIVISIONS
ENERGY
GAS AND OIL
GEOLOGY AND MINERAL RESOURCES
MINED LAND RECLAMATION
MINERAL MINING
MINES
ADMINISTRATION

COMMONWEALTH OF VIRGINIA

Department of Mines, Minerals and Energy

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June 24, 2010

Mr. R. Brooke Lewis
Kathryn M. Zunich, M.D.
Iasis Partners, LLC
3112 N. Peary Street
Arlington, VA 22207-5327

Dear Mr. Lewis and Dr. Zunich:

Thank you for your June 7, 2010, letter seeking clarification of a number of issues concerning the application # 16035 of Carrizo (Marcellus) LLC to drill an exploratory gas well in Bergton, VA. I am sorry we could not respond to your 37 questions sooner, but our gas and oil staff have had to divide their time among several ongoing projects.

Following are your questions and our responses.

1. The Permit Application #16035 is described as "a Marcellus Shale test well." Should gas be discovered, would Carrizo need to obtain an additional permit from DMME to actually produce gas?
 - Yes
2. Do DMME inspectors have Marcellus Shale drilling experience with the methods proposed to be used at the Ennis site for the test well, and for methods that might be used to actually produce gas from a subsequent well?
 - Virginia inspectors have experience with more than 1800 active conventional gas wells in other deep formations.
3. What guidelines does DMME use to establish the criteria under which hydrofracture drilling permits using the method proposed at the Ennis site are approved? May we have either a cite to them or copies, preferably electronically?
 - In addition to industry best practices, Department of Mines, Minerals and Energy (DMME) Statutory and Regulatory Guidelines:
<http://www.dmme.virginia.gov/lawsregs/lawsregs.shtml>

4. What are the guidelines governing DMME's coordination with other governmental agencies, (national, state, or local) before it issues a permit such as #16035? May we have either a cite to them or copies, preferably electronically?
 - DMME's Division of Gas and Oil is the state agency charged with permitting and compliance activities of natural gas resources in the Commonwealth.

5. The proposed site is in a 100-year floodplain, though it has a history of flooding far more frequently than that. Did DMME take this into consideration before approving the permit?
 - The flood plain was considered. The risk of exposure is only during a short period of time (less than 180 days) when the site will include designed pits for brine storage. After the well is developed, the pit will be reclaimed. After that time period, the well will be plugged or produced. If produced, the production is similar to a "closed-loop" system and is at low risk even during a flood event. The pit volumes and contents would be quickly diluted should a 100 year flood event occur. The dilution would likely occur even before the diluted volumes left the permitted site.

6. What steps, if any, were taken to address the environmental and health risks posed by the fact that the site is in a floodplain?
 - The floodplain and construction / development were considered during permit review. This included site visits by the staff and the Division Director and design of the well access, pad and pit areas. **An attachment** diagram is included showing the pit(s) diagram and how the engineering design did consider the floodplain.

7. Did DMME in fact consult any other governmental agencies (national, state, or local) before approving #16035? If so, which agencies did it consult?
 - DMME's Division of Gas and Oil has not issued #16035 but has notified the applicant and Rockingham County officials that the permit has substantially met all state requirements for permit issuance.

 - During the permit review process, research is routinely conducted relative to the local environmental landscape that includes contacts with the U.S. Forest Service and/or the Virginia Department of Forestry. The Operator has certain responsibilities during the permit process and is required to contact agencies that require additional site permitting, including Virginia Marine Resources, Virginia Department of Transportation and others. The number of agencies contacted by DMME and the Operator will vary on a site by site basis.

 - DMME first made an outreach effort to Rockingham County Officials in early January 2010, when the agency requested and held a meeting with the County Administrator, District 1 representative and Board Chairman, County Engineer, and Fire and Rescue representatives in Rockingham County.

8. Does the Virginia Department of Environmental Quality retain any oversight authority over the proposed activity once the permit is approved and issued? If so, what is the extent of its authority?
 - No. DMME's Division of Gas and Oil (DGO) is the regulatory authority for statewide gas and oil permitting and operations. However, interstate pipelines and gas storage fields are under the jurisdiction of the State Corporation Commission. DMME-DGO permitting and compliance requirements meet or exceed that of the Department of Environmental Quality (DEQ).
9. If the drilling activity goes forward, will any other governmental agencies (federal, state, or local) be involved in overseeing, regulating, monitoring, and testing the environmental impact of, the activity? If so, what agencies?
 - DMME's Division of Gas and Oil is the regulatory authority for statewide gas and oil permitting and operations. Each gas well site is reviewed and permitted with a focus on public and worker safety, and protection of the environment. Most sites include contact / permitting consideration from Virginia Marine Resources Commission or the Army Corp of Engineers based on their stream crossing criteria. The DGO has a cooperative framework with other state agencies and routinely reviews "best practices" throughout the Commonwealth and eastern gas producing states.
10. Do DMME inspectors have Erosion and Sediment Control Inspector Certification by the Virginia Department of Conservation and Recreation?
 - No. DMME and the Department of Conservation and Recreation (DCR) have a cooperative working relationship and make an effort to train gas operators and their contractors annually regarding "Best Practices" for erosion and sediment control issues. DCR regulations exempt gas and oil operations because compliance standards enforced by DMME-DGO meet or exceed DCR standards.
11. Hydrofracture drilling has been known to use extremely toxic chemicals. A list of 345 of them with substantial product and toxicological information can be found at <http://www.endocrinedisruption.com/chemicals.fracturing.php>. The spreadsheet of these chemicals found at that site is attached to the same email that conveys this letter. Companies have often asserted proprietary reasons for refusing to disclose the chemical makeup of drilling and hydrofracture chemicals. Will DMME know, prior to their use, exactly what chemicals will be used either in the drilling or hydrofracture portions of this activity?
 - Virginia geology and hydrofracing techniques are significantly different from northern and western states. An attached document describes the hydrofracing technique and chemicals used in the Commonwealth currently. The injection of liquid nitrogen has been proven most effective and more environmentally friendly.
 - In your continued research and information provided to Rockingham County officials and others, we suggest you also compare each chemical used "by-volume" in the fracing process and match that volume to human exposure threshold limits under

current law by Occupational Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (NIOSH).

- State regulations require ground water protection strings in the drilling and well development process to a minimum 300 feet in depth and many times to 1,000 feet. The fracing process occurs several thousand feet below the surface (2,500 to 10,000 feet) and is typically contained in the target formation.

12. What criteria will DMME use to allow or disallow certain chemicals in drilling or hydrofracture? May we have either a cite to them or copies, preferably electronically?

- DMME-DGO reviews and monitors circumstances regarding chemicals used in drilling or fracing on a well-by-well basis. The basis of approval / disapproval will be from OSHA or EPA standards. We are aware of and are participating in the national review of hydrofracing and the "Frac Bill" studies being conducted nationwide by the EPA.

13. Hydrofracture drilling, especially in the Marcellus formation, has been known to produce radioactive solids and wastewater. Has DMME taken this fact into consideration in approving permit #16035?

- DMME-DGO is aware of the potential for Naturally Occurring Radioactive Materials (NORM) from rock and mineral formations. These occurrences have been extensively documented by the U.S. Department of Energy. References include a report by John A. Veil, Argonne National Laboratory in December 1977 and other references since that time by the U.S. Department of Transportation and the Interstate Oil and Gas Compact Commission (IOGCC).
- While this potential risk is known to be present in all deep formation drilling, it is believed to be an extremely low risk for Rockingham County area due to the geology in Virginia where the Marcellus formation occurs at a depth of only 2700 feet and within the Bergton Anticline dome. The exposure limits are of short time frame and not anticipated to be of human risk to the gas worker or public in general. Most NORM are produced from deep formation drilling and are dependent on regional geologic structure. For your information, we have attached an executive summary of recently released investigation of NORM in oil and gas wells in New York State. The investigation was conducted by the New York State Department of Environmental Conservation.

14. What requirements are placed upon the permit applicant to deal with radioactive waste?

- Material will be monitored but is not expected to be present in Rockingham County. If encountered, federal guidelines and threshold limits will be followed. If necessary, the DMME-DGO has an active working relationship with the Virginia Department of Emergency Management and would consult with their regional Haz-Mat team if warranted.

15. We understand that the permit has been “approved” but not “issued.” Is this correct? What conditions must be met before DMME issues the permit?
- Yes. DMME-DGO is cooperating with Rockingham County officials to allow a time for the study of risks / benefits for their county. There have been 23 deep formation wells drilled in Rockingham County between 1950 and 1983, eleven of which surround the proposed well site. All were drilled without environmental harm and without reported evidence of radioactive materials. Each of these wells was drilled to almost 10,000 feet in depth but were not proven economically viable at that time and were plugged / abandoned.
16. Given the potential damage that can be caused by this activity, and the actual damages suffered by a number of communities in other states, how much is the performance bond that Carrizo will be required to post, or other demonstration of financial responsibility, for this site?
- Statutory bonding requirements can be reviewed from this link: <http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+45.1-361.31>
17. On April 5, 2010, the Virginia Department of Game and Inland Fisheries wrote a strongly-worded letter to the Rockingham County Board of Supervisors, copy to DMME, raising environmental concerns about this proposed permit. A copy is attached for your convenience. Will DMME take into consideration the contents of this letter before issuing the permit?
- Yes
18. If the activity goes forward, will DMME inspect the site and conduct chemical and radiation testing regularly? On what schedule will this occur?
- DMME will inspect the site and ensure compliance. The operator is required to have an independent lab do testing of pit waters to determine the method of disposal. Radioactive material at detectable limits is not anticipated.
19. Will other state or federal agencies be allowed access to inspect the site if they desire to do so?
- DMME Division of Gas and Oil is the authority for statewide gas and oil permitting and operations. Statutory and regulatory compliance inspections are conducted by the Division with a focus on public safety, worker safety and protection of the environment. We are not authorized to admit other state or federal agencies onto well sites without the well operator’s permission.
20. On page 10 of the application, under “Analysis of mud medium/drilling medium/oil based fluid medium attached/filed:” the box “Does Not Apply” is checked. Does this mean that DMME will not know what chemicals are used in the process, since the application

further states that it is possible that such fluids might be needed? Does any other agency have oversight of such?

- This means that drilling activities will not introduce “muds” as is done in deep gas or oil drilling operations in the west. Almost all of the drilling in the Commonwealth is done with air pressure to remove drill cuttings from the hole and sometimes water. When water is used, the introduced fluid must meet water quality standards for the particular region of the state. In Rockingham County, water quality must meet the Valley and Ridge Regional quality standards.

21. Also on page 10, under “SPCC Plan Required by EPA,” the box “No” is checked. Under what criteria did DMME determine that the proposed activity will have an acceptable level of environmental impact?

- A Spill Prevention Control and Countermeasure (SPCC) plan is not required by the EPA unless it is a Class II Injection (waste disposal) well. All such wells are permitted by the EPA nationwide. Gas wells are not this Class type of well.

22. A Blooey pit lined with 30 mil plastic is approved. Did DMME take into account the fact that the site lies in a floodplain before approving this method of fluid storage?

- Yes. The 30 mil plastic exceeds best practice standards and will prevent leakage of salt water (brine) on the site.

23. On page 13, “Disposal of Drilling Fluid” is marked “Yes-Approved.” What is the method of fluid disposal that is approved?

- The water management plan within the permit is specific to disposal of drilling fluids. The plan is “three-deep” by Carrizo’s, meaning three options are available for the disposal of fluids. One such option is the disposal of fluids with the local waste-water treatment facility. This well operation is anticipated to require a volume of 300 to 500 thousand gallons of water. DMME-DGO anticipates this volume not to be troublesome to the local waste water treatment facility that has a throughput of 13 to 16 million gallons of water every 24 hours. See all three options in 25.

24. “Fresh Water” is also marked “Yes-Approved.” Is this an approval of a source of obtaining fresh water, and if so, what source is approved?

- The fresh water sources meet the Valley and Ridge Region water quality standards anticipated for this operation. The planned sources include nearby stream withdrawal (if quality standards are met) or Public Service Authority water trucked to the site.

25. “Disposal of Produced Fluids” is marked “Yes-Approved.” What is “approved?” That is, how will the produced fluids, or wastewater, be disposed of?

- State requirements allow for different methods for the Disposal of Produced Fluids:
 - After water quality testing and Division approval, a one-time ground application is allowed on the permitted site. The ground application, if

approved, is similar to hydro seeding operations with criteria for the spreading of fluids.

- Utilization of a local waste-water treatment facility.
- Transporting fluids to an off-site EPA-approved injection well.

26. Is a copy of any agreement with the local wastewater treatment facility for receiving site wastewater available? If so, may we have a copy of it?

- The local waste-water treatment facility can not guarantee approval to receive the pit fluids until tested. Those tests will be conducted by an independent lab once produced and then it will be determined if the waste-water treatment facility will receive / process the salt water. The use of local waste-water treatment facilities has been economically helpful for localities and has been common practice throughout the Commonwealth in years past without incident.

27. "Salt Water" is marked "Yes-Approved." What does this mean?

- Salt water / fluids are anticipated to be produced and can be returned to the formation in the fracturing process.

28. On page 14, under "Lacking," is the comment, "Discuss the disposal of produced fluid." Has this discussion taken place? If so, what was decided?

- Yes. (See comments in 25 and 26).

29. The Drill Pad Narrative on the application notes a "sediment containment area on the southwest corner of the construction site." This is not shown on the site plan sketch. How will this be achieved?

- Sediment containment will be accomplished by fencing and straw bales.

30. Allegedly, the applicant may not spray or otherwise land-apply wastewater on the site. Where in writing is the restriction prohibiting such?

- As noted in item 25, the one-time land application of pit fluids would be allowed only after quality testing and Division review / approval.

31. The site plan and narrative does not address the containment and disposal of wastewater. How will this be accomplished?

- See comments above.

32. The plans show areas labeled "Fluid Dispersal Area[s]". Are these areas in which wastewater and other toxic fluids may be applied?

- This is the area proposed for the one time land application if approved. No toxic fluids.

33. The following statement is made by Carrizo on page 29 of the application: "If chlorides and other parameters meet Virginia requirements, the water will be discharged onto adjacent ground via sprayer heads or soaker hoses with no runoff accepted". Will DMME make the determination of what is acceptable? What are the guidelines that determine what is acceptable? May we have either a cite to them or copies, preferably electronically?
- Yes. Guidelines follow regional ground water criteria as discussed above. The site and Rockingham County is in the Valley and Ridge Region of the Commonwealth. Water quality standards for the site will be based on these regional standards.
34. The following statement is also made by Carrizo on page 29 of the application: "If they do not meet Virginia requirements, they will be diluted to below discharge requirements if possible. They will then be discharged as before." This would appear to allow the dilution of toxic wastewater with more water and then dumping or spraying it on the same ground. Is this an acceptable method? Has DMME determined that this is environmentally sound? Does dilution of toxic wastewater with more water do anything to protect surface and underground waters?
- DMME-DGO will use Regional ground water quality as stated above in determining the approval/disapproval of the one time land application.
35. The following statement is also made by Carrizo on page 29 of the application: "Arrangements have been made with Harrisonburg -Rockingham Regional Sewer Authority (Contact Sharon Foley --540-434-1053) for disposal of fluids if they cannot be spray discharged as planned." We have reason to believe that the Sewer Authority does not have the capability to dispose of the toxic wastewater that will be produced by this drilling activity. Has DMME checked to see if such "arrangements" have been made? Are they in writing? If so, may we have a copy of them? If such "arrangements" have not actually been made, is this grounds for revocation or non-issuance of the permit? **If DMME has not already done so, we request that it verify the accuracy of the statement that such "arrangements" have been made.**
- DMME-DGO did contact Mrs. Foley to verify the circumstances and arrangements discussed with Carrizo and wastewater disposal. Mrs. Foley described requirements in place to approve the receipt and processing of waste-water by her facility. There is no written agreement between the treatment facility and the company, and a commitment by Mrs. Foley can not be made until the water quality is tested. The water quality can not be tested until produced by the well. As discussed in 25 above.
36. The following statement is also made by Carrizo on page 29 of the application: "Drill solids will be collected in the drilling pit during operations. They will have as much associated water as practical initially until removal during the remediation phase. After drilling, the pit chlorides and other parameters will be evaluated to determine disposal method." Will DMME evaluate these parameters? What criteria will DMME use? May we have either a cite to them or copies, preferably electronically?

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- Testing is anticipated by an independent lab with results evaluated by the Division of Gas and Oil. Afterwards the method of disposal will be determined. We attached information that was provided to the Rockingham County Board of Supervisors.

37. The following statement is also made by Carrizo on page 29 of the application: "A Pit Disposal Permit will be sought from the VA DMME. It is planned to sequester and encapsulate the cuttings with the pit liner and additional liner installed on the top. It is then planned to bury the cuttings a minimum of 4' below ground level. If this approach is unattainable, arrangements have been made with the Rockingham County Landfill (Contact Jeff Smith – 540-564-3159) for disposal." Does the Rockingham County Landfill have a permit for accepting drill cuttings, wet or dry? Does it have a radiation detector installed to monitor NORM levels in such cuttings? Has DMME checked to see if such "arrangements" have been made? Are they in writing? If so, may we have a copy of them? If such "arrangements" have not actually been made, is this grounds for revocation or non-issuance of the permit? **If DMME has not already done so, we request that it verify the accuracy of the statement that such "arrangements" have been made.**

- DMME-DGO verified that Carrizo had contacted the landfill and had taken to Mr. Smith a sample of material from another drilling in West Virginia that is similar to this site. Before a disposal plan is approved by the DGO, Carrizo will test the material for NORM. If the material is not suitable for disposal in the pit, Carrizo must identify where the material will be disposed of, such as a wastewater/sewage treatment facility or landfill and provide documentation that the site can accept the drill cuttings

I hope you find this information useful. If you need further clarification or have additional questions, please contact David Asbury, Director, Division of Gas and Oil, at (276) 415-9700 or David.Asbury@dmme.virginia.gov. Thank you.

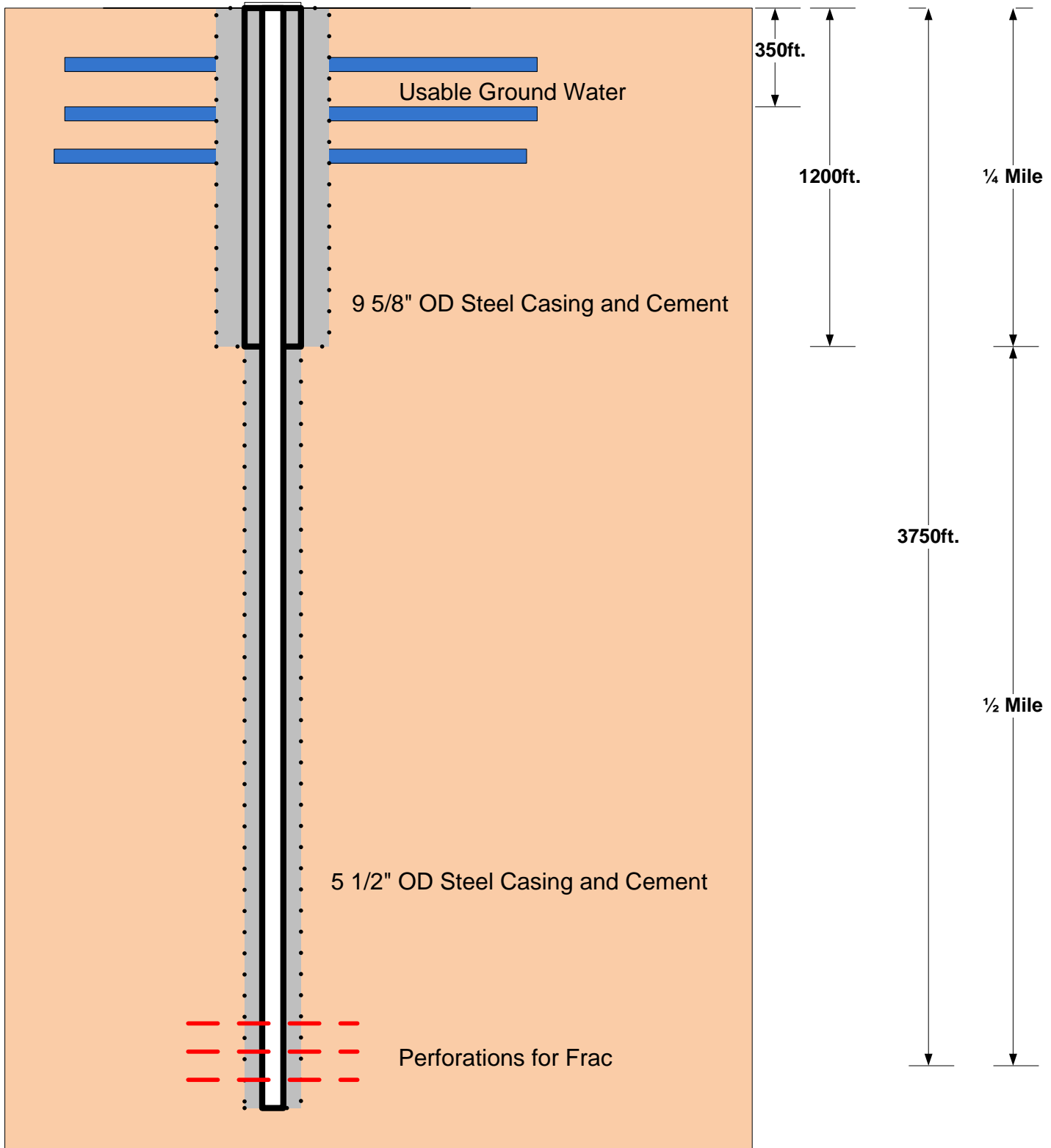
Sincerely,



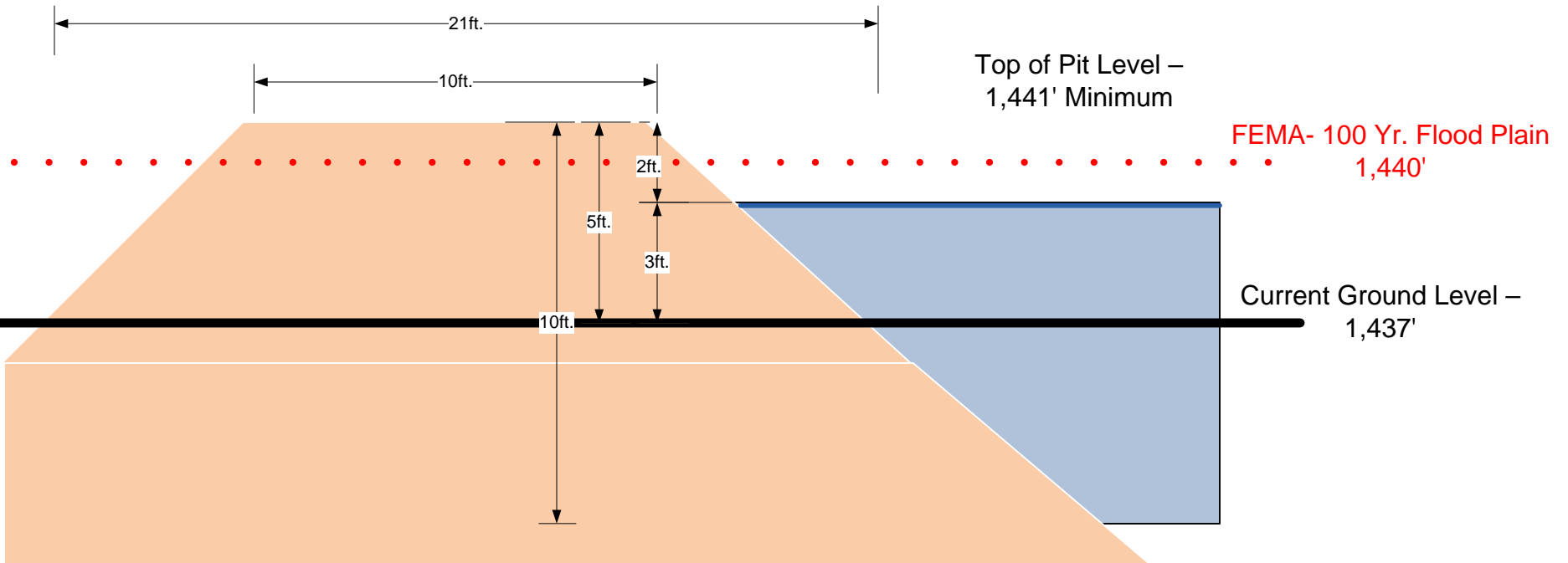
Bradley C. Lambert
Deputy Director

Attachments

c: David Asbury



		Carrizo (Marcellus) LLC			
		Casing View (Vertical)			
David Schnitz	SIZE	FSCM NO	DWG NO	REV	
2/23/10	SCALE	1 : 6000	SHEET	1 OF 1	



	Carrizo (Marcellus) LLC			
	Typical Pit Wall Cutaway Diagram			
David Schnitz	SIZE	FSCM NO	DWG NO 1	REV
2/23/10	SCALE	1/4" = 1'-0"	SHEET	1 OF 1



An Investigation of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Wells in New York State, Executive Summary

Investigation of Naturally Occurring Radioactive Materials - Executive Summary

Introduction

This report presents the findings of the New York State Department of Environmental Conservation (NYSDEC) that New York State oil and gas production equipment and wastes are not significantly contaminated by naturally occurring radioactive materials (NORM). The concentrations of NORM found on oil and gas production equipment and wastes pose no threat to the public health and the environment. The research and analysis supporting this conclusion were performed in 1996. Direct measurements of the radioactivity at well sites were performed. Samples of scales, sludges, sediments, soils, water, rock, brines, waxes, and oils were taken and analyzed by gamma spectrometry

The full report "An Investigation of Naturally Occurring radioactive Materials (NORM) in Oil and Gas Wells in New York State" has been converted to the portable document format.

[normrpt.pdf](#) (2.1meg)

Background

NORM can be found in many geological formations and may be brought to the surface during oil/gas drilling and abstraction. Once at the surface it may accumulate in scales and sludges on and within drilling and processing equipment. It may also accumulate in brines and sediments within holding tanks or ponds.

During the 1980's, elevated concentrations of NORM were found on oil and gas mining equipment in the North Sea and in the Southern United States (Escott, 1984). This discovery generated concern in the United States and Europe. Elevated NORM concentrations may subject oil and gas workers to unnecessary radiation exposure. Concern was also raised about public exposure to people



Pulled 2" pipe at a recently plugged and abandoned oil well. This is the type of equipment sampled for NORM

through the recycling of radioactively contaminated equipment or from the application of radioactive brines to roads for snow and ice removal.

In 1990, the New York State Department of Environmental Conservation Region 9 office performed an initial survey to determine if elevated concentrations of NORM existed at any of 17 western New York State oil and gas wells or on the related equipment. Using Geiger-Mueller (G-M) detectors for the survey, no significant contamination (defined as more than twice background levels) was found. The State of Pennsylvania found similar results during a 1994 NORM investigation of oil and gas well waste.



Drilling at the Avoca natural gas storage project, Steuben County, August, 1996. The derrick on the left is at the deep disposal well no. 6. The derrick on the right is at the shallow cavern well 3-A. Naturally occurring radioactive materials (NORM) can be a concern at oil and gas drilling locations.

However, since the 1990 New York State investigation was limited (no samples were taken and only a small number of sites (17) were visited), the former Bureau of Pesticides and Radiation (BPR) planned a more extensive survey for 1996. This survey included a wider representation of New York State gas and oil fields and took physical samples to determine the actual concentration of the radionuclides involved.

Radiological Sampling and Surveying

The investigation was performed by the BPR with the assistance of staff from the Division of Mineral Resources (DMN) and the respective NYS DEC regional offices. The BPR staff made six different field excursions, each to a different geographic location, to sample and/or take selected survey instrument readings at a total of 74 oil and gas well sites. Sampling and limited radiological surveys were performed in the following counties: Madison, Erie, Genesee, Wyoming, Cattaraugus, Livingston, Ontario, Seneca, Cayuga, Tioga and Chautauqua. A total of 101 samples were collected by field staff for analysis at the BPR gamma spectroscopy unit in Albany, New York, and/or the BPR's contract laboratory. Samples included water, brines, separator pit sediments, pipe scales, soils adjacent to oil/gas operations, and scales and sludges from tank bottoms. Eleven soil and rock samples were taken from nearby areas to establish background concentrations. Twenty-nine samples were taken to search for oil well contamination, 59 to search for gas well contamination, and two samples were taken from a

mixed oil and gas area.

Survey instrument readings were taken at well heads, pipe exteriors, tank exteriors, soil beneath drains and spigots, drainage pits, and ditches. The more efficient thallium activated sodium iodide [NaI(Tl)] detectors (with a 2"x2" probe for most investigations, a 1"x 1" probe for the remainder) were used in lieu of the G-M instruments employed in the previous survey. For comparison, background readings were taken near each selected survey site.

Results

Samples were analyzed for 10 NORM isotopes. Radium-226 (Ra-226) and radium-228 (Ra-228) were of primary concern as these isotopes, due to their relative solubility, have been shown to accumulate in oil/gas production equipment and wastes. Ninety-one percent (71 out of 80) of samples from oil/gas equipment and wastes showed radium concentrations that were within twice the background concentration of local soils and rock. Background concentrations were found to average around 5 pCi/g total radium. (Total radium is defined as the sum of the radioactivity of Ra-226 and Ra-228.) No comparative background values existed for brines, oils, and waxes. Therefore the concentrations were judged solely on their radiological effects. The nine exceptions - three at gas well sites and six at oil well sites - are discussed below.

Gas well samples included 43 brine (salty waters brought to the surface as a by-product of gas production), 10 scale, two sludge, two water and one soil sample. Only two brine and one scale sample indicated radium isotope concentrations that were greater than 5.0 picocuries per gram (pCi/g) total radium (pCi/ml for liquid samples such as brines). The brine radium results, 0.95 and 24 picocuries per milliliter (pCi/ml) for one sample, and 3.8 and 7.7 pCi/ml for the other (Ra-226 and Ra-228 respectively), pose no threat to public health or the environment. This conclusion is supported by an analysis of road disposal of the brine with the U.S. Department of Energy's (USDOE) Residual Radioactive Material Guideline computer model (RESRAD). The scale result, 11 pCi/g for Ra-226 and 3.8 pCi/g for Ra-228, also poses no threat to public health or the environment due to the low amount of scale deposited in gas plant piping.

The 29 oil well samples were of more diversified origin, including four brine, one scale, six sludge, eight sediment, one water, two oil, and six wax samples. (Wax, or paraffin, may coat the interior of some pipes as a consequence of oil abstraction.) No brine, scale, wax, or oil samples appeared elevated. No radium could be detected in the one water sample collected. However, three sediment samples and three sludge samples exceeded the twice background range for local soils (up to a



factor of four greater). Such concentrations should not pose a public health threat or an environmental risk given their isolated locations and low quantities. Again the USDOE's RESRAD system was used to evaluate abandoned brine pits to confirm the negligible risk posed by the sediment and sludge radioactivity concentrations. *Sediment sampling at a brine pool.*

The survey instrument readings taken at well heads, pipe exteriors, tank exteriors, soil beneath drains and spigots, drainage pits, and ditches revealed no radioactivity more than twice background.

Comparison With Other Investigations

The concentrations of NORM generated by New York State gas/oil production were slightly greater than those found in a 1994 Pennsylvania study of sediments in brine holding ponds. The analytical results from the Pennsylvania oil field wastes showed uranium and thorium chain isotopes to be present at concentrations no greater than 5 pCi/g. The amount of thorium found in this investigation was in approximate agreement with that of the Pennsylvania investigation. The amounts of radium isotopes were somewhat higher but, as stated above, neither in a location or in a sufficient quantity to pose a hazard.

The New York State NORM concentrations were significantly lower than the North Sea samples, which generated some concern (Smith, 1987; Waldram, 1988). Scale samples from the North Sea oil fields contained Ra-226 at concentrations between 2,000 and 30,000 pCi/g (New York State samples ranged from none detected to 11 pCi/g). Sludge samples contained Ra-226 from 100 to 1,300 pCi/g (from 0.2 to 7.4 pCi/g in New York State). Hence, the North Sea scale samples were more than two orders of magnitude greater, and the sludge samples more than one order of magnitude greater, than those found in New York State.

Discussion of Results

NYSDECs Cleanup Guideline for Soils Contaminated with Radiation Materials [DHSM-05-01](#) recommends a maximum dose limit to the general public of 10 millirem per year (mrem/yr) above background for free release of a site following the cleanup of radioactively contaminated materials. Given the NORM concentrations identified in this report, there are no plausible exposure scenarios that will yield 10 mrem/yr dose rates at New York State oil and gas wells (see following section). In fact, 91 percent of sample concentrations did not appear elevated above and/or were indistinguishable from background. The low survey instrument readings (within twice background) are consistent with the sample concentrations taken from the sites. Hence, NORM contamination at oil and gas mining sites poses no threat to the public or the environment.

Disposal of Oil and Gas Well Wastes Containing NORM

The wastes from oil and gas drilling operations may contain low concentrations of elevated NORM. Of these wastes, the highest concentrations of radium were found in brines. To determine if disposal methods of these wastes may be of concern to the general public, the BPR used USDOE's RESRAD modeling program. The modeling showed that the most common method of brine disposal in New York State, spreading it on the roads to control ice and snow, does not present significant doses to the public. This is true even if it is assumed that all brines contain the highest concentration of radioactivity detected. The resulting dose from this worst-case scenario was estimated at slightly less than 3 mR/year - well below the 10 mR/year standard presented in [DSHM-RAD-05-01](#). RESRAD modeling also showed that abandoned sludge and sediment pits (an unauthorized practice that nevertheless occurs) do not pose any significant dose to the public.

Conclusions

While NORM-contaminated equipment has been a concern in North Sea oil well drilling, the results of this investigation show that NORM contamination of New York State equipment is insignificant. New York State well drilling equipment and wastes do not constitute a health risk for the State's residents nor present a potential degradation of the State's environment.