




pennsylvania
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

TO

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THRU

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DATE

May 17, 2017

RE:

Geologic Review of Proposed Injection/Disposal Well
Windfall Oil & Gas, Inc. - Zelman #1 Well
Brady Township, Clearfield County

REMARKS:

This document summarizes the Department's internal geologic review of the well permit application submitted by Windfall Oil & Gas, Inc for their proposed Zelman #1 injection/disposal well located in Brady Township, Clearfield County pursuant to 25 Pa. Code § 91.51(b)(3).

Sources of information for this report include: Windfall Oil & Gas, Inc well permit application No. 033-27255, the EPA UIC permit application, DEP internal electronic maps, drillers logs for nearby wells, and the EPA document: "Response to Comments for The Issuance of an Underground Injection Control (UIC) Permit for Windfall Oil & Gas, Inc."

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: Fourteen water supplies have been identified on the Well Location Plat in the gas well permit application as being located within a 1,000-foot radius of the proposed injection well. The nearest of these fourteen supplies is located a distance of 655 feet from the proposed injection well.

Information gathered from the driller's logs for seven gas wells in the area surrounding the proposed injection well indicates the deepest fresh groundwater to occur at a depth of 750 feet below ground surface. However, most fresh groundwater sources occurred at depths shallower than 500 feet.

The depth from ground surface to the top of the Huntersville Chert formation is approximately 7,300 feet, which provides 6,550 vertical feet of protective isolation between the injection formation (7,300 feet) and the deepest fresh groundwater (750 feet) as encountered in nearby gas well drillers logs.

Injection zone: The disposal well is proposed to be drilled through the Oriskany Formation, with the zone of injection intended to be the Huntersville Chert and the underlying Oriskany Sandstone formation. The Huntersville Chert occurs at a depth of approximately 7300 feet to 7358 feet, and the Oriskany Sandstone occurs from approximately 7358 feet to 7387 feet below ground surface.

Existing nearby gas wells in the injection zone: There is one currently producing gas well drilled to a total depth of 3576 feet, which does not penetrate the injection zone. This well is identified by API #033-20597 and is located a horizontal distance of 456 feet from the proposed location. There are no existing oil and gas wells that penetrate the injection zone within the ¼ mile radius from the proposed location.

Confining zones: According to Pages 6 and 7 of the EPA public response document, the confining zone is the fault block within which the well is to be located. The faults defining the fault block in which the Zelman well is to be located have been interpreted to be the seal which captured the natural gas deposits and production fluids that have been produced. These faults have been interpreted to be the seal that will contain any fluids injected for disposal. According to Page 5 of the EPA document, there is no geologic evidence that these faults are transmissive to the deeper basement rocks, or to the surface. This interpretation appears to be reasonable.

In addition to the above structural confining features, there are dense 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. In fact, Pages 9 and 10 of the EPA document correctly indicate the effective confinement by the Onondaga Limestone that has been established by gas storage pools in the Chert/Oriskany formations throughout Pennsylvania for several decades.

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 Response to Comments for The Issuance of an Underground Injection Control (UIC) Permit for Windfall Oil and Gas, Inc., Question 7 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 11,000 feet below the injection zone of approximately 7,306 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 a separation distance of thousands of feet, in this case approximately 8,700 feet. Based on the current understanding of induced seismicity, an increase in separation from the injection zone to the Precambrian basement rock, may reduce the likelihood of induced seismicity.

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, 4th Series. This review confirmed the location of the three faults within the quarter mile radius which were determined to be "non-transmissive" based on seismic information evaluated by the EPA. The Department also reviewed the geologic map from "Geology and Mineral Resources of the Southern Half of the Penfield 15-Minute Quadrangle, Pennsylvania", Atlas 74cd, 1971, prepared by William E. Edmunds and Thomas M. Berg for Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Topographic and Geologic Survey and the geologic map from "Geology and Mineral Resources of the Hazen, Falls Creek, Reynoldsville and Dubois Quadrangles, Clearfield and Jefferson Counties, Pennsylvania", Atlas 64, 1978, prepared by Albert D. Glover and William A. Bragonier for Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Topographic and Geologic Survey. This review indicates the site is on the southeastern flank of the Punxsutawney-Caledonia Syncline. No other structural geologic features were noted around the proposed well. Based on this review, the Department concurs with EPA's statement in their comment response document that injection will not occur within, or should not 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 (separation from injection zone 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 as noted in the prior paragraph 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 low 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 #PAS2D020BCLE for the proposed injection/disposal well. The EPA permit became effective on July 30, 2015.

Conclusion: From a geological standpoint, and with seismic monitoring, DEP believes it to be improbable that the use of this disposal well 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 (1) 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.