

MEMO

**TO** Eric A. Gustafson *COB 5/25/17*  
District Oil and Gas Manager  
Southwest Oil and Gas District

**THRU** Thomas E. Donohue, P.G. *TD*  
Professional Geologist Manager  
Southwest Oil & Gas District

**FROM** Thomas Flaherty III, P.G. *TF*  
Licensed Professional Geologist  
Southwest Oil & Gas District

Harry C. Wise, P.G. *HCW*  
Licensed Professional Geologist  
Bureau of Oil & Gas Planning and Program Management

**DATE** April 4, 2017

**RE:** Geologic Review of Proposed Injection/Disposal Well  
Sammy-Mar LLC - Povlik #1 Well  
Huston Township, Clearfield County

**REMARKS:**

This document summarizes the Department's internal geologic review of the well permit application submitted by Sammy-Mar LLC for their proposed Povlik #1 injection/disposal well located in Huston Township, Clearfield County pursuant to 25 Pa. Code § 91.51(b)(3).

Sources of information for this report include: Sammy-Mar LLC's well permit application No. 059-27257, the EPA UIC permit application, DEP internal electronic maps, Subsurface Rock Correlation Diagram-Oil and Gas Regions Of Pennsylvania, drillers logs for nearby wells, and the EPA document: "Response to Comments for Issuance of a UIC Permit for Sammy-Mar LLC".

The geologic review covers an area of a ¼ mile radius surrounding the proposed location of the injection well. Following is a summary of the geologic review:

Operating underground coal mines: There are no operating underground coal mines within the ¼ mile radius.

Underground gas storage reservoirs: There are no underground gas storage reservoirs within the ¼ mile radius.

Water supplies: deepest fresh groundwater: A single water supply exists within the ¼ mile radius; located approximately 200 feet northwest of the proposed injection well, a water well is indicated on the well location plat. According to the disposal well permit application, the water well is owned by John J. Povlik, who has given

his written consent to the proposed disposal well location. The driller's logs for existing gas wells in the area show the deepest fresh groundwater to be approximately 500 feet deep, although most fresh groundwater sources occurred at depths shallower than 500 feet. The depth of the Oriskany Sandstone is 7,000 feet, which provides 6,500 vertical feet of protective isolation between the injection formation and the deepest fresh groundwater as encountered in nearby gas well drillers logs.

Injection zone: The disposal well is proposed to be drilled into the Oriskany Formation, with the zone of injection intended to be the Huntersville Chert and the underlying Oriskany Sandstone formation.

Existing nearby wells in the injection zone: There are two existing conservation gas wells drilled for production into the Oriskany sand approximately ¼ mile from the proposed location. The company intends to use these two wells for monitoring purposes after the Povlik #1 disposal well begins operation. The two wells are identified as API #033-20263 and API #033-20228 (injection test for the EPA permit was performed on 033-20228 since the Povlik #1 well is proposed but not yet drilled).

Faulting: There are 2 faults identified within the ¼ mile radius. However, the EPA has determined these faults to be "non-transmissive" due to seismic information evaluated by the agency. According to Page 8 of the EPA public response document, "non-transmissive" means that any fluid that is injected into the injection zone should be confined within that zone. This interpretation appears to be reasonable.

Confining zones: According to Page 8 of the EPA public response document, the confining zone is the fault block within which the well is to be located. The 2 faults described in the paragraph above have been interpreted to be the seal which captured the natural gas deposit that has been produced, and they have been interpreted to be the seal that will contain any fluids injected for disposal. According to Page 8 and Page 9 of the EPA document, the faults do not extend to the deeper basement rocks, nor do they extend to the surface. This interpretation appears to be reasonable.

In addition to the above structural confining features, there are stratigraphic confining layers which should contain fluid within the injection zone. The stratigraphic confining layers are identified as the Onondaga Limestone positioned directly above the injection zone, and the Helderberg Limestone positioned directly below the injection zone. These limestone units held the gas in place prior to Oriskany production in the area. The company does not intend to penetrate the Helderberg Limestone.

Seismic events (prepared by Harry Wise, P.G.):

The Department's review indicates there are no historical seismic events within the quarter mile radius area of review. There are no historical earthquakes (since 1970) of magnitude two (2M) or greater within Clearfield County.

In EPA's Responsiveness Summary for Public Comments, Question 8 notes "The proposed injection well is located close to several geologic faults and this could cause fluid migration and seismic activity." In response to this statement, EPA discusses how induced seismic events associated with injection wells in Ohio were created by disposal in Precambrian basement rock. These rocks are often cross-cut by blind faults or are crystalline in nature. Additional studies by the State of Oklahoma (<http://earthquakes.ok.gov/>) and within the geologic community appear to corroborate the belief that injecting fluid into brittle, crystalline basement rock can induce seismicity. The EPA comment response document noted that the Precambrian basement rock is located

approximately 9,500 feet below the injection zone of approximately 7,030 feet below land surface. The Department's review of the basement rock (depth of approximately 16,000 to 17,000 feet below land surface) confirmed the indication of a separation distance of approximately 9,500 feet.

In the EPA comment response document, there is discussion of faulting near the well. The Department reviewed "Subsurface Structure of the Plateau Region of North-Central and Western Pennsylvania on Top of the Oriskany Formation", 1962, prepared by Addison S. Cate for the Pennsylvania Geological Survey, 4<sup>th</sup> Series. This review confirmed the location of the two faults determined to be "non-transmissive" due to seismic information evaluated by the EPA. The Department also reviewed the geologic map from "Geology and Mineral Resources of the Sabula and Penfield Quadrangles, Clearfield, Elk and Jefferson Counties, Pennsylvania, Atlas 74ab, 1976, prepared by Thomas M. Berg and Albert D. Glover for Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Topographic and Geologic Survey. This review indicates the presence of the Mountain Run Fault approximately 4 miles to the northwest of the injection site. This fault indicates displacement on the order of 400 feet on the southeastern flank of the Boone Mountain (Sabinsville) anticline. The displacement is through the upper Devonian and younger rocks. The fault location in the Oriskany Formation is inferred in the works of Cate (1962), but does not appear to have a Precambrian basement expression based on reviews of Precambrian Basement Map of the Appalachian Basin and Piedmont Province in Pennsylvania, Version 1, prepared by D.P. Gold in collaboration with S.S. Alexander, R. Cakir, A. G. Doden and S. I. Root, 2005, Open-File General Geology (OFGG) Report OFGG 05-01.0 prepared for Pennsylvania Geologic Survey. The Department concurs with EPA's statement in their comment response document that injection will not occur within, or flow into, the deeper Precambrian crystalline rocks.

Induced seismicity relating to the operation of injection wells results from the interrelationship of factors such as depth to basement rock, distance to existing faults, fault plane orientation and pore pressure regimes. This geologic analysis has not revealed indicators suggestive of a heightened potential for induced seismicity; however, there are some reported structural geologic anomalies that have been noted within the area surrounding the well. Based upon the review of all available information, it is my professional opinion that injection activities at this well pose a low risk with regards to induced seismicity. It is recommended that this risk be managed through the application of the specific permit conditions addressing seismic monitoring and mitigation listed in Appendix A.

EPA Permit Issued: The EPA issued a final permit decision approving Underground Injection Control Permit #PAS2D030BCLE for the proposed injection/disposal well. The EPA permit became effective on March 16, 2016

Conclusion: From a geological standpoint, DEP believes it to be improbable that the disposal would be prejudicial to the public interest.

#### Appendix A.

##### Seismic Monitoring and Mitigation

The permittee shall prepare and implement a seismic Monitoring and Mitigation Plan. The seismic Monitoring and Mitigation Plan shall be submitted to the Department of Environmental Protection ("Department") at least 30 days prior to the anticipated start date of disposal activities in an existing well.

This plan, or the plan as modified by the Department, shall be fully implemented at the time disposal activities begin and thereafter and shall include the following components:

- (1) Installation of a seismometer that, at minimum, includes the following:
  - a. One 3-component velocity sensor (X, Y, and Z axes), high-frequency seismometer or a local network consisting of a **minimum** of four high-frequency seismometers that have 3-component velocity sensors.
  - b. For purposes of this seismic Monitoring and Mitigation Plan, a "seismic event" shall mean circumstances which reflect tectonic seismic activity above the thresholds and within the distances set forth in Paragraphs (11) or (12) below.
  - c. For purposes of this seismic Monitoring and Mitigation Plan, an "Injection-Induced Seismic Event" shall mean circumstances which reflect seismic activity that may be directly attributable to the permitted injection activities. Raw seismic data gathered by the seismometer(s) described in (1) a. will be processed to calculate event location (epicenter/hypocenter) and magnitude. Events attributable to surface activities (such as, but not limited to, mining or blasting) or system noise will not be considered potential Injection-Induced Seismic Events.
  - d. If the one sensor option is chosen, and an Injection-Induced Seismic Event occurs at or above the thresholds specified in (11) c and d below, the operator will mobilize a local network consisting of a minimum of four (4) high-frequency seismometers that have 3-component velocity sensors within 48 hours of the event.
  - e. All seismometers shall be installed in accordance with the manufacturer's instructions prior to operation of the disposal well.
- (2) A description of and specification sheet for the seismometer installed at the disposal well site.
- (3) The installation of a recorder that, at a minimum, continuously records 100 samples per second using a data logger with 24-bit digitizer and Global Positioning System (GPS) timing, in accordance with the manufacturer's instructions prior to operation of the disposal well.
- (4) A description of and specification sheet for the seismic recorder installed at the disposal well site.
- (5) A description of the protocol for operating and completing calibration of the seismometer and seismic recorder installed at the disposal well site demonstrating that it conforms with the standards employed by the Pennsylvania State Seismic Network (PASEIS) and the manufacturer's instructions.
- (6) A description of the routine maintenance and service checks that will be implemented to monitor the operability or running condition of the seismometer and seismic recorder installed at the disposal well site. The description should detail how the checks satisfy the manufacturer's instructions.
- (7) Verification that tectonic seismic event data will be captured at the disposal well site electronically and in a manner that is suitable for tectonic seismic event recordation and analysis.
- (8) Verification that seismic data will be provided to the Incorporated Research Institutions for Seismology (IRIS) Network in real time and that the continuous, real time data conforms to the data format required by IRIS for archiving under PASEIS' network code (PE) and open distribution. If data transmission is interrupted, notification will be provided to the Department verbally within 24 hours and in writing within seven (7) days.
- (9) A description of measures that will be taken to install the seismometer in a manner that will minimize interference from background sources and allow for optimal Seismic Event identification and location (epicenter and hypocenter). This shall include a plan view map of proposed seismometer location(s).

- (10) Contact information for the responsible person in charge of conducting seismic monitoring activities at the disposal well site.
- (11) If the one sensor option is chosen, a tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:
- a. Immediate electronic notification to the Department and the Department of Conservation and Natural Resources' Bureau of Topographic and Geologic Survey (BTGS) of detection of any measurable event, within six (6) miles measured radially from the disposal well.
  - b. Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department's statewide toll-free number in the case of seismic activity referenced in a. above will include filtering/processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).
  - c. Should an Injection-Induced Seismic Event occur (i.e., not a surface-related event or system noise), the Operator will reduce the well's operating injection rates. Reduction of the disposal well's operating injection rates in use at the time of the Injection-Induced Seismic Event by 50% within 48 hours of the occurrence of 3 or more consecutive Injection-Induced Seismic Events greater than 1.0 and less than 2.0 on the Richter Scale over a seven (7) day period occurring within three (3) miles measured radially from the disposal well. The seven (7) day period is defined as starting with the occurrence of any Injection-Induced Seismic Event of magnitude 1.0 or greater. Reduced operating injection rates shall be maintained until the Department provides written notice addressing injection rates.
  - d. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of magnitude 2.0 or greater within three (3) miles measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:
    - i. Magnitude and frequency of events detected;
    - ii. Operational history prior to the event and operating conditions at the time of the event (rates, volumes, pressures);
    - iii. Any mitigation/intervention attempts made prior to termination of activities;
    - iv. Ability of permittee to identify another potential source for the event based on data processing and analysis of conditions.
- (12) If the network option is chosen, a tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:
- a. Immediate electronic notification to the Department and the BTGS of detection of any measurable event, within three (3) miles measured radially from the disposal well.
  - b. Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department's statewide toll-free number in the case of seismic activity referenced in a. above will include filtering/processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).
  - c. Should an Injection-Induced Seismic Event occur (i.e., not a surface-related event or system noise), the Operator will reduce the well's operating injection rates. Reduction of the disposal well's operating injection rates in use at the time of the Injection-Induced Seismic Event by 50% within 48 hours of the occurrence of 3 or more consecutive Injection-Induced Seismic Events greater than 1.0 and less than 2.0 on the Richter Scale over a seven (7) day period occurring within three (3) miles measured radially from the disposal well. The seven (7) day period is defined as starting with the occurrence of any Injection-Induced Seismic Event of

- magnitude 1.0 or greater. Reduced operating injection rates shall be maintained until the Department provides written notice addressing injection rates.
- d. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of magnitude 2.0 or greater within two (2) miles measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:
    - i. Magnitude and frequency of events detected;
    - ii. Operational history prior to the event and operating conditions at the time of the event (rates, volumes, pressures);
    - iii. Any mitigation/intervention attempts made prior to termination of activities;
    - iv. Ability of permittee to identify another potential source for the event based on data processing and analysis of conditions.
- (13) Provisions for submitting an updated seismic Monitoring and Mitigation Plan as needed or as may be required by the Department. Updates may be necessary in cases where the risk profile associated with injection activities changes. A signed and certified statement by a qualified professional person responsible for preparing the seismic Monitoring Plan that the plan is true and accurate and includes the components outlined above. The certification shall provide: "I, (insert name), hereby certify, under penalty of law as provided in 18 Pa.C.S. § 4904 (relating to unsworn falsification to authorities) that I prepared the seismic Monitoring Plan for (insert facility name) and the information provided is true, accurate and complete to the best of my knowledge and belief."
  - (14) Upon commencement of disposal activities at the disposal well, the permittee shall record tectonic seismic event data electronically in an appropriate format for analysis (event location and magnitude) and maintain daily records of tectonic seismic event data electronically for review at the request of the Department. Tectonic seismic event records must be maintained for one (1) year.
  - (15) The permittee shall maintain all calibration, maintenance and repair records for the seismometer for at least five (5) years.
  - (16) The permittee shall maintain all calibration, maintenance and repair records for the seismic recorder for at least five (5) years.
  - (17) The operator may submit a summary report and plan for modification or discontinuation of the seismic Monitoring Plan five (5) years after injection activities commence. The Department's review will be completed as soon as practicable after receipt of the summary report and a written response will be provided to the operator. DEP's assessment of the report will be dependent on, but not limited to, the following criteria:
    - a. Magnitude and frequency of any events during the monitoring period;
    - b. Operational history during the monitoring period (rates, volumes, pressures);
    - c. Planned operational conditions moving ahead (rates, volumes, pressures);
    - d. Demonstration through pressure fall-off that system is at equilibrium and behaving in as a homogenous reservoir;
    - e. Need for any mitigation/intervention during the monitoring period.