Ohio Department of Natural Resources

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Review of Comments and Objections Submitted during Powhatan Salt Company LLC's Public Notice comment period ending February 6, 2021 and the Draft Permit comment period ending April 10, 2021 for Application Numbers aPATT035111, aPATT035112 and aPATT035113 for the Proposed Powhatan Salt Company LLC, No. Salt-1; Powhatan Salt Company LLC, No. Salt-2, and Powhatan Salt Company LLC, No. Salt-3 Wells in Salem Township, Monroe County

Pursuant to the Ohio Administrative Code 1501:9-7-07(H)(4)(c), the Division of Oil and Gas Resources Management ("Division") has reviewed all comments and objections ("objections") submitted regarding Powhatan Salt Company, LLC's three applications for permits to drill Class III solution mining wells pending with the Division:

1. Application Number aPATT035111, for the proposed Powhatan Salt Company LLC, No. Salt-1 Well in Salem Township, Monroe County,
2. Application Number aPATT035112, for the proposed Powhatan Salt Company LLC, No. Salt-2 Well in Salem Township, Monroe County, and
3. Application Number aPATT035113, for the proposed Powhatan Salt Company LLC, No. Salt-3 Well in Salem Township, Monroe County.

Additionally, pursuant to the Ohio Administrative Code 1501:9-7-07(H)(2), the Division issued three draft permits for a comment period ending April 10, 2021 for the three applications listed above.

In accordance with Ohio Administrative Code 1501:9-7-07(H)(4), the Division reviewed all objections submitted regarding Powhatan Salt Company, LLC's three applications and the Division's draft permits. Full consideration has been given each objection submitted to the Division. The Division critically reviewed all objections and each one was analyzed in-depth. However, the Division determined that all objections lacked validity and none of the objections submitted warranted changes to the provisions of the draft permits.

Division Changes to the Draft Permits

Ohio Administrative Code 1501:9-7-07(H)(4)(e)(1) requires the Division to disclose what provisions, if any, of the draft permits have been changed in the final permits and the reason for the changes. The following changes were made to each of the draft permits:

1) All instances of the word "draft" has been removed in the final permits because the final permits are not "drafts."
2) Page 1 of each draft permit is removed from the final permits because Page 1 was an explanatory page for the public and not intended to be part of the final permits.

3) The “issue date” and “expiration date” have been updated on the final permits to reflect the actual dates and durations for the permits to construct, in accordance with Ohio Revised Code. 1509.06.
4) The Oil and Gas Well Inspector has been changed on the final permits due to a retirement within the Division.
5) Because each final permit is assigned an API Well Number at issuance, the API Well Numbers on the draft permits were modified from 34-111-2-XXXX-00-00 to:
   a) 34-111-2-4819-00-00 (Powhatan Salt Company, LLC No. Salt-1),
   b) 34-111-2-4918-00-00 (Powhatan Salt Company, LLC No. Salt-2), and
   c) 34-111-2-4917-00-00 (Powhatan Salt Company, LLC No. Salt-3).
6) To ensure all pipes and conveyances are installed and functioning properly prior to solution mining, the Division has added the following condition to the final permits:
   a) Prior to requesting authorization to commence injection, Powhatan Salt Company LLC shall test all installed pipes and conveyances per manufacture specifications. The tests results and summary report shall be submitted to the Division for acceptance.
7) The proposed well locations are not within a flood hazard area, however, development at the Site may occur within a nearby special flood hazard areas. To acknowledge local floodplain regulations, the Division added the following condition to the final permits to ensure if any construction occurs in the flood hazard area that the Monroe County floodplain regulations will be complied with:
   a) Any development that occurs within a special flood hazard area shall comply with the Monroe County floodplain regulations in effect.

Underground Injection Control Section
Division of Oil and Gas Resources Management
Ohio Department of Natural Resources

Multiple comments were received addressing the underground storage of natural gas liquids, including several comments asking why API recommendations established in federal law were not followed?

The applicant has applied for a permit to construct and operate a Class III solution mining project and the Division of Oil and Gas Resources Management (DOGRM or Division) is reviewing these applications pursuant to its delegated authority from the United States Environmental Protection Agency to regulate Class III solution mining projects. The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.

How will a well failure or leak be handled? Will the owner be held responsible for problems that may arise? How would the Division respond to a release of brine?

Ohio's laws and rules require maintenance of a Class III injection well in a manner that does not endanger public health, safety, or the environment. If a release of fluids at a Class III injection well or a failure of the well's multiple layers of casing or cement were to occur, the owner of the well is required to identify any problems, correct them, and remediate any impacts to the environment, including proper disposal of any contaminated materials. The owner is required to notify the Division if a situation described above occurs. The Division would oversee these steps to ensure compliance with Ohio's laws and rules and take any necessary enforcement actions. The application also contains information regarding the applicant's plans to cope with well failures.

How will you monitor for subsidence?

The Ohio Administrative Code (OAC) requires the applicant to propose a monument grid during the application to construct a solution mining well. The monument grid serves as an array of benchmarks where an Ohio registered surveyor will measure and record the elevations annually. The survey data will be reported to the Division as required by OAC 1501:9-7-09 (C)(5). The Division will compare each annual subsidence monitoring report to the past reports to identify any subsidence that has occurred.

Why does the Area of Review (AOR) not include all wells and how was the AOR established? Did the area of review consider the population relying on underground sources of drinking water?

Ohio Administrative Code 1501:9-7-01(M) defines solution mining project as a well or group of wells and associated facilities under one owner or operator utilized for the solution mining of minerals. The applicant provided details within the permit applications, which stated each solution mining project will be manifolded separately and each cavern will be isolated from the other. For this reason, Powhatan Salt Company LLC # Salt –1, Powhatan Salt Company LLC # Salt –2, and Powhatan Salt Company LLC # Salt –3 were all determined to be separate solution mining projects.

The area of review for an individual solution mining project is set forth by OAC 1501:9-7-07(E)(1), which states that for individual solution mining projects consisting of one well, the area of review shall be a fixed radius around the well of not less than one-quarter mile. In determining the fixed area of review, the following factors are taken into consideration: chemistry of injected and formation fluids, hydrogeology, population and groundwater use and dependence, and historical practices in the areas as required by OAC 1501:9-7-07(E)(3).

Hydrogeology, Populations and Groundwater Use and Dependence. The Division evaluated these factors to determine whether it was appropriate to expand the quarter mile area of review. As part of this evaluation, the Division reviewed the groundwater use and dependency. The nearest public drinking water system supplies drinking water to the City of Clarington. The Division reviewed the data for the City of Clarington's municipal water wells. The five-year time of travel around the municipal water wells is more than 3,600 feet away from the Powhatan Salt Company LLC # Salt –3, which is the closest proposed well to the water wells. According to Ohio EPA's municipal systems with endorsement protection plans spreadsheet, the City of Clarington's source water protection plan provides drinking water to 384 individuals.

Part of the permit application is to provide details on how the well or wells are to be constructed. Each well must follow the requirement of the well construction rules in OAC 1501:9-1-08 when proposing the casing depths and cementing program. A conductor casing and surface casing is required to be cemented to surface, protecting the deepest underground source of drinking water (USDW). USDW is defined by OAC 1501:9-1-01(A)(57). Under this definition, USDW means an aquifer or portion of an aquifer that supplies any public water system or that contains a sufficient quantity of groundwater to supply a public water system, and currently supplies drinking water for human consumption, or that contains fewer than ten thousand milligrams per liter total dissolved solids and is not an exempted aquifer.

The Division evaluated each known water well in close proximity to each proposed solution mining well. The proposed depths of conductor and surface casings for each of the three proposed solution mining wells will be protective of the water use from the known water wells in the area. The evaluation of the source water protection area, water wells, and the deepest USDW helped the Division evaluate the local hydrogeology of the area around the proposed solution mining wells.

Chemistry of Injected Fluids and Formation Fluids. The proposed injection fluid is Ohio River water. A sample was provided by the applicant during the permitting process. Formation fluid was also taken into consideration during the area of review determination process. The Salina Salt Formation is not a fluid bearing formation.

Historical Practices in the Area. The Division reviewed historical practices in the area, which included an evaluation of known underground and surface mine locations and other mining operations, known oil and gas well locations, and transportation practices.

For the reasons listed above the Division reviewed the proposed applications and determined that a fixed quarter mile area of review would be appropriate for each solution mining well. The Division required the applicant to supply an area of review map of a quarter mile radius from each proposed solution mining well under OAC 1501:9-7-07(G)(5)(d).

OAC 1501:9-7-07(G)(5)(d) requires the applicant to supply a map of the geographic location of all wells within the area of review that penetrate the zone proposed as the injection zone. The area of review maps were supplied and contained only the Core Hole No. 1 Well, API # 34-111-2-4666-00-00, which is a plugged well in the same formation as the proposed injection zone in the area of review of the Powhatan Salt Company No. Salt-1. There is also a Class V well, Ohio Permit No. UIC 05-56-11 PTO V, which is drilled to the Powhatan 4 Mine. The mine elevation is between 466 feet to 573 feet from mean sea level. There is also the Quarto Mining Company No. SWITZ27DHSU, which is a horizontal oil and gas well drilled to the Point Pleasant Formation. Therefore, the Core Hole No. 1 was the only well required on the area of review map.

Where does the produced saltwater go?

Part of the solution mining application process is to disclose a brief description of the nature of the business associated with the project. The applicant disclosed that the applicant is proposing to transfer saltwater produced from the solution mining operations to the Eagle Natrium manufacturing facility in New Martinsville, West Virginia via a 10-inch pipeline.

How is the floodplain addressed?

None of the proposed wells are to be located within a 100-year floodplain. Any development that may occur within a floodplain would need to comply with the applicable floodplain requirements in effect.

How will the dam be monitored for leaks?

The ODNR Division of Water Resources (DWR) has jurisdiction over a dam. The applicant stated that the proposed dam is not part of the solution mining operation. For this reason, the proposed dam and associated ODNR Division of Water Resources permit issued for the construction of the dam were not included with the solution mining permit application process. However, if the dam would be part of the solution mining process, then the permit would need to be modified.

What is the relationship between the dam and the monitoring wells and the salt cavern?

The Division has permitting, construction, and operational authority of the solution mining wells and the associated salt cavern. ODNR DWR has regulatory authority over the dam. ODNR DWR reviewed a dam permit as discussed in the question above. Contact ODNR DWR for the applicable dam permit and comments concerning the monitoring wells associated with the dam.

What impact will there be from water withdrawals from the Ohio River?

ODNR DWR reviews applications and issues permits for water withdrawal facilities who propose to withdrawal more than 100,000 gallons of water per day. The water withdrawal facility permit for Powhatan Salt Company LLC was issued by DWR under Water Withdrawal Facilities Registration #03032. This permit can be obtained by contacting ODNR DWR at (614) 265-6620 or water@dnr.ohio.gov.

ODNR DOGRM does not have authority to review and permit water withdrawal facilities. DOGRM has authority to requires the applicant to disclose water usage for production operations (ORC 1509.06 (A)(8)(a)) and solution mining operations. Each solution mining project is required to disclose how much injection fluid was injected per well on a monthly basis and supplied on a quarterly report form as required by OAC 1501:9-7-09(B)(2).

Is the applicant properly insured and bonded?

Yes – well owners in the State of Ohio are required to maintain insurance and bond pursuant to law and rule. The bond amount posted is $15,000 and the liability insurance certificate on file with the Division is for an amount of $6,000,000.

How does the public comment period and public notice process work? Does my comment matter? Why wasn't the fact sheet available for public comment during the Powhatan Salt Company Public comment period?

Public comment and public notice requirements for Class III injection wells are established in OAC 1501:9-7-07(H). The Powhatan Salt Company ran a public notice as required. The Division published notice of a draft permit and provided a fact sheet regarding the applications to anyone who requested it. A comment period was held, and the Division reviewed all comments and provided these responses to the comments received.

The Division takes every comment it receives for every solution mining permit application serious and reviews each comment in light of the requirements of the laws and rules governing the permitting, construction, operation, and plugging of solution mining wells. The Division values the public comment when taking a final decision of a solution mining application.

Why is a public hearing not required for this application?

Ohio Administrative Code 1501:9-7-07(H)(4)(c) gives the Chief of the Division discretion to hold a public hearing.

Does the Division have rules regarding the spacing of caverns?

The OAC does not specify the spacing of caverns. However, the OAC 1501:9-7-12 requires setbacks requirements for each solution mining well from occupied dwelling, roads, railroad or any well.

Does the Division have the authority to enforce standards or guidance's not included in the Revised Code or Administrative Code such as an API recommended practice?

The Division's authority is expressly authorized by Ohio Revised Code and Ohio Administrative Code.

Is the Division aware of the alleged gas/brine migration between the axial salt operation and the Triad Hunter horizontal well?

Incidents of fluids migrating in the subsurface from one well to another have occurred in Ohio and other states. The Division's technical review of the applications to drill the Salt-1, Salt-2, and Salt-3 wells concludes that the proposed well construction is protective of USDWs and other resources.

How does the Division protect public health, the environment, and drinking water?

The Division's mission is to protect public health, safety, and the environment including underground sources of drinking water. Our regulation, inspection, and enforcement framework includes strong well construction standards, regular mechanical integrity testing and subsidence monitoring, routine inspections, and annual reporting.

Why doesn't this company invest in clean energy instead of fossil fuels because of climate change?

This question can only by answered by the applicant. The Division is reviewing permit applications for three solution mining wells.

Why don't these applications get more review and stronger regulation?

The Division thoroughly reviews all applications in accordance with the laws enacted by the Ohio General Assembly and the rules adopted under them. All requirements and standards are applied to each application.

This is a poor disadvantaged community that deserves environmental justice.

The Division thoroughly reviews all applications in accordance with the laws enacted by the Ohio General Assembly and the rules adopted under them. All requirements and standards are applied to each application.

Fracking is harmful and impacted my water well.

The wells proposed in these applications are not expected to be hydraulically fractured or "fracked." If any person believes a water well was impacted or is being impacted by oil and gas activity or any other activity the Division regulates, they are encouraged to contact the Division's Environmental Assessment team at (614) 265-6922 to request an investigation to be completed. ORC 1509.22(F) gives the Division the authority to require well owners to replace a water supply that is substantially disrupted by contamination, diminution, or interruption resulting from an oil and gas operation.

Is there a fund paid for by the industry to complete future restorations?

ORC 1509.071 establishes a program that sets aside a portion of the severance tax, paid by operators who produce oil and gas, to plug idle and orphan wells and restore land surfaces at idle and orphaned wells or wells with no responsible owner. In state fiscal year 2021, the Division's orphan well program plugged 181 wells and restored the associated surface locations.

It's important to note that Ohio law requires the operator of a well to maintain their well, utilize their well according to its permitted purposes, or plug the well and reclaim the site. The owner of the solution mining project is responsible for its ultimate plugging and restoration or each solution mining well.

Does this project threaten wildlife?

The proposed class III solution mining provides minimal risk to wildlife as the majority of activity associated with the proposed wells would occur approximately 6,600 to 7,000 feet below ground level. Any surface activity is designed and regulated in a way to minimize disturbance during construction and operation of the well. Well designs and construction standards protect surface and groundwater.

Where does the injected waste go?

No waste will be injected into the proposed wells. The applications submitted by Powhatan Salt Company, LLC are for Class III injection wells for the solution mining of salt from the Salina Salt Formation. Freshwater will be injected into the wells to dissolve the bedded underground salt. The saltwater mixture will then be brought to the surface and transferred to a neighboring facility via a pipeline for use in manufacturing products. Class II injection wells (not the subject of these applications) are used for the injection of fluid waste generated from oil and gas wells.

Will monitoring wells be required if these wells are permitted?

The OAC 1501:9-7-08(A)(11) requires the monitoring wells completed in the USDW when the proposed well is in areas of catastrophic collapse or subsidence. Each solution mining project is required to monitor for subsidence annually. During this monitoring very little recorded subsidence has occurred at the surface surrounding other solution mining projects in the state of Ohio. Using this knowledge and the nature of the solution mining injection zone, the Division is not proposing to require monitoring wells.

Does the Division have the authority to deny the applications?

OAC 1501:9-7-07(H)(4)(d) states the chief shall reject the application if the chief finds that the following conditions have not been met: the applications do not comply with the requirements of the rule; the proposed solution mining project will not be in violation of law; and the proposed solution mining project will not jeopardize public health or safety.

Will there be emergency shut down equipment?

OAC 1501:9-7-07(G)(4)(I) requires an applicant to supply a contingency plan to cope with well failures or shut-ins so as to prevent the migration of the contaminating fluids into underground sources of drinking water. The applicant provided a contingency plan which included the continuously recorded brine production and water injection volumes, flow rates and pressures. Any anomalous condition, including a rate or pressure variation, shall be reported to the chief immediately and injection operations will cease.

Why is seismic monitoring not required for these applications?

The Division believes there is little risk of induced seismicity associated with these wells. Additionally, the Division has an extensive seismic monitoring network that could detect seismic events in the area if they were to occur.

Will this project allow for the release of containments in the air?

Air emissions are regulated by the Ohio EPA**.**

Do the salt caverns need to be pressurized?

This is an application to create a cavern through solution mining process. During this process the bedded salt underground is dissolved by circulating fresh water into the well and extracted brine. The process of dissolving and extracting the salt creates an underground void or cavern.

After a permit to inject has been issued, the applicant may inject at a surface pressure not to exceed the maximum allowable pressure prescribed by the Division. OAC 1501:9-7-09(A)(3) requires the injection pressure to be calculated to ensure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone. The Division uses the following formula to calculate the maximum allowable surface injection pressure:

$$Pm = (0.75 - (Pgf \times SG))D$$; where,

Pm = maximum surface injection pressure (pounds/inches squared)

0.75 psi/ft = maximum injection pressure gradient allowed

D = depth to top of shallowest proposed injection formation (feet)

Pgf = 0.433 (psi/ft) = pressure gradient of fresh water

SG = 1.2 = conservative specific gravity of injection fluid

The result of this formula will be checked against the applicant's calculation or determination of fracture pressure in the proposed injection zone to ensure that the pressure is not high enough to initiate new fractures or propagate existing fractures in the injection zone. The formula accounts for the hydrostatic pressure of the water column from the surface to the production casing seat. The Division will prescribe a pressure in the operational permit for each solution mining well.

Why is the Division not evaluating the financial records and viability of the applicant?

Ohio Revised Code 1509.07 requires proof of liability insurance to be filed with the Division. The Division does not have the authority to request or evaluate an applicant's financial viability as part of the permitting process.

Why was a general geologic characterization for the well location, the salt deposit, or the overlying formations not provided?

OAC 1501:9-7-07 does not require a site-specific geologic characterization for the proposed well location and the application was considered complete as outlined by OAC 1501:9-7-07. However, the Division has reviewed ODNR Division of Geological Survey documents on the extent of the Salina Salt Formation as well as reviewed the well completion and the data submitted by the applicant's Core Hole #1 to confirm the extents of the geologic formations surrounding the proposed solution mining wells. A second operational permit will address cavern boundary verification.

How will the Division locate nearby faults?

The Division requested and evaluated the ODNR Division of Geological Survey to provide a series of geologic structure maps for six individual geologic horizons above and below the proposed solution mining formation. In addition to the structure maps, the Survey also included the locations of known and inferred faults within the general vicinity of the proposed well. The Division reviews these maps as part of the Division' s evaluation for the permits to construct the three solution mining wells.

How was the fracture pressure determined?

OAC 1501:9-7-08(A)(9)(b) requires the fracture pressure to be determined by the applicant for new solution mining projects. The applicant provided facture pressure for the proposed injection zone measured from the Core Hole #1 Well (API# 34-111-2-4666-0000) testing.

Was geomechanical modeling performed?

The applicant measured the fracture pressure of the proposed injection zone by well testing from the Core Hole #1 well. The OAC does not require any other geomechanical data that the applicant may have to be submitted as a part of the application for a solution mining permit.

How are Underground Sources of Drinking Water (USDWs) and local water sources protected? Was the USDW identified?

During the application review process, the Division examines the proposed casing program and ensures that it adequately protects USDWs. The rule does not require the depth of the USDW to be identified by the applicant; however, OAC 1501:9-7-08(A)(1) does require that the surface casing be set at least 50 through the USDW and cemented to surface.

In these applications, the company proposes to run 260 feet of conductor casing and cement it to surface in each of the wells to protect known sources of drinking water. The applicant also proposes to set 340 feet of surface casing and cement it to surface to protect additional groundwater that may be brackish. The proposed plan also includes a minimum of two more casing strings inside the surface casing. As part of the permit all strings will be required to be cemented to surface. This proposal is adequate to protect USDWs in this area. Local water wells are drilled to depths between 27 feet and 65 feet. The Village of Clarington's Public Water System wells are drilled to depths between 70 feet and 76 feet.

How will this permit meet drilling and well construction requirements? Do the applications include details on the casing proposed to be used?

OAC 1501:9-7-08(A)(1) requires surface casing to be cemented to surface. The USDW in the area of the proposed locations of these solution mining wells is not mapped due to the complex stratigraphy of the discontinuous and interbedded lenses of sandstones and siltstones which may hold Southeast Ohio's deepest usable drinking water. For this type of USDW, Ohio rules require that a minimum of 100 feet of conductor casing be set and cemented to surface. The applications propose 260 feet of conductor casing. The surface casing depth will be determined by the surrounding hydrogeology. OAC 1501:9-1-08(M)(4)(f) is used to determine the required depth of surface casing with this type of USDW. Here, the applicant has proposed 340 feet of surface casing.

OAC 1501:9-1-02 requires the applicant to disclose information regarding the amount and type of casing proposed to be used in construction of the well. The proposed casing plans submitted on the applications state that the production casing will be set and cemented at the top of the salt section. Then an open hole section will be drilled below the bottom of the cemented production casing to an estimated 7000 feet.

The type of cement or drilling fluids are not required to be disclosed at the time of application, but cementing records are required to be submitted for Division's review as part of the well completion record submittal. OAC 1501:9-1-08(J)(1-7) describes the cement standards.

If circulation is lost during drilling, the applicant is required to disclose the loss circulation zones on the well construction record (DOGRM Form 8). OAC 1501:9-1-08(H)(1) requires the diameter of each section of the wellbore in which casing will be set and cemented must be at least one inch greater than the outside diameter of casing collar to be installed.

Each casing string is required to meet pressure requirements established in OAC 1501:9-1-08(D)(1), which, in summary, has a minimum internal yield pressure rating designed to withstand at least 1.2 times the maximum pressure to which the casing may be subjected during drilling, production or stimulation operations.

The wells will be tested during construction. During the construction of a solution mining well, each cemented casing string over 200 feet must be pressure tested to ensure that compressive strength of the cement has reached the required 500 psi and there are no leaks within the casing. OAC 1501:9-1-08(D)(3)(b) requires the pressure tested to at least 500 psi for 15 minutes with not more than five percent decline in pressure, whichever is at a greater pressure. OAC 1501:9-7-10 specifies how each solution mining well must demonstrate mechanical integrity and the frequency of the test.

How will the fluid be tested and the well monitored once it's operating?

The applicant submitted a qualitative analysis of the fluid to be injected pursuant to OAC 1501:9-7-07(G)(4)(b)(iii). That sample sets the baseline characteristics of the fluid to be injected. OAC 1501:9-7-09(B)(1) requires a representative sample of injected fluid on a quarterly basis to be taken. If analysis of that sample shows that the characteristics of the fluid have changed significantly, the owner must provide a new analysis to the Chief.

OAC 1501:9-7-09(C)(3) requires the volume relationship or withdrawal-injection ratios reported annually. Ohio Administrative Code 1501:9-7-07 (G)(4)(b)(i) requires "the average and maximum daily rate and volume of fluid to be injected per well or per project when a manifold system is used." The Division requested Powhatan Salt Company LLC to disclose if each well was individually manifolded or commonly manifolded. The Powhatan Salt Company stated that the wells will be individually manifolded.

Are the pressures in the permit at the surface or the bottom of the well?

Pressures in the permit are pressures at the surface.

Document created by commentor and all labels and content (columns A-H) is the responsiblity of the commentor.

For ease of response, the Division responded on the document created by the commentor. This column (I) was created by the Division.

	Recommended for NGL Storage in API RP 1115	**Required for NGL Storage in API RP 1115**	**Recommended for Natural Gas Storage in API 1170 and 1171**	**Required for Natural Gas Storage in API 1170 and 1171**	**ODNR Requirements for Solution Mining Permit Applications**	**Earthjustice/PSE Healthy Energy Comments**	**ODNR Response to Comments**	DOGRM Response to Comments as required by OAC 1501:9-7-07(H)(4)
Geological								
General Geologic Characterization	X		X		X	As stated in API RP 1170 and 1115, data used in a geologic site characterization should incorporate subregional and regional data from all readily available sources. ODNR regulations require a discussion of local geology in permit applications. From materials provided in the permit applications, there was either no attempt to do this or information gathered was not presented. Without these materials it is difficult to assess the suitability of the intended injection area for a structurally sound solution mined cavern. Carter et al. (2017) provided a conceptualization of the Salina Group relevant to the vicinity of the Mountaineer NGL facility (Figure 1). Overlying and underlying formations are illustrated in addition to variation in lithology in the Salina Group. The Salina Group consists of interbedded dolomite, anhydrite, shale, and halite. These layers are subdivided into seven stratigraphic intervals (units A–G). Halite is found with the B, D, E and F units, while anhydrites are found within the A, C and G units (Wickstrom et al 2008). The Salina F4 Salt is currently being solution-mined along the Ohio River and is the thickest salt within the Salina Group (Carter et al. 2017). However, a thin, persistent dolomite/anhydrite zone is present below the F4 Salt, with a second, but thinner, salt layer at the base. As stated in API RP 1170 and 1115, geologic maps should be used to assess and communicate geologic uncertainty. For bedded salt deposits, as is the case here, geologic maps generally emphasize stratigraphy, bed thickness, and lithologic controls on solubility and cavern stability similar to that illustrated by Carter et al. (2017). It is assumed that solution mining will be limited to the Salina F4 Salt because of the presence of laterally extensive dolomite/anhydrite layer at the base of the Salina F4 Salt. However, this should be explicitly stated in the permit applications. If the PSC intends on	No response	OAC 1501:9-7-07 does not require a site-specific geologic characterization for the proposed well location and the application was considered complete as outlined by OAC 1501:9-7-07. However the Division has reviewed ODNR Geologic Survey documents on the extent of the Salina Salt Formation and reviewed the well completion and the data submitted by the applicant's Core Hole #1 well to confirm the extents of the geologic formations surrounding the proposed solution mining wells.
						also be explicitly stated. At a minimum, the ODNR should require geologic maps in permit application packages that clearly illustrate targeted units.		

Geologic Characterization of the Salt Deposit	X		X		X	As stated in API RP 1170 and 1115, structure maps for both the top and base of the salt plus a salt isopach map should be developed for hydrocarbon storage. Again, ODNR regulations require a discussion of local geology that is lacking in permit application packages. Carter et al. (2017) mapped four areas along the Ohio River where the Salina F4 Salt is sufficiently thick (>100 feet) for NGL storage. Carter et al. (2017) state that developing salt caverns for NGL storage requires the identification of salt formations that are relatively "clean" and have adequate thicknesses to support both product storage and allow for residual insoluble materials that may accumulate at the base of the caverns over time. They explain that the presence of high-quality salt is preferred to maintain cavern integrity and eliminate the likelihood of weak zones and lateral migration pathways. Therefore, understanding lateral and vertical variability within the salt interval is important. There is a need to correlate interbedded dolomite or anhydrite within the salt. In the area closest to the Mountaineer NGL storage facility, the Salina F4 Salt appears to be less than 100 feet thick (Figure 2). The Salina F4 Salt isopach maps generated by Carter et al. (2017) illustrate net salt thicknesses interpreted to be entirely comprised of salt above a persistent dolomite or anhydrite zone and does not include the thickness of that zone or any salt below the dolomite or anhydrite zone. Mountaineer NGL Storage LLC drilled a test borehole having a lease name "Core Hole 1" with API Well Number 34-111-2-4666-00-00 that was plugged on 9/6/2016. The Well Completion Record (Form 8) indicated that the top and bottom of the "Salina Salt" at the borehole were at 6596 and 6738 feet respectively (thickness of 142 feet). However, it is unclear whether this thickness is for the Salina Formation or the Salina F4 Salt. Carter et al. (2017) prepared a west-east cross	No response	This is an application for a solution mining permit, not an application for a NGL storage cavern. However, the Division requested and evaluated the ODNR Division of Geological Survey to provide a series of geologic structure maps for six individual geologic horizons above and below the proposed solution mining formation. The Division also reviewed ODNR Geologic Survey documents on the extent of the Salina Salt Formation and reviewed the well completion and the data submitted by the applicant's Core Hole #1 well to confirm the extents of the geologic formations surrounding the proposed solution mining wells.
Characterization of overlying formations	X		X		X	In bedded salt deposits, overlying rock deposits usually have much greater porosity and permeability than rock salt (Liu et al. 2020b). Hence for product storage in bedded salt deposits, once a portion of the cavern roof is damaged, leakage of product is inevitable (Liu et al. 2020b). As stated in APR RP 1170 and 1115, an evaluation of solution mining for storage of natural gas or NGL should include an evaluation of overlying formations. Breach of a cavern roof or well integrity issues may result in migration of NGLs. Again, ODNR regulations require a discussion of local geology in a permit application. Geophysical logs which cut across the Burger Well proposed for geological sequestration of carbon dioxide indicate that the Bass Island Dolomite lies	Insufficient Response. The ODNR states that the Powhatan Salt Company LLC shall maintain a written record of any fluids encountered in the "Big Lime" section, and provide this information on the well completion record. As the "Big Lime" appears to be a driller's name for the Bass Island Dolomite (and	OAC 1501:9-7-07 does not require a site-specific geologic characterization for the proposed well location and the application was considered complete as outlined by OAC 1501:9-7-07. However the Division has reviewed ODNR Geological Survey documents on the extent of the Salina Salt Formation and reviewed the well completion and the data submitted by the applicant's Core Hole #1 well to confirm the extents of the geologic formations surrounding the proposed solution mining wells. A second operational permit will address cavern boundary verification.

						directly above the Silurian Salina Group (Wickstrom et al. 2008). Within many wells of eastern Ohio, this interval appears to consist of a carbonate breccia zone. Where observed as a breccia, this zone has very high porosity and permeability. Several brine-injection wells utilize this zone in Ohio, with reported injection rates as high as 37 gallons per minute. This interval has had little detailed study in the subsurface of eastern Ohio (Wickstrom et al. 2008). ODNR should require that overlying units and their associated integrity be discussed in permit applications. At the very least, this would ensure there is no possibility of brine migration from the solution mined formations to overlying formations.	the Salina Group), it appears that the ODNR wishes to acquire more information about this unit in an area where it is relatively under-characterized. However, there is still no requirement for Powhatan Salt Company to discuss the integrity of this unit against fluid migration.	
Location of Nearby Faults	X		X			In the event of leak through casing or a cavern itself, a fault could facilitate transport of NGLs away from caverns. It appears that a 3D seismic study has been conducted (Eyermann 2017) with a noted absence of faults in the immediate area of the proposed caverns.	Addressed in permit applications	The Division requested and evaluated the ODNR Division of Geological Survey to provide a series of geologic structure maps for six individual geologic horizons above and below the proposed solution mining formation. In addition to the structure maps, the Survey also included the locations of known and inferred faults within the general vicinity of the proposed solution mining wells. The Division reviews these maps as part of the Division's evaluation for the permits to construct the three solution mining wells.
Area of Review	X		X		X	In determining the Area of Review (AOR), ODNR states that the following factors shall be taken into consideration: chemistry of injected and formation fluids, hydrogeology, population, groundwater use and dependence, and historical practices in the area. ODNR regulations require that for solution mining projects consisting of more than one well, an AOR shall be the project area plus a circumscribing area the width of which is not less than ¼- mile. PSC chose an AOR of ¼ mile but provided no justification for this distance. Permit application materials illustrate the AOR of the three proposed UIC wells. The horizontal lateral of CNX Gas Co well API 34-111- 2-48-5 (Figure 5) is at the boundary of the AOR. This well is producing from the Point Pleasant Formation at a depth of 10,740 feet. The lateral lines of several oil and gas wells lie directly across the Ohio River in West Virginia (Figure 6). The producing depths of these wells could not be determined from the West Virginia Resource Management Plan Viewer. The Viewer just lists depths of wells as "<3,000 feet" and "deep." The area surrounding the Mountaineer NGL storage facility is one of intense surface and subsurface activity including underground mining (Figure 7). The presence of legacy mining activities and nearby hydraulic fracturing activity likely has altered the natural hydrogeological setting and warrants an expansion of the AOR beyond 0.25 mi to adequately constrain risks to nearby populations. Depending on subsurface temperature and pressure, NGLs can transition to a gas phase as well migrate as a liquid phase. In 2013, natural gas that migrated 1.5 miles from a hydraulic fracturing well (API 34111242560000) managed by Triad Hunter caused a gas blow out at the nearby #28 Brine Well (API 4705101381) at the Natrium plant in West Virginia. However, gas can migrate distances far greater than this distance from a	No response	Due to size restrictions within Excel please see the Divisions response on the area of review determination as stated in the related document titled "DOGRM responses to public comment for PSC SMP permit applications.docx" for complete response.

						mobile home park more than 7 miles from the facility (Warren 2016). After the accident, poor regulation was incriminated as a causative factor by several experts (Berest and Brouard 2003). The Kansas Department of Health and Environment subsequently modified regulations including requirements for corrosion control and mandatory double casing in wells (Warren 2016). Also, the ongoing Washington County Produced Water Investigation highlights concerns about arbitrarily delineating a ¼-mile AOR. Produced water from the Redbird #4 Injection Well traveled at least 2000 feet vertically and over 5 miles laterally in the Ohio Shale prior to extraction of brine in wells producing from the Berea Sandstone. It is difficult to understand how ODNR could have permitted an injection well in a shale formation limited to secondary permeability in natural fractures. In this scenario, lack of matrix permeability and flow in fractures would have been expected, and did, travel extensive distances. A similar situation exists for NGL storage in salt. Matrix permeability in undisturbed halite is negligible. While halite is to some degree "self-healing", if product cycling or subsidence induces fractures in halite or surrounding limestone or dolostone, product migration would be extensive. It is recommended that the AOR be extended – the degree of which would be subject to additional technical evaluation.		
Wireline Logging for Lithology	X		X		X	Based on Figure 4 of Wickstrom et al. (2008), there do not appear to be wells with geophysical logs in the vicinity of the permitted areas. ODNR regulations for solution mining require that "appropriate" logs be conducted for new solution mines by a "knowledgeable" log analyst. As stated in APR RP 1170 and 1115, geophysical logs to support solution mining should include gamma ray, litho-density, compensated neutron, compensated sonic, dipole or array sonic, and caliper logs. These logs are also useful to characterize overlying strata. Extensive open-hole logging occurred in September 2016 in Core Hole 1. However, there is no description of this logging in the permit application, or more importantly, an explanation of the significance of these findings. It is unclear why this information was collected by the operator, and presumably interpreted by a trained geophysicist, but not included in the permit applications. ODNR should require an interpretation of geophysical logs in permit application packages. The interpretation of geophysical logs should include a discussion of subunits within the Salina Formation and delineation of the F4 Salt unit.	Insufficient response. The ODNR states that the Powhatan Salt Company LLC shall run at minimum, a gamma ray, compensated density-neutron, and resistivity geophysical log. Each log shall be submitted to the Division's UIC Section within 48 hours after the geophysical logging has been accomplished. The ODNR still does not require an interpretation of geophysical logs in permit	OAC 1501:9-7-08(A)(8) requires the applicant to have appropriate logs and other test run.
Identification of base of a USDW.	X		X		X	API RP 1170 and 1115 recommend setting surface casing below the depth of the deepest Underground Source of Drinking Water (USDW). ODNR regulations for solution mining mandate protection of an USDW. API RP 1170 and 1115 recommends identification of the base of an USDW using spontaneous potential (SP) or resistivity logs. Resistivity logging was conducted on Core Hole 1 in September 2016 however the permit application	No response	OAC 1501:9-7-08(A)(1) requires the applicant to have surface casing free of apparent defects, set at least fifty feet below the deepest underground source of drinking water, and sealed by circulating cement to the surface under the supervision of the division. OAC 1501:9-7-06(A) authorizes the chief to identify USDW's. Ohio rules require that the surface casing be set and cement to surface at least 50 through the USDW. OAC 1501:9-1-08(M)(4) determines the required depth of surface casing. The Division has identified the deepest USDW by using the ODNR Geological Survey Map EG-6 and requiring the surface casing to be set at least 50 feet through the deepest USDW.
						provides no description of the base of USDWs. According to ODNR regulations, the operator must determine the base of the lowest USDW in the area and provide evidence of this determination to the ODNR. This basic regulatory requirement was not addressed in permit applications.		

Wireline logging for Mineralogy	X		X			As discussed in API RP 1170 and 1115, wireline logging could provide insight on salt purity, non-salt stringers or interbeds, and the presence of potassium – magnesium (K-Mg) salts that are highly soluble and creep prone. As previously discussed, there is no interpretation of geophysical logs in permit applications. Bedded salt is more likely to enclose layered intrasalt beds with varying levers of solubility and fracture intensity (Warren 2016) that affect cavern shape during solution mining and potential loss of fluids in caverns during storage, thus posing a risk to cavern stability and impermeability.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Population relying on USDW for drinking water source					X	ODNR regulations require a description of the population relying on USDWs for a drinking water source and the proximity of injection points to withdrawal of drinking water in the project area. This information appears to be required irrespective of whether drinking water wells are within combined AORs and is lacking in permit applications. There are three water supply wells serving the City of Clarington southwest of the Mountaineer NGL Storage outside the AOR (Figure 8). Well No 367285 is 76 feet deep and screened in limestone. Well No. 416051 is 70 feet deep and screened in sand and gravel. Well No. 361434 is 70 feet deep and screened in sand and gravel.	No response	Due to size restrictions within Excel please see the Divisions response on the area of review determination as stated in the related document titled "DOGRM responses to public comment for PSC SMP permit applications.docx" for complete response.
Core Data to Support Geological and Mineralogical Characterization	X		X			Halite (NaCl) masses typically contain thinner intercalated layers, composed either of less soluble salts such as anhydrite (CaSO4) or dolomite (CaMg(CO3)2), or more soluble salts, such as carnallite (KClMgCl2·6(H2O)) or bischofite (MgCl2·6(H2O)) (Warren 2016). With less soluble salt layers intersecting a cavern edge there is a tendency to form unsupported ledges and bevels which eventually collapse to the floor of the expanding cavity. This can damage the roof in the vicinity of the feeder pipe or break the drill string. In the case of more soluble beds, their rapid solution can leave behind blocks of unstable halite, which have a propensity for collapse, or can lead to cavity shapes that become enlarged in one direction and encroach on the structural integrity of the well design, especially when there are adjacent solution cavities (Warren 2016) as is the case here. API RP 1170 and 1115 recommend that estimates of the insoluble percentage in the salt mass be determined from core samples and open-hole logs during the drilling phase. Two pairs of samples were cut from cores collected from Core Hole 1. One sample was retrieved from the "middle of the upper salt zone (6,598 feet to 6,688 feet)" (90-foot salt section) and another sample from the middle of the "lower salt zone (6,708 feet to 6,738 feet)" (30-foot salt section). Is the upper "salt zone" the Salina F4 Salt? If so, PSC should explicitly state so. These cores do not address the mineralogy of the 20-foot depth interval between 6,688 feet to 6,708 feet. It is possible that this 20-foot depth interval represents a non-salt dolomite/anhydrite layer. What is the "lower salt zone"	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
						below this layer? It is unclear from the permit materials how the operator will address a non-salt layer in the cavern design. This ambiguity directly results from the lack of geologic documents, and absence of any discussion of cavern design/geometry in the permit materials. Insoluble residue tests were conducted. The first core contained 2.48% insoluble residue consisting of anhydrite (78%), dolomite (20%), and quartz (2%). The second core contained 0.74% insoluble residue consisting of anhydrite (77.6%), dolomite (17.4%), and quartz (5.0%).		
Geomechanical Testing								

Core Data		X		X		As stated in API RP 1170 and 1115, core test data provide the geomechanical properties of salt and key units that are input into geomechanical models used to evaluate cavern stability, subsidence, and the operating pressures of storage caverns. API RP 1170 and 1115 require that cores be collected to evaluate elastic and strength properties of salt and non-salt deposits and creep of salt deposits. API RP 1170 and 1115 recommend that sufficient core should be cut to sample key lithologic units and interbeds in salt. Cylindrical specimens of salt and non-salt samples must be prepared for testing with procedures that meet or exceeds ASTM D4543. If a Brazilian indirect tension test is performed, it must be performed in a manner that meets or exceeds ASTM D3967. Triaxial compression tests must be performed in a manner that meets or exceeds ASTM D7012. A triaxial creep test must be performed in a manner that meets or exceeds ASTM D7070. At least three triaxial creep tests should be performed on similar salt specimens at different effective stresses to define creep response as a function of effective stress. There is no evidence that cores were collected during installation of Core Hole 1 for mechanical integrity testing nor indication that cores will be collected during well installation. The ODNR should require collection of cores for mechanical testing during installation of caverns with an interpretation of tests provided by a geotechnical engineer.	No response	OAC 1501:9-7-08(A)(9)(b) requires the fracture pressure to be determined by the applicant for new solution mining projects. The applicant provided facture pressure for the proposed injection zone measured from the Core Hole #1 Well (API# 34-111-2-4666-0000) testing.
In Situ Temperature	X		X			API RP 1170 and 1115 recommend the use of a temperature log in a borehole after drilling is completed to establish the in-situ distribution of temperature. Temperature logging should be delayed as long as possible (at least 3 to 5 days) to allow temperature equilibrium. Salt creep increases with temperature rise. It does not appear that use of a temperature log is planned.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
In Situ Stress		X		X	X	As stated in API RP 1170 and 1115, it is generally accepted that stress in salt units and non-salt units is isotropic and anisotropic, respectively. If reliable regional estimates of in situ stress are not available, the horizontal components of in situ stress should be established by hydraulic fracturing tests in non-salt units. Minifrac tests should be performed and interpretated with a procedure that meets or exceeds ASTM D4645. ODNR regulations also require estimation of the fracture gradient to ensure that injection does not initiate fractures. The operator states that the lithologic pressure was estimated at 6490 psig at a depth of 5470 feet with hydraulic fracture pressure estimated in the range of 9090 to 9640 psig at this depth. The	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. OAC 1501:9-7-08(A)(9)(b) requires the fracture pressure to be determined by the applicant for new solution mining projects. The applicant provided facture pressure for the proposed injection zone measured from the Core Hole #1 Well (API# 34-111-2-4666-0000) testing.
						operator should review requirements for in situ stress estimation in API RP 1170 and 1115 and provide a written explanation to the ODNR demonstrating full compliance with this requirement		
Geomechanical Modeling	X		X			API RP 1170 and 1115 recommend the use of numerical models that represent the geometries of caverns, their development history, operating conditions during gas or NGL storage, the geologic structure around the caverns, the mechanical properties of salt and nonsalt units, and preexisting conditions. The objective of numerical modeling is to determine key parameters to maintain the structural stability and mechanical integrity of the caverns. Geomechanical modeling should be performed to evaluate the effect of pressure cycling, brine compensation, and salt creep. It does not appear that geomechanical modeling is planned for this facility.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Wellbore Installation and Design								

Drilling in Salt		X		X		Due to salt dissolution, API RP 1170 and 1115 stipulate use of a salt saturated solution when drilling through halite that will constitute part of the roof of a cavern. Chloride concentrations in drilling mud should be representative of saturated conditions when drilling through halite. Nonaqueous drilling fluids can also be utilized if highly soluble magnesium or potassium salt stringers are present. There is no discussion in the permit application regarding drilling methods. The operator should include a discussion of use of drilling fluids in the permit application.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. However, the proposed casing plan submitted on the application states that the production casing will be set and cemented at the top of the salt section. Then an open hole section will be drilled below the bottom of the cemented production casing to an estimated 7000 feet.
Lost Circulation	X		X			As discussed in API RP 1170 and 1115, lost circulation during drilling can result in loss of borehole stability, loss of pressure control, and in severe instances, loss of the well. API RP 1170 and 1115 recommend that operators prepare a detailed lost circulation plan prior to drilling to ensure a timely response. This is especially important given the proximity and history of subsurface mining activities in the area. A lost circulation plan was not submitted with the permit application	No response	If circulation is lost during drilling, the applicant is required to disclose the lost circulation zones on the well construction record (DOGRM Form 8).
Borehole Diameters	X		X			API RP 1170 and 1115 recommend that borehole diameters be adequate for proper placement of cement in annuli and must be cemented to the surface. For large diameter casing used for cavern storage, borehole diameter should be at least 6 inches greater than the diameter of the next inner casing. From provided borehole schematics, 30-inch diameter surface casing will be placed within a 36-inch borehole; 20-inch intermediate casing will be placed within a 28-inch borehole; 16-inch contingency casing will be placed within a 20- inch borehole; and 13.375-inch casing will be placed within a 17.5-inch borehole. In terms of well integrity, the last cemented casing string is the most important since it comes in direct contact with product. In this case, where competent cement outside casing is most critical, there is only a 4.125- inch difference between the casing and borehole diameter resulting in only 2.06-inch annular space. ODNR should require greater annular space in this last casing string.	Insufficient response. ODNR states that Powhatan Salt Company LLC shall install 13-3/8-inch diameter casing in a 17½-inch borehole to a depth of approximately 6650 feet and cemented to the surface. Hence, no change to casing and borehole diameter in the lowest most string have been made.	These are applications for drilling a solution mining well. OAC 1501:9-1-08(H)(1) requires the diameter of each section of the wellbore in which casing will be set and cemented to be at least one inch greater than the outside diameter of casing collar to be installed.
Open-Hole Caliper Logs		X		X		API RP 1170 and 1115 stipulate than an excess cement volume be determined following an evaluation using an open-hole caliper log. There is no indication in the permit applications that open-hole caliper logs will be utilized.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Depth of Surface Casing	X		X		X	ODNR regulations require that surface casing must be at least 50 feet below the lowest USDW. Borehole schematics indicate surface casing to 340 feet. ODNR regulations mandate protection of USDWs. Evidence needs to be provided that this depth is below the deepest USDW.	Insufficient response. ODNR states that Powhatan Salt Company LLC shall: (1) install 30-inch diameter surface casing in a 36-inch diameter borehole to a depth of	OAC 1501:9-7-08(A)(1) requires surface casing to be set 50 feet below the deepest USDW. The proposed locations of these solution mining wells are in an unmappable USDW area due to the interbedded sandstones and siltstones within Southeast Ohio. OAC 1501:9-1-08(M)(4)(f) is used in determining the required depth of surface casing with this type of USDW, which would be a minimum of 300 feet.
Cement Outside Surface Casing		X		X	X	API RP 1170 and 1115 and ODNR regulations mandate that surface casing be cemented to the surface. The borehole schematic indicates that surface casing will be cemented to the surface.	Addressed in the permit applications	The Division agrees this is a sufficient response. Additionally, as required by OAC 1501:9-7-08(A)(1), the surface casing shall be cemented to surface.

Collapse Strength of Surface Casing		X		X		API RP 1170 and 1115 require calculation of collapse strength of surface casing and pressures encountered during cementing of surface casing be calculated to ensure that the collapse strength of surface casing will not be exceeded. These calculations are not present in the permit application. The operator should provide these calculations to the ODNR.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. However, each casing string for a solution mining well is required to meet the following state requirements: OAC 1501:9-1-08(D)(1), which requires all casing installed in a well shall be steel alloy casing that has been manufactured and tested consistent with standards established by the American petroleum institute (API) in "5 CT Specification for Casing and Tubing" or ASTM international (ASTM) in "A500/A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes" and has a minimum internal yield pressure rating designed to withstand at least 1.2 times the maximum pressure to which the casing may be subjected during drilling, production or stimulation operations.
Cement Outside Intermediate Casing		X		X		API RP 1170 and 1115 require that if practical, intermediate casing be cemented to the surface. The borehole schematic indicates that intermediate and contingency casing will be cemented to the surface.	Addressed in the permit applications	The Division agrees this is a sufficient response.
Collapse and Burst Strength of Intermediate Casing		X		X		API RP 1170 and 1115 require that pressures encountered during cementing of intermediate casing be calculated to ensure that the collapse strength of casing will not be exceeded during cementing. Burst design for the top of intermediate casing must be based on the maximum operating pressure without allowance for pressure containment due to the cement sheath or hydrostatic head outside casing. Collapse strength at the bottom of casing must be based at a minimum on the cementing differential pressure to be encountered. Calculations of collapse and burst strength of intermediate casing are not provided in the permit application. The operator should provide these calculations to the ODNR.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. However, each casing string for a solution mining well is required to meet the following state requirements: OAC 1501:9-1-08(D)(1), which requires all casing installed in a well shall be steel alloy casing that has been manufactured and tested consistent with standards established by the American petroleum institute (API) in "5 CT Specification for Casing and Tubing" or ASTM international (ASTM) in "A500/A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes" and has a minimum internal yield pressure rating designed to withstand at least 1.2 times the maximum pressure to which the casing may be subjected during drilling, production or stimulation operations.
Cement Outside Production Casing	X		X			API RP 1170 and 1115 recommend when practical, production casing should be cemented with salt-saturated materials in halite and then cemented to the surface. The borehole schematic indicates that production casing will be cemented to the surface. However, the nature of materials is not described.	No response	The proposed casing plans submitted on the applications states that the production casing will be set and cemented at the top of the salt section and not into the salt bearing formation. Then an open hole section will be drilled below the bottom of the cemented production casing to an estimated 7000 feet. The type of cement or drilling fluids are not required to be disclosed at the time of application, but cementing records are required to be submitted for the Division's review as part of the well completion record submittal. OAC 1501:9-1-08(J)(1-7) describes the cement standards.
Depth of Production Casing		X		X		API RP 1170 and 1115 require that production casing should be set below top of salt. If production casing is set above the salt, the rock forming the cavern roof must be nonporous and impermeable. The borehole schematics indicate that production casing will be set within salt.	Addressed in the permit applications	The Division agrees this is a sufficient response.
Pressure Testing of Production Casing Shoe		X		X		API RP 1170 and 1115 require that production casing be pressure tested before drilling out the plug or shoe. At least 10 feet of the salt below the casing shoe must be penetrated prior to the test. A minimum of 95% of the 120-hr compressive strength of cement should be achieved prior to pressure	Addressed in the permit applications	The Division agrees this is a sufficient response.
						testing. The test pressure at a minimum must be the maximum operating pressure but not exceed the yield pressure of the casing. The pressure should be maintained a minimum of 30 minutes. In the permit application, both the top of salt and production casing are estimated at 6600 feet while the illustration indicates that the casing is below the top of salt. In the permit application, it is stated that the production casing will be tested 24 to 96 hours after cementing by pressurizing the well to 75% of the calculated fracture pressure at the shoe, holding for one hour with less than 5% pressure loss.		

Collapse and Burst Design of Production Casing		X		X		API 1170 and 1115 require that burst strength of production casing be calculated using the maximum operating pressure or mechanical integrity testing (MIT) pressure without allowance for pressure containment due to the cement sheath or hydrostatic pressure outside of casing. The collapse strength should be based on full lithostatic load externally and atmospheric pressure internally. Calculations of collapse and burst strength of production casing are not included in permit applications. The operator should provide these calculations to the ODNR.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. However, each casing string for a solution mining well is required to meet the following state requirements: OAC 1501:9-1-08(D)(1), which requires all casing installed in a well shall be steel alloy casing that has been manufactured and tested consistent with standards established by the American petroleum institute (API) in "5 CT Specification for Casing and Tubing" or ASTM international (ASTM) in "A500/A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes" and has a minimum internal yield pressure rating designed to withstand at least 1.2 times the maximum pressure to which the casing may be subjected during drilling, production or stimulation operations.
Production Casing Logs	X		X			API 1170 and 1115 recommend utilization of a casing inspection log which uses either magnetic flux leakage or ultrasonic measurements to establish the production casing's wall thickness for future comparison to evaluate corrosion. There is no discussion in the permit application packages to monitor production casing thickness.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Cement Application		X		X		API RP 1170 and 1115 stipulates that cement quality and testing meet or exceed API 10A and API 10F, respectively. API RP 1170 and 1115 recommend that laboratory testing be conducted on all proposed cements and actual mix water. Non-salt-saturated cements should include tests for 24-, 48-, and 72-hour compressive strengths at temperatures expected in the borehole. Salt-saturated cements used in halite should include tests for 24-, 48-, and 120-hour compressive tests at temperatures expected. No laboratory testing of cement mixtures is planned in the permit application. The operator should be required to submit a cement application plan to the ODNR.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. These proposed wells would have to meet the cementing standards set forth by OAC 1501:9-1-08(J).
Casing Centralization		X		X	X	API RP 1170 and 1115 stipulates casing centralization to achieve proper placement of cement around casing. ODNR regulations on solution mining state that the Chief may require the use of centralizers on intermediate and production or long string casing. Centralizers are routinely used to center casing prior to cement application. However, in the absence of submittal of a drilling plan which should explicitly address this issue, it cannot be assumed that centralizers will be utilized.	Sufficient response. ODNR states that bow-string or rigid centralizers shall be used to provide sufficient casing standoff and faster effective circulation of cement to isolate critical zones including aquifers, flow zones, voids, loss circulation zones, and hydrocarbon bearing zones.	The Division agrees this is a sufficient response.
Spacers and Flushes	X		X			API RP 1170 and 1115 recommend the use of spacers and flushes ahead of the cement slurry to displace drilling fluids. Although this is common practice when installation oil and gas wells, a drilling plan was not submitted with the permit application specifying the use of spacers and flushes.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. These proposed wells would have to meet the cementing standards set forth by OAC 1501:9-1-08(J).

Cement Evaluation Logs	X		X		X	API RP 1170 and 1115 recommend the use of cement evaluation tools to evaluate integrity of cement outside casing. ODNR regulations require use of a cement bond log or other log required by the chief to verify cement coverage outside production casing. The permit application states that a cement bond log will be run outside casing strings to verify cement integrity.	Addressed in permit applications. ODNR states that a cement bond log shall be run after the cementing of the 20-inch casing and the 13- 3/8-inch casing. The cement bond log tool, at a minimum, shall be centralized and consist of a combination of an amplitude, variable density log (VDL)-time of travel bond curve.	The Division agrees this is a sufficient response.
Solution Well Mechanical Integrity Testing					X	ODNR regulations require mechanical integrity testing every five years. In its regulations, it is unclear whether ODNR requires mechanical integrity testing at the end of well construction prior to commencement of solution mining. This issue is of direct concern to the general public and thus should be included in the permit submission materials, so the public can have the opportunity to comment during the comment period. ODNR regulations state that, a solution mining well has mechanical integrity if: (1) There is no significant leak in the casing, tubing, or packer: and (2) There is no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the well-bore." One of the following methods shall be used to evaluate the absence of significant leaks in casing, tubing, or a packer: (1) monitoring of annulus pressure; or (2) pressure test with liquid or gas; or (3) a freshwater-brine interface test. One of the following methods may be used to detect fluid movement adjacent to the wellbore; (1) results of a temperature, noise, or cement bond log, (2) when solution well preclude the use of logs, use of cementing records demonstrating the presence of adequate cement to prevent fluid migration, and (3) if cementing records are used to evaluate fluid movement adjacent to the borehole procedures applicable to section 1501:9-7-09 for operation, monitoring, reporting, and recordkeeping are to be utilized.	Insufficient response. The ODNR states that each cemented casing shall be pressure tested in accordance with Ohio Adm.Code 1501:9-1-08(D)(3)(b) or pressure tested to at least 500 psi for 15 minutes with not more than 5% decline in pressure, whichever is at a greater pressure. The maximum operating pressure during solution mining specified in	The proposed solution mining wells will be pressure tested during construction. During the construction of a solution mining well, each cemented casing string over 200 feet must be pressure tested to ensure that compressive strength of the cement has reached the required 500 psi and there are no leaks within the casing. OAC 1501:9-1-08(D)(3)(b) requires the pressure tested to at least 500 psi for 15 minutes with not more than five percent decline in pressure, whichever is at a greater pressure. OAC 1501:9-7-10 specifies how each solution mining well must demonstrate mechanical integrity and the frequency of the test.

Casing Seat Integrity Test	X		X			API RP 1170 and 1115 recommend that a casing seat integrity test be conducted after drilling and well completion but before solution mining. The test should be run at maximum allowable operating pressure (MAOP) and conducted with nitrogen or other nonmiscible gases or fluids. The permit application does not include a casing seat integrity test prior to solution mining.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. OAC 1501:9-1-08(D)(3) requires pressure testing of cemented casing over 200 feet in length. The test procedures are specified in OAC 1501:9-1-08(D)(3).
Solution Mining Operations								
Solution Model		X		X		API RP 1170 and 1115 stipulate the use of a solution mining model for the design and during the development of at least the first cavern. The solution mining model should be used to predict the geometries of the cavern shape during the phases of cavern development. A solution mining model should also be used to determine if and when cavern workovers may be required to shift the setting depths of the hanging strings to create the desired cavern shape. As stated in API RP 2270 and 1115, the solution mining model should	No Response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
						be seen as a starting point for cavern development. Once solution mining starts, comparisons should be made to actual mining results. PSC should submit the results of solution modeling to support permit applications.		
Cavern Neck	X		X			As stated in API 1170 and 1115, the distance from the bottom of cemented casing to the cavern roof should be sufficient to prevent roof strains from affecting the integrity of the cemented casing and casing connections. Proper design of the uncased wellbore section and the cavern roof mitigates the stress and creep strain placed on the casing salt and casing connections, reducing the risk of casing damage or loss of integrity in the cement bond at the casing seat. API RP 1170 and 1115 recommend that the cavern neck (casing seat to cavern roof) be greater than one-half the diameter of the predicted, fully developed cavern. There is no description of the design of the cavern neck in permit applications. The operator should provide the ODNR with a description of proposed cavern necks.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Cavern Roof and Blanket Monitoring		X		X		A salt roof must be left between the cavern top and the overburden to prevent weathering of the overburden (Bèrest 2017). As stated in API RP 1170 and 1115, during solution mining, it is critical that the roof of a cavern is prevented from dissolving (and thus compromising cavern stability) by placing and floating a blanket material which does not dissolve salt. After the roof is developed, API RP 1170 and 1115 stipulate that the blanket-water interface be periodically monitored with an interface log or similar method. During cavern excavation, the volume of the blanket is increased or decreased to help shape the cavity and prevent uncontrolled dissolution at the top of the cavern potentially leading to caverns having a much wider top than base which is structurally undesirable. Regulatory agencies generally now require that an adequate salt roof be maintained above caverns with downhole wireline logging (e.g. sonar) to periodically check the shape and sizes of caverns (Warren 2016). The permit applications indicate that a nitrogen blanket will be used to protect cavern roofs but there is no discussion of blanket	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. A second operational permit will address cavern boundary verification requirements by requiring the operator to annually determine the boundaries of the solution mined caverns and voids associated with all three solution mining wells.

Cavern Shape Monitoring		X		X		The presence of non-salt interlayers greatly increases the difficulty of cavern construction. Because of vertical and lateral stratigraphic variability in bedded salt deposits, it is difficult to construct caverns with regular shapes (Liu et al. 2020a, b) resulting in less reliable product storage compared to salt domes common along the Gulf Coast (Warren 2016). The most stable cavern shape for product storage resembles a giant carrot or cucumber embedded deep in a mass of salt. This ideal shape is impossible in bedded salt (Warren 2016). If a cavern has an irregular shape, stress concentrations and large deformations may appear in the wall rock which greatly increase the probability of failure necessitating more rigorous monitoring compared to	Sufficient response. ODNR states that beginning one year after commencement of solution mining operations and on or before December 1 every other year thereafter, Powhatan Salt Company LLC (Powhatan Salt) shall determine the boundaries of the solution mined caverns and voids associated	The Division agrees this is a sufficient response.
						salt domes (Liu et al. 2020a). In order to reduce the deformation of the wall rock, the roof of caverns must be designed as an arch (Liu et al. 2020a). Most solution-mined salt cavern collapses have been caused by roof instability and have resulted in subsequent brine leakage (Liu et al. 2020a). API RP 1170 and 1115 stipulate the use of periodic interface logs, such as sonar surveys to be performed to confirm the desired shape and volume of caverns during solution mining. Logically, a sonar survey should be performed at the end of solution mining. Maximum stability is achieved with a spherical cavern. However, an inverted cone shape with an arched roof is generally considered an acceptable alternative. Sonar surveys are not included in permit applications. Sonar surveys are critical in evaluating the shape of caverns during solution mining and should be included as a requirement in permit applications. Sonar surveys should be included with permit materials to monitor cavern geometry and eliminate possible subsidence risks.	ODNR states that Powhatan Salt shall submit a report, on or before December 1 each year the report is required, to the Division showing the boundaries of the solution mined caverns and voids associated with the Powhatan Salt Company	
Pillar Distance	X		X			API RP 1170 and 1115 recommend that a P:D ratio greater than 1:1 where P equals the distance between two cavern boundaries and D equals the average of the maximum diameter of the two caverns. As stated in API RP 1170 and 1115, industry experience has shown that pillar widths of two to three times the average maximum diameter of adjacent caverns have satisfied mechanical modeling evaluations to determine safe cavern spacing for given pressure and operating scenarios. During the initial application process, there was concern of potential cavern interference between the proposed PSC caverns and existing caverns of the Westlake Facility in West Virginia. A conservative estimate of the long axis of caverns at the Westlake facility is 12,000 feet placing the northern extent of the cavity 1300 feet northwest of the northern most well (Eyermann 2017). The average width of the combined Field 1 and 3 caverns at the Westlake Facility is ~860 feet. The current distance between the Westlake caverns and the proposed PSC caverns is 11,600 feet with the Westlake caverns moving northward toward the PSC caverns at a rate ~ 16	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.

						concern is pillar spacing between caverns at the PSC facility itself. The permit applications do not include a discussion of planned P:D ratios or pillar space at all. Eyermann (2017) states that the average diameter of caverns at the PSC facility will be 300 feet. Hence, there must be a least 300 feet but preferably 600 to 900 feet of spacing between caverns. Using an approximate (mapping in ArcGIS) cavern diameter of 300 feet, it appears that spacing between neighboring caverns will be approximately 160 to 180 feet (P:D ratios of 0.53 and 0.60, respectively) (Figure 9). Thus, from this estimation, pillar distances between salt cavern 1 and salt cavern 2 and salt cavern 2 and salt cavern 3 do not appear to be sufficient. As such, information on anticipated pillar distances should be provided to the ODNR. If possible, geomechanical modeling should be used to determine adequate salt thickness		
Separation Distance	X		X			API RP 1170 and 1115 recommend a S:D ratio greater than 2:1 where S equals the separation distance between the centers of two adjacent caverns and D equals the average of the maximum diameter of the two caverns. According to the permit materials, the distance between the centers of salt cavern 1 and salt cavern 2 and salt cavern 2 and salt cavern 3 appear to be 778 and 769 feet, respectively using ArcGIS. Thus, the S:D ratios for these caverns (~2.6) appear to satisfy the recommendations of API RP 1170 and 1115. However, permit applications do not include a discussion of S:D	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Source Water and Brine Monitoring		X		X		API RP 1170 and 1115 stipulate that the operator to measure the rate and salinity of water entering and brine leaving the cavern. This facilitates calculation of the volume and efficiency of the solution-mining process source water and resultant brine enables estimation of cavern growth. The brine should be checked for minerals, including the percentage of NaCL, KCL, and $MgCl_2$. Higher solubility salts KCl and $MgCl_2$ can undercut upper strata and cause strain or collapse. Permit applications indicate the water used for debrining will be sampled and analyzed quarterly. Brine will be sampled twice per day for specific gravity. The daily brine samples will be consolidated for more detailed chemical analysis on a monthly basis. In the permit applications, chemical analysis is presented for the source water which is the Ohio River, however the data presented generates both concerns and questions. Specifically, the concentration of arsenic is provided as 100 ppm (mg/L). This arsenic concentration is several orders of magnitude higher than nearby water quality measurements made by the U.S. Geological Survey. Measurements made at a station on the Ohio River (site number 395516080451501) on November 7, 2019 indicate an arsenic concentration of 0.46 ppb (µg/L). Hence, it is highly unlikely that the Ohio River has arsenic concentrations at 100 mg/L. If the units of this concentration were misreported as ppm, with the measured concentration being 100 ppb (µg/L) instead of 100 ppm, this concentration would still be exceeding high. This appears to be an example of sloppy reporting. Other elements are given in concentrations of GPL (grams per liter, grains per liter?). Grains per liter is a	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. OAC 1501:9-7-09(B)(1) requires a representative sample of injected fluid on a quarterly basis to be taken. OAC 1501:9-7-09(C)(3) requires the volume relationship or withdrawal-injection ratios to be reported annually.
						measure of hardness. PSC should resubmit a table summarizing the quality of water that will be used for solution mining.		
Average and Maximum Injection Pressures					X	The ODNR requires specification of average and maximum injection pressures. The operator specified average and maximum pressures of 950 and 1150 psig, respectively. Are these pressures at the casing shoe or the surface? During solution mining there will likely be significant frictional head loss associated with movement down casing.	No response	OAC 1501:9-7-07(G)(4)(b)(ii) requires the average and maximum injection pressure. The Division considers the propose pressure in the application documents to be surface pressure, not down hole pressure.

Manifold Monitoring					X	ODNR regulations state that "solution mining projects may be monitored on a field or project basis, rather than an individual well basis, by manifold monitoring when such projects consist of more than one injection well, operating with a common manifold." It is unclear from the permit application packages whether injection at three solution mining wells will occur from a common manifold. Monitoring the solution mining process from a common manifold is incompatible with the rigor required for solution mining for utilization of NGL storage and at least for cavern roof and blanket monitoring is incompatible with requirements in API RP 1170 and 1115. PSC should make it clear in their applications that caverns will be monitored on an	No response	OAC 1501:9-7-07 (G)(4)(b)(i) requires "the average and maximum daily rate and volume of fluid to be injected per well or per project when a manifold system is used." The Division requested Powhatan Salt Company LLC to disclose if each well was individually manifolded or commonly manifolded. The Powhatan Salt Company stated that the wells will be individually manifolded. The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Workover Prior to Natural Gas Liquid Storage								
Inspection of Production Casing		X		X		API RP 1170 and 1115 stipulate inspection of production casing prior to natural gas or NGL storage. Wireline logs should be run that measure wall thickness, ovality, and internal/external anomalies. Since permit applications do not consider storage of product, permit applications do not include a discussion of a workover to configure the cavern for product storage including inspection of production casing. There does not appear to be another time when this would take place, creating an unacceptable regulatory void that could jeopardize public health	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Full-Cavern Sonar Survey		X		X		API RP 1170 and 1115 stipulate running a full-cavern sonar survey to make a final verification of cavern geometries (shape, size, depths) and to ensure that there are no spatial features that could limit cavern storage. Since permit applications do not consider storage of product, the permit applications do not include full-cavern surveys prior to NGL storage. Again, there does not appear to be another time when this would take place, creating an unacceptable regulatory void that could jeopardize public health and safety	Sufficient response. ODNR states that beginning one year after commenceme nt of solution mining operations and on or before December 1 every other year thereafter,	The Division agrees this is a sufficient response.
							Company LLC wells and describe the details of how the boundary determination s were made. Before determining the boundaries, Powhatan Salt shall submit in writing to, and obtain the approval of, the Division the method used to determine the boundaries. In addition, Powhatan Salt shall submit any documents necessary to substantiate the owner's legal right to	

Brine Strings		X		X		API RP 1170 and 1115 stipulate that brine strings of unknown quality cannot be used. The brine string should be new pipe with complete documentation. The use of new pipe for brine strings is not specified in permit applications. ODNR should require documentation demonstrating that new pipe will be used.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Cavern MIT		X		X		API RP 1170 and 1115 stipulate that a cavern mechanical integrity test (MIT) be performed prior to being put in service. The test may be a nitrogen/brine interface test or an alternative equivalent test. ODNR regulations discuss requirements for MIT testing on well casing, not caverns, every five years. Since permit applications do not consider storage of product, a cavern MIT is not included in the permit applications. Again, there does not appear to be another time when this would take place, creating an unacceptable regulatory void that could jeopardize public health	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Operation								
Operating Flows for Product Storage					X	As in the CEC 2018 report, the site is planned to provide approximately 2 million barrels (bbls) of baseline storage capacity, with at least 25,000 bbls per day of load-in and load-out. Each storage well will have the capacity to separately store a minimum of 300,000 bbls.	Insufficient response. This information is presented in a support document not submitted in permit application packages. Verification of operating flows and product storage volumes should be required by the ODNR.	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Operating Pressures for Product Storage		X			X	API RP 1170 and 1115 stipulate conversion of maximum and minimum operating pressures at the casing to the wellhead due to frictional head loss during operation. ODNR regulations require injection pressure and flow rate to be monitored on a semi-monthly basis unless daily metering of injected fluids is monitored. In the permit applications, it is stated that brine production and water injection volumes, flow rates and pressures will be recorded continuously in the control room. However, there is no description	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
						of pressure and flow monitoring frequency or methodology of natural gas liquids in the permit application. This is a fundamental public safety consideration. Operating pressures for NGL storage should be specified in permit applications.		
Analysis of Injected Fluids					X	ODNR regulations require specification of the “nature” of the injected fluid. ODNR states that the nature of injected fluids must be monitored quarterly to yield representative data. ODNR also requires qualitative analysis and ranges in concentrations of all constituents of injected fluids unless the applicant requests confidentiality. Sample analysis of water to be used for debrining has been provided. There are no plans in the permit application for sampling or analysis of natural gas liquids to be injected.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.

ESD Equipment and Procedures		X		X		Due to reduced compressibility but relatively low density of NGLs and immiscibility with water, caverns are operated by a brine compensation mechanism. As brine is injected through a central tube at the bottom of the cavern, an equivalent volume of produce is withdrawn through the annular space between the steel cemented casing and a central brine tube. For storage of NGLs, failure of an emergency shutdown (ESD) value would result in expulsion of NGLs in a liquid form. This liquid would evaporate on the ground surface and form a gas cloud denser than air. Accidental ignition of this gas would then result in an explosion as was the case in Brenham, Texas in 1992 killing 3 and injuring 21 people. This accident prompted the Texas Railroad Commission to mandate that NGL storage cavities by protected by a least two overfill detection and automatic shut-in methods (Warren 2016). API RP 115 stipulates that each outlet must have an emergency shutdown (ESD) valve (fail-close) installed adjacent to manual valves (wing valves). Each cavern must have an ESD system installed to isolate a	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Overpressure Monitoring	X		X			API RP 1170 and 1115 recommend that the pressure in a cavern be monitored at all times to ensure that the production casing shoe maximum pressure is not exceeded. Continuous pressure measurement during NGL storage is not outlined in the permit application.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Bradenhead Monitoring	X		X			API RP 1170 and 1115 recommend that the cemented annulus between production casing and the next cemented casing should be monitored for pressure. Pressure increases could indicate a leak in production casing or a micro-annulus leak through cement from a cavern. Bradenhead monitoring should be standard in any NGL or gas storage operation and is not included in the permit	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
Contingency for Flooding						As illustrated in Figure 5, all 3 salt solution mining wells are within a 100- year floodplain. The operator needs to specify what contingencies are necessary in the event of flooding.	No response	None of the proposed wells are to be located within a 100-year floodplain. Any development that may occur within a floodplain would need to comply with the applicable floodplain requirements in effect.
Cavern Integrity Monitoring								
Cavern Integrity Monitoring Program		X		X		API 1170, 1171, and 1115 require that the integrity of the well and salt cavern system must be maintained and monitored. Once in operation and throughout its life, a cavern system must be monitored to ensure functional integrity. There must be a formal written integrity monitoring program that must contain, at a minimum, the following components: (1) identification of cavern system components to be monitored; (2) monitoring methods specifying the type of method and frequency of application; (3) cavern volume and growth monitoring; (4) analysis of data from inspections, reporting, and archiving of results; (5) periodic reviews of the monitoring program for effectiveness; and (6) subsidence monitoring. The permit application does not contain a formal written integrity monitoring program. This is absolutely critical for safe operation of NGL storage. PSC must include a cavern integrity monitoring program in permit applications or describe when a cavern integrity monitoring program will be	No Response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.

Cavern Shape Monitoring		X		X		API 1170, 1171, and 1115 require cavern shape monitoring. This is especially important for NGL storage. Brine pumped into a cavern to compensate for displaced product must be less than saturated with respect to halite. While this prevents salt crystallization in access casing, it also leaches additional salt from cavern walls. Hence, regular product cycling using brine compensation increases the size of salt caverns necessitating the need for continual monitoring of cavern shape throughout the life of a facility (Warren 2016). Salt creep appears to be less critical for NGL storage compared to gas storage so volume loss over time is less of a concern (Warren 2016). Salt acts like a non-Newtonian fluid that will flow in response to deviatoric stress (Habibi, 2019). Some older salt caverns in the USA and Canada are now twice as large as when they were first filled due to brine compensation (Warren 2016). Uncontrolled enlargement of a storage cavern can evolve into a stability problem as the retreating salt roof and walls are increasingly susceptible to sloughing, caving, fusion, and associated damage to long string casing. As a result of numerous collapses, the State of Kansas now requires caverns created by solution wells to be acoustically monitored and a salt roof of at least 40 feet to be maintained (Warren 2016). Cavern expansion has led to accidents as some NGL storage facilities such as at Mineola, Texas in 1995. A subsurface blowout occurred when a salt wall separating two storage caverns storing propane had become so thin from enlargement due to brine compensation and product cycling that it cracked (Warren 2016). Pressure buildup led to a casing leak with escape of propane through soil as far as 100 feet from the well which ignited requiring an innovative well technique to	No response. The ODNR has now mandated cavern shape monitoring during and after solution mining but they do not directly specify the lifespan of this monitoring, and if it will continue during NGL storage operation.	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations.
						Railroad Commission to require an "acceptable" degree of enlargement prior to abandonment of a salt storage cavern (Warren 2016). PSC must include a cavern shape monitoring program in permit applications or describe when a cavern shape monitoring plan will be provided to the ODNR.		
Subsidence Monitoring		X			X	Some degree of subsidence of the land surface above a cavern is expected. From a storage perspective, subsidence is not a problem unless the roof span breaches and the rate of subsidence increases (Warren 2016). Responsible operators now conduct periodic or continuous subsidence monitoring to determine the rate of subsidence (Warren 2016). Automated subsidence monitoring is justified when there is a significant risk of environmental or property damage or when facilities are in close proximity to pipelines and other infrastructure (Warren 2016) as is the case here. ODNR regulations require a "brief description of existing or proposed monument grids and surveying method to be used in obtaining yearly measurements of second order accuracy for the detection of ground surface movement." ODNR requires that the permit applicant "describe monument types, construction,	Addressed in permit applications.	The Division agrees this is a sufficient response.
Groundwater Monitoring								
Installation of Monitoring Wells					X	The ODNR requires submittal of plans for meeting monitoring requirements for an USDW. The ODNR also requires installation of monitoring wells outside the physical influence of subsidence or potential catastrophic collapse. Since the installation of caverns will result in some level of subsidence at the ground surface, this should trigger a requirement for the installation of monitoring wells. Seven groundwater monitoring wells are installed along the southeast side of the proposed impoundment to store brine between March 21-27, 2018. While there is a mention of several observation wells that will be drilled by an affiliate in the future, no specific plan for monitoring USDWs at this facility is included in the permit applications. These monitoring wells are specific to the facility and separate from monitoring wells that will be installed to monitor impoundments. PSC should include a plan for monitoring well installation in permit applications.	No response	The Division does not have authority to regulate the underground storage of natural gas liquids, that authority rests with the Pipeline and Hazardous Materials Safety Administration. API recommendations pertain to the underground storage of natural gas liquids and are part of the federal, not state regulations. However, OAC 1501:9-7-08(A)(11) requires the applicant to install monitoring wells when the injection wells penetrate an underground source of drinking water in an area subject to subsidence or catastrophic collapse.