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Expert Report on Proposed Revisions to Pit Rule

By J. Daniel Arthur, PE, SPEC

About the Author

Mr. Arthur is a registered professional petroleum engineer specializing in fossil energy, planning/engineering analysis, and environmental issues. He has over 25 years of diverse experience that includes work in industry, government and consulting. Mr. Arthur's experience includes serving as an enforcement officer and National Expert for the U.S. Environmental Protection Agency (EPA); a drilling and operations engineer with an independent oil producer; and as an engineer with an oilfield service company in the mid-continent. Mr. Arthur is a recognized expert in the areas of oilfield waste management and environmental law/regulations.

Introduction

The following assessment is based on professional experience in dealing with oil field waste and pit-related issues for over 25 years. As the construction and materials used in the construction of pits have evolved, so have pit rules. Operators and regulators have become more conscious of the potential impacts to precious water resources. As such, both are working to ensure practices related to the use of temporary pits are modernized in order to minimize impacts to the environment effectively while still being sufficiently capable of performing the necessary tasks for well-related activities. The following report looks at the historic use and design of pits, some statistics on pit incidents, revisions to the New Mexico Pit Rules, a comparison of the NM rules to those of other states, and also provides an analysis of whether the proposed revisions to the Pit Rules will be protective of public health, and the environment.

History of Pits for Oil and Gas Operations

The oil and gas industry has used pits to hold wastes from drilling and production operations from the time the first oil and gas wells were drilled to present day. The use of excavated pits is the most common manner in which drilling and workover fluids are stored today.[1] In their earliest uses, oil and gas pits were simple dug holes in which fluids were stored with no care for the loss of fluids through infiltration or overflow. Early drilling wastes were disposed of via land spreading or road spreading or were simply buried onsite.[2]

The use and regulation of pits have changed considerably since the early days of oil and gas development. A growing awareness of the potential impacts to the environment resulting from historic disposal practices in the 1970s resulted in some of the earliest regulation of oil field waste disposal. By the early 1990s the federal government had decided that the state oil and gas agencies were capable of sufficiently managing the regulation of drilling waste disposal.[3] During this time, pit regulations began to develop, along with some of the fundamental principles related to siting and construction requirements. The rules have become more restrictive to limit infiltration of waste fluids into the sub-surface and ensure that on-site burial of pit materials results in minimal impact.

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Comparison of Incidents from Modern Pits to Old Pits

Information related to the number of leaking pit incidents in New Mexico has been gathered by industry groups since the 2007 hearing on pit rule revisions. The New Mexico Industry Committee (a consortium of oil and gas operating companies) has issued a summary related to the number of leaking pit incidents in New Mexico as of the end of 2007.[4] From this presentation the following data was detailed:

- New Mexico Oil Conservation Division (NMOCD) reported between 80,000 and 100,000 pits have been constructed in New Mexico.
- NMOCD has identified between 400 and 500 "pits" that have caused some impact to groundwater (this includes all "pits," not just the temporary reserve pits being addressed by the current proposed revisions to Rule 17).
- Using the high value of 500 pits, less than 0.5% of all pits have been suspected of causing groundwater problems. This number includes historic pits constructed when pits were allowed to be unlined. These means 99.5% of the pits constructed in New Mexico have not been suspected of causing contamination when less stringent standards were in place.
- As of 2007, of the 500 pits suspect of causing some impact to groundwater, only 10 were temporary reserve pits (0.0125% of all the pits constructed in New Mexico). This means 99.98% of temporary pits are not suspected of causing contamination. An assessment of data available since the 2007 study conducted as part of this testimony identified an additional 4 to 8 reserve pits that may have leaked some fluids (between 0.014% and 0.018% of all pits).
- Of the 10 pits identified in 2007, none of the "suspected" incidents were identified as having been post-closure incidents (i.e., the cause was not the closing of the pits but some failure during their operational use of the pit which was mitigated prior to the closure of the pit).
- These 10 temporary pits were constructed using less stringent standards than what is in the current and proposed Rule 17. The liners consisted of 12-mil thick liners with sewn seams, not the 20-mil thick string-reinforced low density polyethylene (LDPE)-sealed liners proposed in the current and proposed regulations.

Joining the Seam of a Synthetic Liner

Source: Ground Water Protection Council (GWPC), "State Oil and Natural Gas Regulations Designed to Protect Water Resources."

Based on experience with pits and liners in other areas of the country, the new liners are stronger, with the seams heat-sealed in a process that effectively "welds" the two pieces of liner into a single stronger (and thicker) bonded piece. Past experience observing problems with lined pits shows that sewn liners, and more specifically the seams of these sewn liners, were often points of failure. Modern, heat-bonded liners are stronger and less likely to separate at the seams than the old-style sewn liners, and are often internally reinforced to resist puncture or tearing due to stretching of the material.

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Review of Pit Related Incident Statistics

Analysis of the pits completed since between 2005 and 2007 was performed to assess the effect of the implementation of the NMOCD rules requiring operators to perform a leakage assessment below their pits. The operators were required to check for leakage below the temporary pits if brine was used to drill the well and the distance to the water table was less than 50 ft below the pit. Over this 3-year period 5,763 wells were reportedly spud (this total was determined from the reported spud date in the NMOCD database). Using calculated data from a select sample of these 5,763 wells, it has been determined that an estimated 95% of these wells (or 5,450 wells) were drilled with temporary pits instead of closed loop drilling systems. According to a a November 2008 NMOCD list of "Pits with Ground Water Contamination"" there were 6 wells with temporary pits spudded between 2005 and 2007 that exhibited some form of impact to groundwater. These 6 pits represent approximately 0.11% of the pits used during this time. Thus 99.89% of the pits were constructed and utilized successfully with no contamination.

Exhibit 1 provides details from investigation or closure reports at 13 temporary pits in which releases of fluids occurred, including the 6 pits that were utilized between 2005 and 2007. The table identifies the age of the pit, the type of liner when known, the contaminants detected (chlorides, typically), concentrations of the contaminants, depth to groundwater, and any soil contamination that was detected. Review of the data included in the closure reports for these temporary pits reveals that when chloride impacts do occur below these pits the impacts are highly localized occurring within shallower intervals than the groundwater resources which are located an average of 55 feet below ground surface. Review of this data also shows that none of these pits have nor would be expected to cause groundwater quality to exceed NM standards at place of present use or reasonably foreseeable future use. For 10 of the 13 pits, the impacts were detected prior to the closure of the pit and therefore would have been required to be cleaned up prior to closure under the current Rule 17 and the proposed revisions. A review of the age of these pits indicates the pits were constructed using 12-mil sewn liners, which are not as protective as the 20-mil welded liners proposed in the revised Rule 17.

The historic review of pits shows that unregulated, unlined pits used historically in New Mexico had an estimated 99.5% rate of not being suspected of causing contamination. Since 2005 when the first regulations for pits came in this rate increased to 99.89% of pits not being suspected of causing contamination. In 2007 the rules were substantially strengthened, and the proposed revisions maintain the strength in the regulation of pits. It is the opinion of the author based on the analysis shown here and previous professional experience that the revised requirements in the proposed Rule 17 would have been sufficient to identify the issues at these historic pits to facilitate the necessary mitigation.

General Discussion of Revised Rules for Temporary Pits

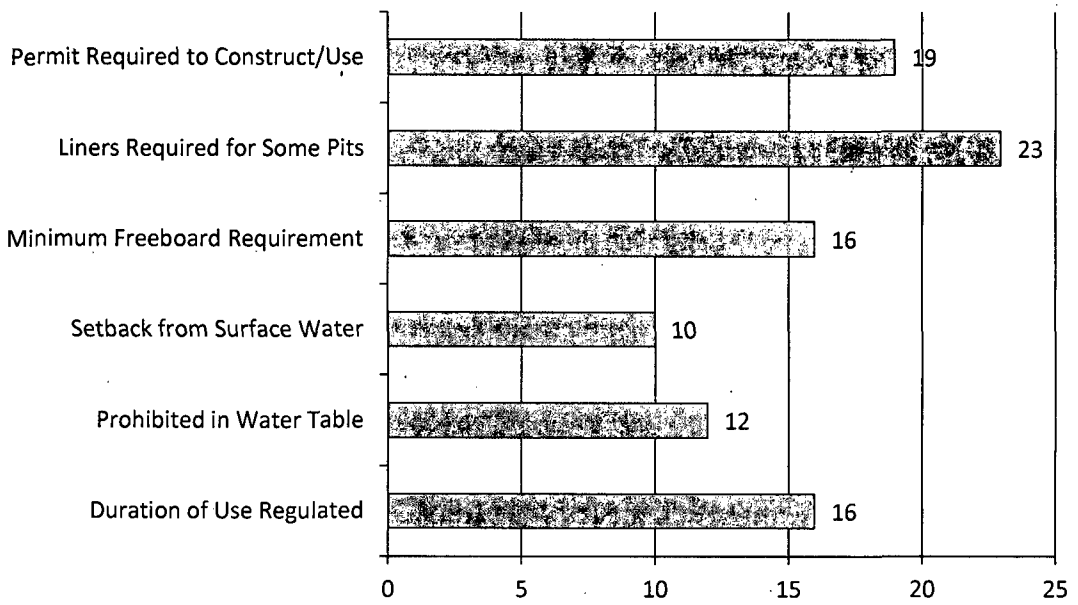
Modern-day pit regulations protect groundwater and surface water resources by preventing the migration of fluids from the pits to these water resources. These regulations need to ensure the prevention of spills and overland releases, prevent direct contact with pit contents, prevent punctures and leaks in the liner during the operation and closure phases. In the post closure phase the regulations need to prevent erosion and exposure of pit contents, and prevent the leaching of liquids from within the pit. The GWPC report prepared for the DOE identified six key elements to the regulation of pits for the protection of aquatic resources. These include the following: authorization for the construction and use of pits, liners for the bottom of pits, minimum freeboard requirements, duration of use, and setbacks from surface and groundwater

Exhibit 1: Summary of 13 Temporary Pits Identified as Having Liners That Leaked

Site	Identifier	Pit Constructed	Liner	Year of Occurrence
Samson BD-04[5,6,7]	1RP-474	2004	Not identified[1]	2005; Prior to closure
Apache NEDU 527[8]	AP-68	2006	Yes[1]	2006; Prior to closure
Pride South Four Lakes #14[9]	AP-77	Not reported	Not identified	Unknown
Samson Livestock[10]	AP-62	2003-2004	20 mil plastic	2005; Prior to closure
Pride State X1 Pit[11]	AP-79	1957-1958: original 2005-2006: re-entry	Not identified[1]	2007; Prior to closure
Yates QE 13 #1[12]	AP-80	1986: original 2005: re-entry	1986: possible synthetic liner; 2005: 12 mil with sewn seams	2008; Prior to closure
Mallon Drake 16 State #1[13]	AP-70	2006	Not identified[1]	2006; Prior to closure
Chevron Mark Owen #9 Reserve Pit[14]	AP-56	2006	Not identified[1]	2006; Prior to closure
St. Mary Hopi Federal #2 Reserve Pit[15]	AP-95	2008	Not identified[1]	2008; Prior to closure
Chesapeake Williams 14 Federal #1[16]	1R-485	2004-2005	Not identified[1]	2007; Post closure
Chevron Mark #13 Drill Pit[17]	AP-81	2005-2006	12 mil polyethylene	2006; Prior to closure
Marbob Scratch State Com #1[18]	AP-94	2005	Plastic liner[1]	2007; Prior to closure
Chesapeake Herradura #3[19]	AP-61	2002	Yes; details not reported	2006; Post closure
1. Because these pits were constructed after the revision to Rule 17 it is assumed the pits were lined using a 12-mil sewn-seam liner.				

(See **Exhibit 2**).[20] The proposed changes to the New Mexico Oil Conservation Division Rules for Pits, Closed-Loop Systems, Below-Grade Tanks & Sumps (found in Title 19 Chapter 5 Part 17 of the New Mexico Administrative Code) include changes to the Permit or Registration, Application, Siting, Design and Construction, Operational, and Closure, and Site Reclamation requirements which address these six key elements identified by the GWPC.

Exhibit 2: Pit Requirements for Various States



Modified from Ground Water Protection Council (GWPC), "State Oil and Natural Gas Regulations Designed to Protect Water Resources," prepared for the U.S. Department of Energy Office of Fossil Energy, Oil and Natural Gas Program and the National Energy Technology Laboratory, Washington, D.C. (May 2009), 29-30.

Siting Requirements

The proposed rules in Part 17 establish setbacks from potential receptors (groundwater and surface water resources, unstable land conditions, and land uses or past land uses in the case of subsurface mines) designed to protect aquatic resources, public health and prevent uncontrolled discharges to surface water or groundwater. Setbacks from houses remain unchanged in the new regulations. The key aspect of determining the protective nature of any setbacks from aquatic resources consists of understanding the infiltration and overland flow rates for any fluids which escape the pits. Infiltration rates are important for the potential impact of groundwater resources while overland flow rates, which primarily are affected by slope of land surface and vegetative cover, are important for potential impacts to surface water resources. The setbacks proposed prevent immediate release of pit contents to aquatic resources by utilizing the semi-arid climate of the state allowing time for the detection and mitigation of any releases that may occur. The semi-arid climate controls overland releases (surface spills) by high evaporation rates and percolation into unsaturated soils while below ground leaks migrate slowly because of the unsaturated soil conditions.

The climate of New Mexico is arid to semi-arid where soil conditions are dominated by unsaturated flow conditions.[21] Because unsaturated flow conditions exist across much of the

state, salt migration is primarily downward due to water infiltration, except for in areas where frequent flood irrigation is performed. For salts to migrate downward, a differential pressure head coupled with the forces of gravity act to pull the soluble salts downward with the infiltrating fluids. Since salt migration is primarily downward, the proposed siting guidelines establish setbacks from groundwater resources and surface water resources sufficient to offer protections necessary for climate conditions. The setback distances proposed are reflective of a safety factor distance between the bottom of the pit and the depth of groundwater, with lesser setbacks for low chloride drilling mud containing pits.

Review of the data available from previously documented incidents of pit releases demonstrates that these setbacks are sufficient to provide separation of contamination from groundwater and allow detection of leaking pit contents before they could reach surface water resources. The rate of infiltration is sufficiently slow across New Mexico to allow for the detection of fluids seeping from the pit or below-grade tank and to allow remediation efforts to be performed to prevent further discharge to prevent impacts to groundwater. The low precipitation rates and high evaporation rates present in the arid to semi-arid climate provide little hydraulic head to push fluids downward toward groundwater. Furthermore, the semi-arid environment with high evaporation rates will lead to spills ponding and evaporating reducing the risk of surface spills being carried to watercourses, these environmental conditions assist in the cleaned up of surface spills.

The siting requirements for low chloride mud temporary pits and multi-well fluid management pits should be equally protective of groundwater and surface water resources as there would be reduced risk from lower concentrations of chlorides and the shorter duration of contents for the multi-well fluid pits. The same processes which prevent the migration of fluids from a standard temporary pit apply to these other pits, with the lower chloride temporary pits the setback distance can be reduced because the infiltration rates are low and the arid climate reduces the chances of fluids migrating from the pits. Combined with the construction requirements these setback distances should be sufficient to prevent low chloride fluids and multi-well fluids from impacting groundwater and surface water resources.

The setback requirements from surface water bodies prevent direct discharge of pit contents from occurring. The setbacks also reduce the risk of spills that have to flow overland from reaching surface water as unsaturated soils common in a semi-arid environment facilitate the infiltration of fluids, while fluids that settle in low areas are evaporated.

The proposed revisions to siting requirements in Rule 17 provide protections for public health and the environment by:

- Establishing setbacks for percolation or unsaturated zone transport where transport is slow allowing detection and mitigation of any spills,
- Having less restrictive setbacks for low chloride fluids which present lower risks and lesser impacts,
- Allowing tanks which present less risk than pits because leaks are easier to detect and repair,
- Reducing the risk to vunerable unconfined aquifers (confined groundwater is relatively invulnerable) to contamination from leaks, and
- Ensuring protection of domestic and stock watering uses.

Design, and Construction Requirements

Previous professional experience indicates that the proposed Rule 17 provides construction and operational requirements that are more stringent than other states' rules and if properly followed should provide minimum opportunity for leaks from the pit resulting from design, construction, and operational errors. Of particular importance to ensuring the proper design and construction of the temporary pits these are the key points to minimizing incidents) are:

- placement on a "firm, unyielding base, smooth and free of rocks, debris, sharp edges or irregularities" – This approach minimizes the potential for punctures to occur in the liners resulting from sharp edges or the stretching of the liner material due to the failure of uncompacted foundation materials,
- using a slope which places "no undue stress on the liner, consistent with the angle of repose of the base materials" – This approach ensures the sides of the pit are sufficiently constructed to prevent the collapse of the side walls, which could provide a pathway for fluids to migrate outward to the land surface,
- installation of "geomembrane liner consistent of 20-mil string reinforced LLDPE or equivalent....that complies with EPA SW-846 method 9090A" – These modern materials are much stronger and far more resistant to tears and punctures than previous 12-mil liner materials, thus reducing the risk of unregulated discharge through rips or tears,
- the requirement for permanent pits to contain a leak detection system between primary and secondary liners. The leak detection system would allow sufficient time given the setbacks to detect releases before the fluids reach surface water.
- the minimization of "liner seams and orientation of the seams up and down instead of across the slope...overlap liner seams by four to six inches and orient seams parallel to the line of maximum slope...minimize the number of seams in corners and irregularly shaped areas" – These approaches are intended to minimize the stress placed on the seams and reduce the chance of stress causing damage to the seam areas and causing leaks.[a]

The lifespan of the synthetic liners varies based on the exposure to sunlight, temperatures and chemical exposure, but average lifespans for liners have been estimated to range between 100 yrs and 700 yrs.[22] Prior to the expiration by degradation of liners, tears or punctures are common forms of failures. While these should be reduced by the requirements of Rule 17 may still occur. Impacts from tears or punctures are reduced however by the presence of the bentonite clays used in the drilling muds which are present in the pits. Data collected at temporary pits in Texas demonstrate the presence of drilling mud clays acted to seal pit bottoms preventing the percolation of pit contents.[23] Follow up analysis in the Texas study showed the muds in the pit contents provided a sufficient barrier to the prevent the migration of most soluble contents with only bicarbonate, sulfate and sodium remaining mobile through the pit bottoms with the flux control by the hydraulic head inside the pit.[24] The combined protections provided by the use of thicker 20-mil LLDPE liners proposed in Rule 17 and bentonite containing drilling muds should provide reduced opportunities for pit contents to migrate to groundwater.

The protective features of these synthetic liners and bentonite containing drilling muds should be equally effective in preventing the migration of fluids from low chloride mud pits and multi-well fluid management pits. The pit liners are designed to be chemical resistant, while the liners would likely have reduced resistant if certain chemical compounds were present in their pure

[a] This is not to say that other aspects of the rule are not important, but based on previous observations in the author's experience reducing the stresses placed on seams and reducing bunching of the liner material results in longer life with fewer leaks.

form, chemical additives used in fracturing fluids are highly diluted.[25] As such the chemical resistance of the LLDPE liners should be sufficient to provide the necessary containment for the temporary life of the pits. Multi-well fluid management pits are further equipped with leak detection systems, that should effectively prevent leaks or allow prompt response and mitigation.

The proposed revisions to design and construction requirements in Rule 17 provide protections for public health and the environment by:

- ensuring slopes are stable by assessing the materials being used for construction to ensure the slope does not exceed the angle of repose for pit walls,
- ensuring liners are securely anchored in trenches of sufficient soil depth or into bedrock when soil depth is not sufficient
- by limiting the total size of the temporary pits, which results in a limit in the potential volume of pit contents.

Operational Requirements

Operational requirements in the proposed Rule 17 ensure that the materials present in the pit are capable of minimizing impacts to water resources (by ensuring no hazardous wastes are stored in the pits, inspecting the pit liner at regular intervals to ensure there are no leaks, ensuring there are no foreign materials present in the pit which could puncture the liner, and maintaining the necessary free board to prevent overflow of liquid pit contents). Finally, because Rule 17 allows for 120 days before all fluids must be removed from the surface, considerable evaporation of fresh water can occur, which minimizes the volume of fluids to be disposed of and releases fresh water back into the water cycle that would otherwise be lost by injection of the fluid..

Additionally barriers such as the fencing requirements prevent direct contact with pit contents, while strict maintenance and repair obligations minimize the risk of failures. Inspections and reporting notifications if incidents do occur are sufficient to ensure timely repair and mitigation of spills while keeping the OCD informed. Additionally for below-grade tanks, integrity testing must be performed annually with records kept for five years.

The proposed revisions to design, construction, and operations requirements in Rule 17 provide protections for public health and the environment by:

- reducing the risk of spills from overflowing pits by maintaining free board
- ensuring notifications are filed in a timely manner with OCD for all repairs,
- requiring monthly inspections to ensure no overflow occurs,
- additional days for fluid removal prior to closure, and
- stricter integrity testing including testing for tanks.

Closure and Site Reclamation Requirements

The changes to the closure requirements in proposed Rule 17 are sufficient to ensure impacts to water resources are minimal. According to the modeling analysis presented in 2007 hearings by Daniel B. Stephens and Associates, Inc.,[26] the chloride concentrations presented in Tables I and II in the proposed revisions to Rule 17 are sufficiently protective of groundwater resources. . Permitting six months for closure of the temporary pits allows for evaporation to further reduce liquid content in the materials to be enclosed in the covered onsite burial. Reducing liquid content is important to ensuring there is not a hydraulic head this makes the contents less amenable for future leaching.

The closure and reclamation requirements present in the current and proposed Rule 17 serve to provide protections to human health, groundwater and the environment from volatile organic compounds (like benzene and TPHs), which naturally occur in the cuttings. Volatile organic compounds present in the pit contents will be reduce by evaporation as the fluids are removed and pit contents are exposed to air. After the contents are mixed with fresh soils the concentrations of the compounds would be reduced by simple mixing processes. The placement of the four feet of soil over the buried pits provides additional distance where infiltrating water can be retained or evaporated reducing the potential for a hydraulic head to be developed that would result in benzene, BTEX and TPHs moving downward by convective movement. . If a leak does occur concentrations of benzene and TPH will decrease from dispersion as the fluids migrate towards water, during this migration the compounds will experience some biodegradation. Because of the naturally slow rate of infiltration in unsaturated soils and benzene's short half-life the potential impacts to groundwater are low.

Example of a Synthetic Liner Being Installed

Source: ALL Consulting

Both TPH and benzene can be degraded through aerobic process, with some minor degradation through anaerobic process but with considerably longer half life values than aerobic degradation. For benzene, aerobic half life values averaging 3.3 days was reported in a summary of other benzene degradation studies prepared by the Environmental Science Center for the Environmental Protection Agency.[27] With such a short half life value, much of the benzene that could be present in the pit contents would be lost during the six month period in which the contents of the temporary pit are drying. Additional degradation of benzene would occur upon burial even under anaerobic conditions where half live values of closer to 1,000 days are estimated to exist.[28] Similarly, TPH shows more rapid biodegradation half life values some as low as 8 days in aerobic conditions when compared to anaerobic conditions where half life values exceeding 100 days have been observed.[29] TPH biodegradation half life values are more variable then benzene because of the different types of crude oil, half life values ranging from 5 weeks to 32 weeks were reported by a Chevron Texaco study summarized by the EPA.

The closure criteria proposed in Table I and Table II of the proposed Part 17 rules are sufficient to prevent impacts from benzene, BTEX, TPH and chlorides reaching a place of present or reasonably foreseeable future use of groundwater. Volatilization and aerobic degradation processes would be expected to result in considerable reduction of benzene, BTEX and TPH concentrations during the period where the pits are allowed to remain open prior to the required closure. Additional degradation would be expected to occur as a result of biodegradation after closure which should reduce the concentration of these compounds in the pit contents. Furthermore, review of data from reports on the very few pits that have leaked shows that most of the impacts are highly localized and do not move far from the pit where the release occurred. The volume of fluid migrating from the pits would be expected to be small based on the removal of fluids prior to burial and the time the contents are allowed to dry at the surface. If this fluid were to reach a saturated water zone, the small volume would be diluted by the much larger

volume of saturated groundwater. Overall, the criteria proposed in Table I and Table II would be sufficient to ensure public health, and the environment are protected from impact.

Reclamation Requirements

The changes to reclamation requirements in proposed Rule 17 should provide sufficient protection to minimize impacts to aquatic resources and to overlying soil and vegetation. The use of grading and re-vegetation minimize the risk of erosion of the overlying materials which could lead to exposure of the buried materials. Furthermore, the requirements for placement of soil cover in segregate soil horizons should facilitate not only erosion control but also the re-establishment of vegetation. Reestablishment of vegetation will further reduce infiltration and the possible hydraulic head in a pit by increasing evapotranspiration. As Dr. Buchanan will testify, in most cases evapotranspiration withdrawal exceeds precipitation, leaving no water to add to the hydraulic head.

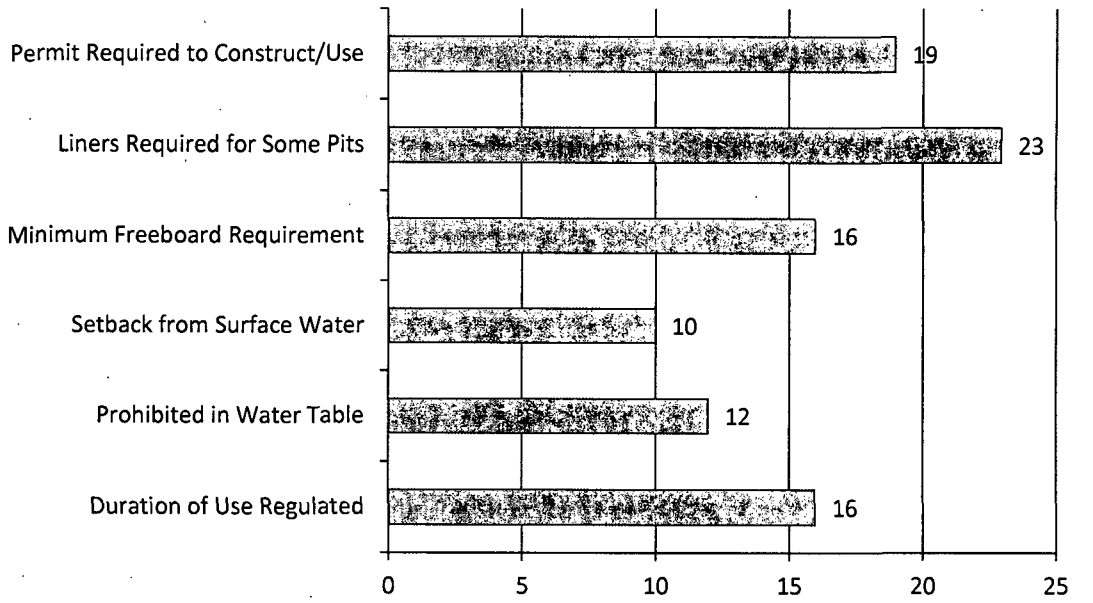
The proposed revisions to reclamation requirements in Rule 17 provide protections for public health and the environment by:

- aiding re-vegetation establishment by using stockpiled soil cover, and
- grading land surface to prevent erosion and exposure of pit contents.

Comparison to Other State Regulations and Guidance

Today state oil and gas regulations detail the requirements that are applied to the use of pits. **Exhibit 2** is summary of pit regulations from the 2009 Ground Water Protection Council (GWPC) report prepared for the Department of Energy (DOE). The bar chart shows the number of states with specific regulations related to different aspects of pit regulation. The chart shows that 23 states require the use of liners for some type of pit, 19 states require some permit authorization to construct a pit, 16 states have minimum freeboard requirements, and 16 states regulate the duration over which a pit may be used.[30] The restrictions placed on pits are intended to prevent the migration of pit fluids into groundwater or to prevent the unauthorized discharge of pit fluids onto the land surface which could eventually reach surface water.

Exhibit 2: Pit Requirements for Various States



Modified from Ground Water Protection Council (GWPC), "State Oil and Natural Gas Regulations Designed to Protect Water Resources," prepared for the U.S. Department of Energy Office of Fossil Energy, Oil and Natural Gas Program and the National Energy Technology Laboratory, Washington, D.C. (May 2009), 29-30.

A comparison of the proposed changes to Rule 17 to six (6) other states (each of which has relatively high levels of oil and gas development occurring) rules shows that the proposed changes are far more detailed. New Mexico's proposed Rule 17 is as protective as or more protective than the rules related to pits in most of these states. **Exhibit 3** shows a comparison of the proposed Rule 17 to the temporary pit regulations in Colorado, Montana, Ohio, Pennsylvania, Texas, and Wyoming.

For many of the rules specified in proposed Rule 17 there are not similar rules specified in the six other states' regulations. None of the other states has the level of setback requirements that are defined in New Mexico. Pennsylvania is the only state that does have some degree of setback requirements but only for situations when the materials are buried onsite. Based on the comparison provided in **Exhibit 3**, the requirement for a 20-mil liner is more protective than most other state requirements, which specify either a 6-mil liner (Ohio) or a liner with a permeability less than 10^{-7} cm/sec (Colorado, Pennsylvania, and Wyoming).

Attachment A includes excerpts from the six states' oil and gas regulations specific to the use of pits.

Summary

Based on previous professional experience, a review of previous expert testimony by Stephens and Hansen from the 2007 hearing on revisions to Rule 17, and the analysis performed for this assessment, it is clear that the proposed revisions to Rule 17 are sufficient to protect groundwater resources. The proposed revisions to Rule 17 provide measures protective of

groundwater resources through the use of permitting and registration requirements, siting requirements (including the use of setbacks), design and construction requirements (including the use of 20-mil liners), operational, closure, and site reclamation requirements. An arid to semi-arid climate like that present across New Mexico is a limiting factor in the potential for contaminant migration out of the temporary pits. In this environment, there is typically minimal infiltration of fluids that could provide a hydraulic head to push fluids downward through the pit bottoms into lower groundwater zones. Research has shown the concentration of contaminants which migrate across a bentonite rich clay bottom of a temporary pit is affected by the hydraulic head driving the liquids present.[31] A dry climate in which little infiltration can percolate down into the temporary pits, where the contents have already been allowed to dry prior to closure should result in minimal hydraulic head to push the liquid contents out of the bottom of the pit.

The proposed changes to Rule 17 are more detailed than the regulations in six other states with levels of oil and gas development equal to or greater than New Mexico. Based on these considerations, I believe, based upon my professional experience, that the Commission can conclude that the Pit Rule regulations, as revised, will be protective of public health, groundwater, and the environment and will be consistent with the requirements of the New Mexico Oil and Gas Act.

Exhibit 3: Comparison of New Mexico Proposed Rule 17 to other State Pit Rules for Temporary Pits

State	Liner Required?	Liner required based on Depth to Water?	Liner Material	Liner Thickness	Liner Seam Type	Freeboard	Disposal	Setbacks
New Mexico	Yes(temporary pit) Fence required.	No pit allowed where unconfined gw is less than 25 ft below the bottom of the pit.	Geomembrane. Geotextiles are required under the liner. Multi-well fluid management pits will use a leak detection system as well.	20-mil reinforced LLDPE. Must comply with EPA SW-846 method 9090A	Use factory welded seams. For field seaming, overlap 4-6 inches. All seems are to be welded.	Prevent run-on of surface water Size shall not exceed 10 acre-ft including freeboard.	No on-site disposal if gw is less than 25 ft deeper than pit.	100 ft from watercourse (low chl) or 300 ft for non low chl. 300 ft from residence 100 ft from well or spring (300 for non low chl) 100/300 ft of wetland
Colorado	Unlined pits may not be constructed on fill material or where pathways for communication with gw are likely. Pits with >15,000ppm chloride concentration or 10,000 ppm TPH must be lined.	NS	Synthetic material Pits requiring a liner must have either a double synthetic liner or a single synthetic liner and a constructed soil liner. Leak detection may be required in sensitive areas.	24 mils	Field seams must be tested.	2 ft	Synthetic liners are to be removed and disposed of as solid waste. Water based fluids may be buried.	NS
Wyoming	Pits constructed in fill or those used to retain oil based drilling muds, high density brines, and/or completion or treating fluids must be lined.	In areas where groundwater is less than 20 feet below the surface, a closed system must be utilized.	Soil liners must be compatible with the contained waste and synthetic liners must have a permeability less than 1x10-7 cm/sec	NS	NS	NS	NS	NS

Exhibit 3: Comparison of New Mexico Proposed Rule 17 to other State Pit Rules for Temporary Pits

State	Liner Required?	Liner required based on Depth to Water?	Liner Material	Liner Thickness	Liner Seam Type	Freeboard	Disposal	Setbacks
Texas	Liner required unless proven that groundwater contamination will not occur.	If it is proven that there is no threat of gw contamination either due to lack of gw under pit or an impervious geologic formation, an unlined pit may be permitted.	NS	NS	NS	NS	Low chloride drilling wastes may be disposed of by landfarming or burial.	NS
Pennsylvania	Yes	NS	Synthetic material with coefficient of permeability of no greater than 1 x 10-7 cm/sec.	liner thickness of at least 30 mil for disposal	NS	2' of freeboard required at all times.	Setbacks for disposal: 200' from building; 100' of stream, water body, or wetland; 200' of water supply.	Setbacks only apply to disposal.
Ohio	A 6-mil synthetic liner may be required in sensitive areas.	NS	NS	A 6-mil synthetic liner may be required in sensitive areas.	Contents should not rise above the level of the ground surface level	NS	Pits may not be used for the ultimate disposal of saltwater or oilfield wastes.	NS
Montana	Liner required for salt- or oil-based drilling fluids.	NS	NS	NS	NS	NS	Salt- or oil-based drilling fluids must be disposed of off-site (unless permission granted by director).	NS

NS = Not Specified

[1] Ground Water Protection Council (GWPC), "State Oil and Natural Gas Regulations Designed to Protect Water Resources," prepared for the U.S. Department of Energy Office of Fossil Energy, Oil and Natural Gas Program and the National Energy Technology Laboratory, Washington, D.C. (May 2009), 29-30.

[2] John A. Viel, "Drilling Waste Management; Past, Present, and Future," SPE paper 77388, presented at the SPE Annual Technical Conference and Exhibitions in San Antonio, Texas, September 29- October 2, 2002.

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