DOE/WIPP-21-2308

Waste Isolation Pilot Plant

Delaware Basin Monitoring Annual Report

September 2021

United States Department of Energy
Carlsbad Field Office

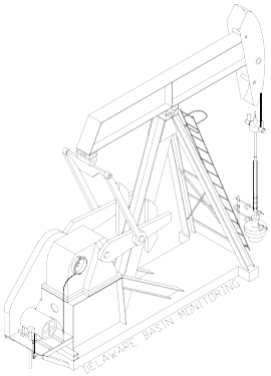
Carlsbad, New Mexico

This document has been submitted as required to:

Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
(865) 576-8401

Additional information about this document may be obtained by calling 1-800-336-9477. Copies may be obtained by contacting the National Technical Information Service, U.S. Department of Commerce, 5301 Shawnee Road, Alexandria, VA 22312.

Delaware Basin Monitoring Annual Report



September 2021

United States Department of Energy
Carlsbad Field Office

Waste Isolation Pilot Plant
Carlsbad, New Mexico

Prepared for
The U.S. Department of Energy by
Nuclear Waste Partnership LLC, Regulatory Environmental Services
Delaware Basin Drilling Surveillance Program

Table of Contents

1.0 Delaware Basin Drilling Surveillance Program 6

2.0 2021 Updates 7

2.1 Miscellaneous Drilling Information 7

2.1.1 Drilling Techniques 8

2.1.2 Drilling Fluids 9

2.1.3 Air Drilling 9

2.2 Shallow Drilling Events 11

2.3 Deep Drilling Events 11

2.4 Past Drilling Rates 12

2.5 Current Drilling Rate 13

2.5.1 Drilling Activities Outside the Nine-Township Area 13

2.6 Castile Brine Encounters 13

2.7 Borehole Permeability Assessment - Plugging Practices 14

2.8 Seismic Activity in the Delaware Basin 16

2.9 Secondary and Tertiary Recovery 16

2.9.1 Nine-Township Injection Wells 17

2.9.2 Nine-Township Salt Water Disposal Wells 17

2.10 Mining 18

2.10.1 Potash Mining 18

2.10.2 Sulfur Extraction 18

2.10.3 Solution Mining 18

2.11 New Drilling Technology 19

2.12 Alternative Energy Activities 19

3.0 Survey of Well Operators for Drilling Information 20

4.0 Summary - 2021 Delaware Basin Drilling Surveillance Program 20

5.0 References 21

List of Figures

Figure 1: WIPP Site, Delaware Basin, and Surrounding Area 23
Figure 2: Typical Well Structure and General Stratigraphy Near the WIPP Site 24
Figure 3: Well Activity within One Mile of the WIPP Site Boundary 25
Figure 4: Typical Borehole Plug Configurations in the Delaware Basin 26
Figure 5: Typical Injection or SWD Well 27
Figure 6: Active Injection and SWD Wells in the Nine-Township Area 28
Figure 7: Potash Areas in the Vicinity of the WIPP Site 29
Figure 8: Active Brine Well Locations in the Delaware Basin 30
Figure 9: Designated Potash Area – R-111-P 31
Figure 10: Wells Used to Determine Plugging Frequency in the 2019 Deferred PA 32

List of Tables

Table 1: Nine-Township Area Casing Sizes 33
Table 2: Nine-Township Area Bit Sizes 33
Table 3: Air-Drilled Wells in the New Mexico Portion of the Delaware Basin 34
Table 4: Shallow Well Status in the Delaware Basin 35
Table 5: Deep Well Status in the Delaware Basin 36
Table 6: Drilling Rates for the Delaware Basin 37
Table 7: Castile Brine Encounters in the Vicinity of the WIPP Site 38
Table 8: Plugged Well Information 40
Table 9: Seismic Activity in the Counties of the Delaware Basin 41
Table 10: Nine-Township Injection and SWD Well Information 42
Table 11: Brine Well Status in the Delaware Basin 44

1.0 DELAWARE BASIN DRILLING SURVEILLANCE PROGRAM

The Delaware Basin Drilling Surveillance Program (DBDSP) is designed to monitor drilling activities in the vicinity of the Waste Isolation Pilot Plant (WIPP) site. This program implements key elements of the U.S. Environmental Protection Agency (EPA) criteria in Title 40 Code of Federal Regulations (CFR) Part 194.33(b)(3) and (c)(1). The EPA Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes are codified in 40 CFR Part 191 (EPA 1993). Subpart B of 40 CFR Part 191 addresses the environmental standards for the disposal of radioactive waste. The standards require the U.S. Department of Energy (DOE) to demonstrate the expected long-term performance of the disposal system using a probabilistic risk assessment or performance assessment (PA). Results of the PA must demonstrate a reasonable expectation that radioactive releases from the WIPP repository will not exceed limits set by the EPA standard. The PA includes the consideration of inadvertent human intrusion into the repository for 10,000 years post-closure. The most severe form of human intrusion into the WIPP repository is deep drilling (greater than or equal to the depth of the repository, i.e., 2,150 feet) for natural resources (U.S. EPA 1996). The DOE concluded in the Compliance Certification Application (CCA), Appendix SCR (U.S. DOE 1996) that shallow drilling could be removed from PA consideration based on low consequence. As a result, the DOE does not include shallow drilling in its PA drilling rate calculations. More detail on shallow drilling can be found in section 2.2.

In 40 CFR Part 194 (EPA 1996), the EPA defined the geographical area for the evaluation of the historical rate of drilling for resources as the Delaware Basin. This same area is used for monitoring mining, drilling, and drilling-related activities. The Delaware Basin is defined in Title 40 CFR §194.2 as:

> "Delaware Basin means those surface and subsurface features which lie inside the boundary formed to the north, east and west of the [WIPP] disposal system, by the innermost edge of the Capitan Reef, and formed, to the south, by a straight line drawn from the southeastern point of the Davis Mountains to the most southwestern point of the Glass Mountains."

The Delaware Basin, depicted in Figure 1, includes all or part of Brewster, Culberson, Jeff Davis, Loving, Pecos, Reeves, Ward, and Winkler counties in west Texas, and portions of Eddy and Lea counties in southeastern New Mexico.

The DBDSP is designed to comply with EPA requirements by monitoring drilling and drilling-related activities in the vicinity of the WIPP site. The DBDSP monitors drilling activities in the Delaware Basin on behalf of DOE in accordance with the criteria established in Title 40 CFR Part 194. Monitoring will continue until the DOE and the EPA mutually agree no further benefit can be gained from continued surveillance. The DBDSP data are used by DOE's scientific advisor to determine if a significant change has occurred which could affect the performance of the disposal system.

The *Delaware Basin Drilling Surveillance Plan* (NWP 2021 places specific emphasis on the nine-township area surrounding the WIPP site, which includes townships 21 through 23 south and ranges 30 through 32 east in southeastern New Mexico. Drilling-related data from the nine-township area are used to augment the information presented in Appendix DATA and Appendix HYDRO Attachment A of the 2019 Compliance Recertification Application (U.S. DOE 2019b). The DBDSP provides data to build on the information presented in the Compliance Certification Application (CCA), Appendix DEL (DOE 1996), the Compliance Recertification Application-2004 (CRA-2004), Appendix DATA (DOE 2004), the CRA-2009, Appendix DATA (DOE 2009), CRA-2014, Appendix DATA-2014 (DOE 2014), and the CRA-2019, Appendix DATA-2019 (DOE 2019).

2.0 2021 UPDATES

The 40 CFR §194.33 standard for a PA requires the consideration of disturbed case scenarios that include intrusions into the repository by inadvertent and intermittent drilling for resources. The DBDSP collects the drilling-related data to be used for PA calculations. The probability of these intrusions is based on a future drilling rate, based on consideration of the record of drilling events in the Delaware Basin for the most recent 100-year period. The DOE models several types of human intrusion scenarios in the PA. These include both single borehole intrusion events and combinations of multiple borehole intrusions.

Two different types of boreholes are considered in the PA: (1) those that penetrate a pressurized brine reservoir in the underlying Castile Formation and (2) those that do not. The presence of pressurized brine under the repository is uncertain. The primary consequence of contacting pressurized brine is the introduction of an additional source of brine beyond that which is assumed to be released into the repository from the Salado Formation. The human intrusion scenarios are based on extensive field data sets collected by the DOE. The data have been continuously collected from the time of the 1996 submittal of the CCA and include specific wells drilled during the last year in the New Mexico portion of the Delaware Basin, specifically the nine-township area immediately surrounding the WIPP site. Data provided in this report covers the period from September 1, 2020, to August 31, 2021. These data are summarized in the following sections.

2.1 MISCELLANEOUS DRILLING INFORMATION

The EPA provided criteria in 40 CFR §194.33(c) to address the consideration of drilling in the PA. Wells used to determine plugging frequency for the 2019 Deferred Performance Assessment are presented in figure 10. These criteria led to the formulation of conceptual models that incorporate the effects of this activity. The conceptual models use parameter values as documented in CCA, Appendix DEL (DOE 1996), such as:

- Drill collar diameter and length
- Casing diameters

- Drill pipe diameter
- Speed of drill string rotation through the Salado Formation
- Penetration rate through the Salado Formation
- Instances of air drilling
- Types of drilling fluids
- Amounts of drilling fluids
- Borehole depths
- Borehole diameters
- Borehole plugs and characteristics
- Instances of encountering pressurized brine in the Castile Formation

The DBDSP data set includes the final borehole depth for wells drilled in the Delaware Basin. Borehole depths range from 2,150 feet to 25,734 feet. The shallowest oil well recorded during the last reporting period is 3,287 feet and the deepest is 25,734 feet. Both oil wells are located outside the nine-township area. The diameter of each well bore is more difficult to ascertain. The DBDSP data set includes the casing size and depth for each section of the hole drilled in the last year within the nine- township area (Table 1). Drill bit size is a reportable element, although hole sizes are reported on Sundry notices (miscellaneous forms) maintained by the New Mexico Oil Conservation Division (NMOCD). Table 2 shows the documented bit sizes used in drilling wells within the nine-township area during the last year. The typical hole and casing sizes in the vicinity of the WIPP site, are shown in Figure 2.

2.1.1 DRILLING TECHNIQUES

The primary drilling techniques reported since the CCA, Appendix DEL is rotary drilling and it is still being implemented by area drillers. However, most hydrocarbon wells currently drilled use horizontal (deviated) drilling techniques for the lower part of the borehole that contacts the targeted zone of production. There were 153 hydrocarbon wells spudded, not necessarily completed, in the New Mexico portion of the Delaware Basin from September 1, 2020, through August 31, 2021. This number is derived from the Delaware Basin Well Tracking Application (DBWTA), a Microsoft® SQL server application maintained by the DBDSP. In reality, the number of new wells is higher; but paperwork on some of the wells has not yet been filed with the NMOCD or will be filed after this report is issued. Therefore, those wells are not included in the count listed above.

Rotary drilling rigs were used to drill the 549 completed wells in this reporting period. The status of these completed wells include oil wells, gas wells, and salt water disposal wells. The 549 wells were conventionally drilled utilizing mud as a medium for circulation. Sixty of these wells were completed in the nine-township area. The total depth of the completed wells in the nine-township area during the last year are between 3,258 feet to 25,870 feet.

To drill horizontally after a lateral kick-off point target depth is reached is a technique used by operators to increase the productivity of a well. The CCA, Appendix DEL reported that this technique was not often used in this area because of the increased costs due to the additional

drilling time needed; however, this is no longer the case. All 17 new wells spudded during the reporting period in the nine-township area had horizontally drilled components.

2.1.2 DRILLING FLUIDS

Drilling fluid, commonly known as mud, is the liquid circulated through the wellbore during rotary drilling and workover operations. In addition to its function of bringing cuttings to the surface, drilling mud cools and lubricates the bit and drill stem, protects against blowouts by holding back subsurface pressures, and deposits a mud cake on the wall of the borehole to prevent loss of fluids into the formation.

Typically, a driller will use fresh water and additives to drill the surface section of the borehole, which ends at the top of the Salado Formation. A change in drilling practices would necessitate a change in the application of drilling fluids. Within the Designated Potash Area (DPA) of southeastern New Mexico, drillers are required under NMOCD Order R-111-P to use saturated brine to drill through the salt formation, which is usually called the "intermediate" section. The DPA is partially within the Delaware Basin boundary, inside the nine-township area in the vicinity of the WIPP site. There are currently 1,411 wells in this area. The purpose of the requirement is to keep the salt from washing out and making the hole larger than necessary. Once this section has been drilled and cased, the driller again changes to fresh water and additives to finish drilling the hole to depth.

2.1.3 AIR DRILLING

A method of hydrocarbon drilling not emphasized in CCA, Appendix DEL is air drilling. As defined by the oil industry, air drilling is a method of rotary drilling using compressed air as the circulation medium. The conventional method of removing cuttings from the wellbore is to use a flow of water or drilling mud. In some cases, compressed air removes the cuttings with equal or greater efficiency. The rate of penetration is usually increased considerably when air drilling is used; however, a fundamental problem in air drilling is the penetration of formations containing water, since the entry of water into the system reduces the ability of the air to remove cuttings. Air drilling occurrences are tracked by the DBDSP in the New Mexico portion of the Delaware Basin only.

Stakeholders noted the air drilling scenario was not included by the DOE in the CCA and raised the following issues: (1) air drilling technology is currently successfully used in the Delaware Basin, (2) air drilling is thought to be a viable drilling technology under the hydrological and geological conditions at the WIPP site, and (3) air drilling could result in releases of radionuclides that are substantially greater than those considered by the DOE in the CCA. Considerable research on air drilling in the Delaware Basin has determined that, although air drilling is an alternative method of drilling wells, it is not practiced in the vicinity of the WIPP site because (1) it is against NMOCD Order R-111-P regulations to drill with anything but saturated brine through the salt formation in the DPA; (2) it is not economical to drill with air when a driller has to use saturated brine for the intermediate section; and (3)

if water is encountered prior to or after drilling the salt formation, the driller would have to convert to a conventional system of drilling.

DOE provided additional information to EPA Air Docket No. A-93-02, IV-G-7 (Kirkes 1998). In this information, the following was provided:

"The well record search has continued and now includes information from the entire New Mexico portion of the Delaware Basin. Within the nine-townships surrounding the WIPP, the records showed no evidence of air drilling. One possible exception to this may be the Lincoln Federal #1. This well is said to have been air drilled due to a loss of circulation at a depth of 1290 feet, but this has not been verified. The records associated with the Lincoln Federal #1 do not contain any evidence of air drilling. Rather, this information is based on verbal communications with the operating and drilling companies involved with the well. Nonetheless, the Lincoln Federal #1 may have been drilled with air, although it was not a systematic use of the technology. Air drilling at this well was used from 2984' to 4725' merely as a mitigated attempt to continue drilling to the next casing transition depth. After this casing transition, mud drilling was used for the remainder of the hole.

The area of the expanded search contains 3,756 boreholes. Of these, 407 well files were unavailable for viewing (in process); therefore, 3,349 well files constitute the database. Among these wells, 11 instances of air drilling were found in which any portion of the borehole was drilled with air. Only 7 of these were drilled through the Salado Formation at the depth of the repository. This results in a frequency of 7/3349, or 0.0021. This value is conservative in that it includes the Lincoln Federal #1, and four other wells which were proposed to be drilled with air, but no subsequent verification of actual drilling exists in the records."

In the CCA Final Rule (FR Vol. 63 No. 95) the EPA ruled air drilling did not have to be considered for PA; however, the DBDSP will continue to monitor for instances of air drilling (EPA 1998a).

During the summer of 1999, another search of these same records was conducted as a follow-up to the original research. This search of the records was used as a quality assurance check of the original search. The database consisted of 3,810 boreholes with only 12 records unavailable for viewing. This search added five more wells with indications of some portion of the borehole being drilled with air. None were located in the nine-township area or were air drilled through the Salado Formation. Of the five wells added to the count, one (the Sheep Draw "28" Federal #13) had the first 358 feet air drilled while the other four had the conductor casing drilled with air which consists of the first 40 feet of the borehole and is not usually reported in the drilling process. The conductor casing is typically drilled, set in place, and cemented prior to setting up the rotary drilling rig that will eventually drill the well.

The records on the new wells spudded during the last year (September 1, 2020, through August 31, 2021) are reviewed as they become available at the NMOCD internet site for instances of air drilling. The records can be submitted to the NMOCD offices as late as two years after the well has been drilled. None of the records reviewed to date have indicated any

additional instances of air drilling. Air drilling is not a common practice in the vicinity of the WIPP site. Table 3 shows the known indications of air drilling that have occurred in the New Mexico portion of the Delaware Basin.

2.2 SHALLOW DRILLING EVENTS

The criteria in 40 CFR Part 194.33 require that the CCA and subsequent CRAs adequately and accurately characterize the frequency of shallow drilling within the Delaware Basin, as well as, support the assumptions and determinations, particularly those that limit consideration of shallow drilling events based on the presence of resources of similar type and quantity found in the controlled area. The EPA defined shallow drilling as "drilling events in the Delaware Basin that do not reach a depth of 2,150 feet below the surface relative to where such drilling occurred." The DOE concluded in CCA, Appendix SCR that shallow drilling could be removed from PA consideration based on low consequence. As a result, the DOE did not include shallow drilling in its PA drilling rate calculations and did not include any reduction in shallow drilling rates during the active and passive institutional control periods. In the CCA, Compliance Application Review Document (CARD) 33 (EPA 1998b), the EPA accepted the DOE's finding that shallow drilling would be of low consequence to repository performance and need not be included in PA.

Although the EPA has agreed, in CARD 33, shallow drilling is of low consequence and could be eliminated from PA, the DBDSP collects data on wells reported to be drilled within the boundaries of the Delaware Basin. Table 4 shows a breakdown of the various types and number of shallow wells located within the Delaware Basin. The wells categorized as Drilling or Waiting on Paperwork are physically in the process of being drilled according to NMOCD. Therefore, until drilling has reached 2,150 feet, the well is a shallow borehole. The information known about these wells is the location, the operator name, the well has been spudded and has a permit. Until the well has been reported as "completed" by NMOCD, the DBDSP cannot determine the well type or completion depth.

2.3 DEEP DRILLING EVENTS

In accordance with the criteria, the DOE used the historical rate of drilling for resources in the Delaware Basin to calculate a future drilling rate. In particular, in calculating the frequency of future deep drilling, the EPA provided the following criteria in 40 CFR §194.33(b)(3)(i) (EPA 1996) to the DOE:

"Identify deep drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared."

The DOE used the historical record of deep drilling for resources below 2,150 feet that has occurred over the past 100 years in the Delaware Basin. This was chosen because this is the depth of the repository, and the repository could not be directly breached by boreholes less than this depth. In the past 100 years, deep drilling occurred for oil, gas, potash, and sulfur.

These drilling events were used in calculating a rate for deep drilling for the PA as discussed in CCA, Appendix DEL. The period of calculation used was from January 1896 through June 1995. Historical drilling for purposes other than resource exploration and recovery (such as WIPP site investigation) were excluded from the calculation in accordance with criteria provided in 40 CFR §194.33.

In the Delaware Basin, deep drilling events are usually associated with oil and gas drilling. Information obtained from commercial databases and state regulatory agencies is used to identify these events. The DBDSP collects data on drilled wells within the Delaware Basin, making no distinction between resources. One combined Microsoft® SQL Server® based well tracking application is maintained on hydrocarbon wells for Texas and New Mexico. As information on wells is acquired, it is entered into this well tracking application. The Texas portion of the well tracking application contains information only on the current status of the well, when it was drilled, its location, the name of the operator, and the total depth of the well. For reporting purposes, the Texas portion is used only for calculating the drilling rate. The New Mexico portion contains the same basic information as Texas, along with the required features, events, and processes for PA-related drilling events identified in the Delaware Basin Drilling Surveillance Plan (NWP 2021).

The DBDSP continues to monitor hydrocarbon drilling activity and any new potash, sulfur, water, or monitoring wells for deep-drilling events. Information from the drilling of these wells is added to the well tracking application maintained for these resources. During this reporting period 549 were completed. Most of the completed wells were drilled for hydrocarbon extraction and were deep-drilling events. Seventeen of these new wells are in the nine-township area immediately surrounding the WIPP site. Table 5 shows the number and type of deep wells located in the Delaware Basin.

2.4 PAST DRILLING RATES

The EPA provided a formula for calculating the current drilling rate or intrusion rate when 40 CFR Part 194 was promulgated. The formula is as follows:

$$\text{Deep Drilling Rate (Boreholes/km}^2\text{)} = \frac{(\text{Total Number of Deep Boreholes}) \text{x } (10{,}000 \text{ Years})}{(23{,}102.1 \text{ km}^2) \text{x } (100 \text{ Years})}$$

The DBDSP uses any deep drilling events (except WIPP Project-related boreholes) to calculate the drilling or intrusion rate.

The annual (September 1 through August 31) drilling rates since the submittal of the CCA in 1996 are shown in Table 6. In addition, the 100-year period is considered a moving period; in which 100 years of data are used each time the calculation is performed. As each new year of data is added, the oldest year, if data exists for that year, is dropped. For example, the drilling rate was calculated in 1999 by using the data from 1900 through 1999. In 2000, the

data from 1901 through 2000 were used to calculate the drilling rate.

2.5 CURRENT DRILLING RATE

The calculated deep drilling rate for 2021 was derived from the information provided in Table 5. There were 34,964boreholes deeper than 2,150 feet. Applying the Deep Drilling Rate formula presented in section 2.4 results in a deep drilling rate of 151.3 boreholes per km^2 over 10,000 years.

This is an increase from the 46.8 boreholes per km^2 reported in the CCA. The deep drilling rate is anticipated to rise for several more years before it begins to drop because the Delaware Basin is currently experiencing a period of increased drilling activity and because of the effect of the 100-year moving time frame used for drilling results. Currently a large number of wells are being added annually, while only a few are being removed due to the 100-year rolling time frame.

2.5.1 DRILLING ACTIVITIES OUTSIDE THE NINE-TOWNSHIP AREA

In the New Mexico portion of the Delaware Basin outside of the nine-township area, there were 153 new wells spudded during the reporting period of September 1, 2020, through August 31, 2021. Of the 153 wells, 34 are located in Eddy County and 119 are in Lea County.

In the Texas portion of the Delaware Basin, 299 new wells were spudded during the reporting period. The DBDSP monitors drilling activities in portions of seven counties and all of one county (Loving).

2.6 CASTILE BRINE ENCOUNTERS

The WIPP PA included the assumption that a borehole results in the establishment of a flow path between the repository and a pressurized brine pocket that might be located beneath the repository in the Castile Formation. Delaware Basin Drilling Surveillance Program records indicated 40 wells encountered pressurized brine in the Castile Formation; of these, 30 wells were hydrocarbon wells scattered over a wide area in the vicinity of the WIPP site. The remaining wells, ERDA-6 and WIPP-12, were drilled in support of WIPP site characterization.

The DBDSP researches the well records of new wells drilled in the New Mexico portion of the Delaware Basin each year by looking for instances of encounters with pressurized brine. As of this report, although 10 older wells were discovered in NMOCD none of the records indicated encounters with pressurized brine during the drilling of new wells spudded in the New Mexico portion of the Delaware Basin between September 1, 2020, and August 31, 2021.

Ten wells drilled since the CCA have encountered Castile Brine. Six were identified when WIPP site personnel performing field work talked to area drillers and the information was

documented in the DBWTA. The new encounters have been in areas where, because of historical Castile Brine encounter data (Powers, Sigda, and Holt 1996), Castile Brine is expected to be encountered during the drilling process. Table 7 shows known Castile Brine encounters in the vicinity of the WIPP site.

In the CCA, the probability for encountering a Castile Brine reservoir was calculated at eight percent with 30 Castile Brine encounters. In the Performance Assessment Verification Test (PAVT), the EPA mandated a range of one percent to sixty percent. These higher values did not have a significant effect on the predicted performance of the repository. The CRA-2004 continued to use the EPA's higher values and a probability for encountering a Castile Brine reservoir was not calculated. The CRA-2009 also used the values from the PAVT. For the CRA-2014, the DOE used a new probability distribution for the potential for encountering pressurized brine based on areas of known brine occurrences as well as neighboring (adjacent) wells that did not encounter pressurized brine. However, the EPA again rejected this distribution and selected their own distribution (EPA 2017). For the CRA-2019, the DOE used EPA's new probability distribution. The DBDSP continues to monitor and collect data on the occurrences of pressurized brine, however the EPA continues to require the use of their probability distribution.

2.7 BOREHOLE PERMEABILITY ASSESSMENT– PLUGGING PRACTICES

Title 40 CFR Part 194.33(c)(1) states: "Future drilling practices and technology will remain consistent with practices in the Delaware Basin at the time a compliance application is prepared. Such future drilling practices shall include, but shall not be limited to: The types and amounts of drilling fluids; borehole depths, diameters, and seals; and the *fraction of such boreholes that are sealed by humans…*" [Emphasis added]. Plugging techniques near the WIPP are driven by State regulations that are in place to protect other resources present, namely potash. For wells within the Designated Potash Area (DPA), Order No. 3324 regulations apply and require the operator to install a solid cement plug through the entire salt section and any water-bearing horizon, in addition to installing a bridge plug above the perforations. This plugging technique provides protection to mineralized potash areas and workings by requiring a continuous plug so there is virtually no chance of flooding nearby mines throughout their development and operation. The WIPP lies within the DPA and plugging in the vicinity generally follows this plugging technique, older plugged wells that pre-date the Order No. 3324 regulation may not be plugged in this manner. There is no process for granting exemptions. Therefore, wells that are not plugged per the process were either plugged before the rule existed in 1988, or the plugged wells were not properly approved by the appropriate regulatory agency (BLM or NMOCD).

In the New Mexico portion of the Delaware Basin, the DBDSP retrieves a copy of the plugging report from the NMOCD internet site when a well has been plugged and abandoned. This information is added to the records maintained by the DBDSP on each well drilled within the Delaware Basin. By maintaining records in such a fashion, any changes or trends to plugging techniques can be identified. Table 8 shows plugging information on the wells plugged and

abandoned within the vicinity of the WIPP from September 1, 2020, to August 31, 2021. For analyzing plugging types, data from the DPA portion of the nine-township area surrounding WIPP are most appropriate, since it is assumed that future boreholes would be plugged using current techniques as specified in 40 CFR 194.33(c)(1).

The CCA, Appendix MASS, Attachment 16-1 (DOE, 1996), provides a "…summary results of regulatory analyses and records research used to determine plugging and abandonment practices in the Delaware Basin." The study within this attachment did not attempt to predict the effectiveness of plugs, but to identify the location and physical characteristics of plugs, which might be important to PA. The following is stated in the Explanation of Assumptions:

Guidance in 40 CFR Part 194 states; "Performance assessments should assume that the permeability of sealed boreholes will be affected by natural processes, and should assume that the fraction of boreholes that will be sealed by man equals the fraction of boreholes which are currently sealed in the Delaware Basin." The rule also states that "...drilling practices will remain as those of today."

The results of this study indicated the PA should assume a 100 percent plugging frequency; that is, all wells are assumed to have some type of plug installed.

To determine the typical configuration and composition of a borehole plug, this same study considered plugging practices listed below to arrive at a model depicting six different types of plugging configurations (see Figure 4):

Type I Plugs will be located at the transition between the surface and intermediate casings and the transition between the intermediate and production casings. This area is usually the top of the Salado Formation and the bottom of the Castile Formation, roughly 800 feet and 4,000 feet below the surface, respectively.

Type II This plugging configuration has a portion of the production casing salvaged. Where the production casing was cut, a plug must be installed. If a plug occurs between 2,150 feet and 2,700 feet (above the hypothetical brine pocket) and the other plugs occur at the top of the Salado Formation and below the Castile Formation, it is considered a Type II configuration.

Type III This configuration is the same as above except the removed production casing plug occurs above 2,150 feet.

Type IV Extra plugs, in addition to those of Type II, have been emplaced above 2,150 feet.

Type V The minimum regulatory requirements require a surface plug and a plug occurring at the bottom, provided no water-bearing zones were encountered. This type of plugging configuration is not common.

Type VI This configuration has a solid cement plug through a significant portion of the salt section. This configuration, like the others, may have additional plugs above

and below the salt section plug. This plug type is typical of those used within the DPA.

There were three wells plugged during the reporting period that lie within the DPA and the nine-township area surrounding the WIPP. The region of data collection for this survey is shown in Figure 9 and Table 8.

2.8 SEISMIC ACTIVITY IN THE DELAWARE BASIN

Known seismic events occurring in southeast New Mexico and West Texas, specifically in the Delaware Basin, are recorded in the DBWTA. This information is obtained every quarter in a report from the New Mexico Institute of Mining and Technology (NMIMT), Socorro, New Mexico, utilizing data from an array of nine seismic stations in the vicinity of the WIPP site (NMIMT 2018, NMIMT 2019a, NMIMT 2019b, NMIMT 2019c). As of 2018, NMIMT acquired new
seismology equipment which is able to detect very small seismic activity.

During this reporting period there were 1,850 seismic events recorded in the counties of the Delaware Basin. In Culberson County, there were 965. Ninety-seven events were recorded in Eddy County. Four seismic event was recorded in Jeff Davis County. One hundred sixty seismic events were recorded in Lea County. One hundred one seismic events were recorded in Loving County. Twenty-nine seismic events were recorded in Pecos County. In Reeves County, there were 440. Thirty seismic events were recorded in Ward County. Thirteen seismic event was recorded in Brewster County. Eleven seismic events were recorded in Winkler County. Table 9 provides information on all recorded seismic events, which have occurred in the counties that make up the Delaware Basin.

2.9 SECONDARY AND TERTIARY RECOVERY

Secondary recovery is defined by the oil industry as the first improved recovery method of any type applied to a reservoir to produce oil not recoverable by primary recovery methods. Waterflooding is one such method. This method involves pumping water through the existing perforations in a well. As the water is pumped into a formation, it stimulates production of oil or gas in other nearby wells. This is a proven method of recovering hydrocarbons.

Waterflooding has been a popular form of secondary recovery for over 40 years. Waterflooding can be accomplished by one injection well or several injection wells in the immediate vicinity of other producing wells. Operators observe the statutory maximum injection pressures, thereby preventing out-of-zone fracturing.

In the New Mexico portion of the Delaware Basin, there are three major waterflood projects and several injection well operations. One of the major waterflood projects in the area is the El Mar, located in T26S-R32E, on the Texas border. At one time, this project had 31 permitted injection wells. Currently, there are three injection wells actively injecting water. The remaining wells are shut-in, temporarily abandoned, or plugged and abandoned. The Padua

waterflood project, located in T25S-R32E, has three permitted injection wells and two are actively injecting water into the formation. The third major waterflood project in this area is the Indian Draw, located in T22S-R28E, it has six permitted injection wells and is currently injecting into all of its permitted wells.

Tertiary recovery is defined by the oil industry as the use of any improved recovery method to remove additional oil after secondary recovery. At the time of this report, there are no known tertiary recovery projects being operated in the vicinity of the WIPP site, although several projects are being operated by oil companies in the Texas portion of the Delaware Basin using carbon dioxide (CO_2).

Previous assessments of the potential for CO_2 flooding near the WIPP site have stressed this fact suggesting nearby CO_2 floods are quite unlikely given the state of CO_2 enhanced oil recovery (EOR) technology today. Because of the larger reservoirs and more successfully CO_2 flooded carbonate formations, the likelihood of the additional supplies of CO_2 and CO_2 EOR's benefit of concurrent storage will still not affect CO_2 injection anywhere near the WIPP project area for at least ten years. And even then, the huge potential for EOR in the many carbonate reservoirs and their residual oil zones will take precedence over the many challenges of flooding the shales and Delaware sandstone reservoirs located closer to the WIPP site (Melzer 2018).

2.9.1 NINE-TOWNSHIP INJECTION WELLS

Secondary recovery projects occurring in the nine-township area are on a small scale. There are five injection wells located in the nine-township area surrounding the WIPP site.

Conoco Phillips Company operates two injection wells northwest of the site in the Cabin Lake field. The other three injection wells are operated by *OXY USA INC* and are located south and east of the site. The five wells are injecting into the Brushy Canyon Formation of the Delaware Mountain Group at a depth of approximately 7,200 feet. In the Delaware Basin, oil producers are moving from completing SWD wells in the Delaware Mountain Group to completing them deeper, in the Devonian. Figure 5 shows a typical injection or salt water disposal well configuration. Table 10 provides information on the injection wells located in the nine-township area.

2.9.2 NINE-TOWNSHIP SALT WATER DISPOSAL WELLS

The most common type of injection well is for the disposal of produced water coming from the producing formation in oil and gas wells. Figure 6 shows the location of active injection and salt water disposal wells in the nine-township area. Most active oil and gas wells produce brine water in addition to oil and gas. Salt Water Disposal (SWD) wells have become necessary as a result of the EPA's ruling that formation water may no longer be disposed of on the surface.

The oil and gas producers now dispose of this water by injecting it into approved SWD wells. In the Delaware Basin, oil producers are now targeting the Devonian Formation as the favored injection horizon.

There are currently 63SWD wells located in the nine-township area surrounding the WIPP site. Three operators, *Devon Energy Production Company LP*, *OXY USA INC*, and *EOG Resources Inc.*, operate the majority of the SWD wells. Injection depths range from 3,400 feet to 18,000 feet. The volume of disposed brine water depends on the number of producing oil and gas wells maintained by the operator in the immediate vicinity of the SWD well. Table 10 provides information on SWD and injection wells in the nine-township area.

2.10 MINING

Resources found in the Delaware Basin that can be mined are potash, sulfur, caliche, gypsum, halite, (NMBMMR 1995), and more recently, polyhalite.

2.10.1 POTASH MINING

Potash mining in the immediate vicinity of the WIPP site continues as reported since the CCA, Appendix DEL. Figure 7 shows the location and the extent of the potash mines in the vicinity of the WIPP site. There have been several changes to the companies that operate in the area, most notably; only two potash companies are actively mining. No plans have been promulgated by either company to sink new shafts or develop new mines. Polynatura (formerly Intercontinental Potash Corp (ICP)) has published plans (BLM 2014) to exploit polyhalite reserves southwest of the WIPP site. To date, no construction has occurred and no activities have been reported since the last reporting period.

2.10.2 SULFUR EXTRACTION

The only sulfur mining activity within the Delaware Basin was conducted by *Freeport-McMoRan Sulphur, Inc.*, formerly operated by *Pennzoil Sulphur Company.* The mine is located in Culberson County, Texas. The mine recovered sulfur utilizing the Frasch process, which consists of a hole drilled into the sulfur bearing formation and then cased. The next step involves the placement of three concentric pipes within the protective casing to facilitate pumping superheated water down the hole, melting the sulfur, then using compressed air to lift the molten sulfur to the surface. The mine was operated until it permanently ceased production on June 30, 1999.

Abandonment and salvage operations continued until early summer of 2000.

2.10.3 SOLUTION MINING

Solution mining is the process by which water is injected into a mineral formation, circulated to dissolve the mineral with the solution, and then pumped back to the surface where the minerals are removed from the water by evaporation. There are 13 active brine mines or wells

in the Delaware Basin, three in New Mexico and ten in Texas (see Figure 8), that use this process to provide a brine solution for area drilling operators to use in the drilling process.

Brine wells are classified as Class II injection wells. In the Delaware Basin, the process involves injecting fresh water into a salt formation to create a saturated brine solution, which is then extracted and used as a drilling agent when drilling a new well. These wells are tracked by the DBDSP.

Table 11 provides the status of brine wells in the Delaware Basin.

Three brine wells are being monitored by the NMOCD. These wells are located within the Carlsbad city limits and are within the New Mexico portion of the Delaware Basin. Eugenie #1 had its last official inspection 7/2008 and in 7/2010 a pressure transducer was installed and the well was secured. Dunaway #1 and Dunaway #2 brine wells had their last inspection 8/8/2019. Both wells failed to meet standards of the New Mexico Oil Conservation Division. Corrective action was done in November 2019 to comply with standards imposed by the rules and regulations of the NMOCD. The Carlsbad Brine Well Remediation Authority is a task force responsible for the brine well concern and budget to repair it.

2.11 NEW DRILLING TECHNOLOGY

New drilling methods are researched by the DBDSP for impacts to the drilling methods currently used in the area. A technique recently employed in the Delaware Basin is zipper fracturing. Zipper fracturing involves simultaneous stimulation of two parallel horizontal wells. The fractures are offset such that that if one were to view a cross section of them, they would appear like a zipper. The purpose of this technique is to create a more extensive fracture network. Another technique is hydraulic fracturing with recycled produced water is making up more of the frac water usage each year (Whitfield 2020). Horizontal development accounts for nearly all new well drilling in the Delaware and Bone Spring formations.

2.12 ALTERNATIVE ENERGY ACTIVITIES

The DBDSP researches alternative energy activities that may have impact on PA. Alternative energy activities that may be conducted in the Delaware Basin include solar, wind, and geothermal power. Currently there are no known geothermal power projects being performed in the Delaware Basin. Solar power is currently being pursued in the Delaware Basin. *Sun Edison* completed construction of a photovoltaic solar power plant on the southern edge of the Carlsbad city limits, which is located within the Delaware Basin. Wind power is a proven technology and has been ongoing in the Delaware Basin since 1995. Two wind farms operated by *FPL Energy* are located in the western mountains of the Delaware Basin. One farm operates approximately 140 turbines and the second one has 40 turbines. Both are located adjacent to each other approximately 10 miles south of the Guadalupe Mountains National Park and 75 miles southwest of the WIPP site.

3.0 SURVEY OF WELL OPERATORS FOR DRILLING INFORMATION

The DBDSP surveys local well operators annually to acquire information on drilling practices normally not available on the sundry notices supplied to the local state and federal offices by the operator or through commercial sources maintained by the DBDSP. Participation in the survey is voluntary. This survey requests information on other items of interest to the WIPP Project such as hydrogen sulfide (H_2S) encounters, Castile Brine encounters, or whether any section of the well was drilled with air. The DBDSP personnel review the records on new wells drilled to look for the above data. The survey provides an additional source of information on drilling activities in the New Mexico portion of the Delaware Basin. The DBDSP submits the survey annually. The most recent responses the DBDSP received were from 2016. No changes were made as a result of those responses.

4.0 SUMMARY– 2021 DELAWARE BASIN DRILLING SURVEILLANCE PROGRAM

- No new instances of air drilling.
- No Castile Brine encounters were reported in the last year.
- The drilling rate increased to 151.3 boreholes per square kilometer from 124.1 boreholes per square kilometer reported in the 2020 annual report (DOE 2020).
- One new SWD well was completed in the nine-township area compared to zero SWD wells reported in the 2020 annual report (DOE 2020).
- Seventeen wells were spudded in the nine-township area compared to nine wells in the 2020 annual report (DOE 2020).
- One hundred fifty-three wells were spudded outside the nine-township area in the Delaware Basin compared to 175 wells in the 2020 annual report (DOE 2020).
- In the Texas portion of the Delaware Basin, 299 wells were spudded.

5.0 REFERENCES

Hall, Russell K. Water Injection in WIPP Vicinity: Current Practices, Failure Rates and Future Operations. Midland, Texas. 01 January 2018.

Kirkes, G. Ross. 1998. *Current Drilling Practices Near WIPP*. EPA Air Docket No. A-93-02, IV-G-7, January 22, 1998.

Melzer, L.S. 2018, An Updated Assessment of the CO_2 Enhanced Oil Recovery Potential in the Vicinity of the Waste Isolation Pilot Plant, Eddy County, New Mexico. July 31, 2018.

New Mexico Bureau of Mines and Mineral Resources (NMBMMR). 1995. *Evaluation of Mineral Resources at the Waste Isolation Pilot Plant*. Final Report, Vols. I-IV.

New Mexico Institute of Mining and Technology (NMIMT). 2018. *A Report on the Seismicity of the WIPP Site for the Period July 1, 2018 through September 30, 2018*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2019a. *A Report on the Seismicity of the WIPP Site for the Period October 1, 2018 through December 31, 2018*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2019b. *A Report on the Seismicity of the WIPP Site for the Period January 1, 2019 through March 31, 2019*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2019c. *A Report on the Seismicity of the WIPP Site for the Period April 1, 2019 through June 30, 2019*. Socorro, New Mexico.

Nuclear Waste Partnership LLC. 2019. *Delaware Basin Drilling Surveillance Plan, Rev. 10.* April 2019. WP 02-PC.02. Carlsbad, NM: Carlsbad Field Office.

Powers, D.W., J.M. Sigda, and R.M. Holt. 1996. *Probability of Intercepting a Pressurized Brine Reservoir Under the WIPP.* July 10, 1996. Albuquerque, NM: Sandia National Laboratories.

U.S. Bureau of Land Management (BLM). 2014. *Ochoa Mine Project Final Environmental Impact Statement*. February 2014. BLM/NM/PL-14-02-3500. Carlsbad, NM: Carlsbad Field Office.

U.S. Department of Energy (DOE). 1996. *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant*. October 1996. DOE/CAO-1996-2184. Carlsbad, NM: Carlsbad Area Office.

U.S. Department of Energy (DOE). 2004. *Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant*. March 2004. DOE/WIPP 2004-3231. Carlsbad, NM: Carlsbad Field Office.

U.S. Department of Energy (DOE). 2009. *Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant*. March 2009. DOE/WIPP 2009-3424. Carlsbad, NM: Carlsbad Field Office.

U.S. Department of Energy (DOE). 2014. *Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant (March)*. DOE/WIPP-14-3503. Carlsbad, NM: Carlsbad Field Office.

U.S. Department of Energy (U.S. DOE). 2019. *Delaware Basin Monitoring Annual Report.* DOE/WIPP-19-2308. Carlsbad, NM: Carlsbad Field Office.

U.S. Department of Energy (DOE). 2019. *Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant.* March 2019. DOE/WIPP-2019-3609. Carlsbad, NM: Carlsbad Field Office.

U.S. Environmental Protection Agency (EPA). 1993. "Title 40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule." *Federal Register*, vol. 58 (Dec. 20, 1993): 66398-416.

U.S. Environmental Protection Agency (EPA). 1996. "Title 40 CFR Part 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations; Final Rule." *Federal Register*, vol. 61 (February 9, 1996): 5223–45.

U.S. Environmental Protection Agency (EPA). 1998a. "Title 40 CFR Part 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Certification Decision; Final Rule." *Federal Register*, vol. 63 (May 18, 1998): 27353–406.

U.S. Environmental Protection Agency (EPA). 1998b. "CARD No. 33: Consideration of Drilling Events in Performance Assessments." *Compliance Application Review Documents for the Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR 191 Disposal Regulations: Final Certification Decision*. May 1998. Washington, DC: Office of Radiation and Indoor Air.

U.S. Environmental Protection Agency (EPA). 2017. *Probability of Encountering Castile Brine Beneath the WIPP Waste Panels Using the TDEM Block Method*. June, 2017. Office of Radiation and Indoor Air, Docket EPA-HQ-OAR-2014-0609-0047.

Whitfield, Stephen. 2020. *Apache Aims to Boost Produced Water Reuse in Permian*. Society of Petroleum Engineers. https://pubs.spe.org/en/ogf/ogf-article-detail/?art=3923.

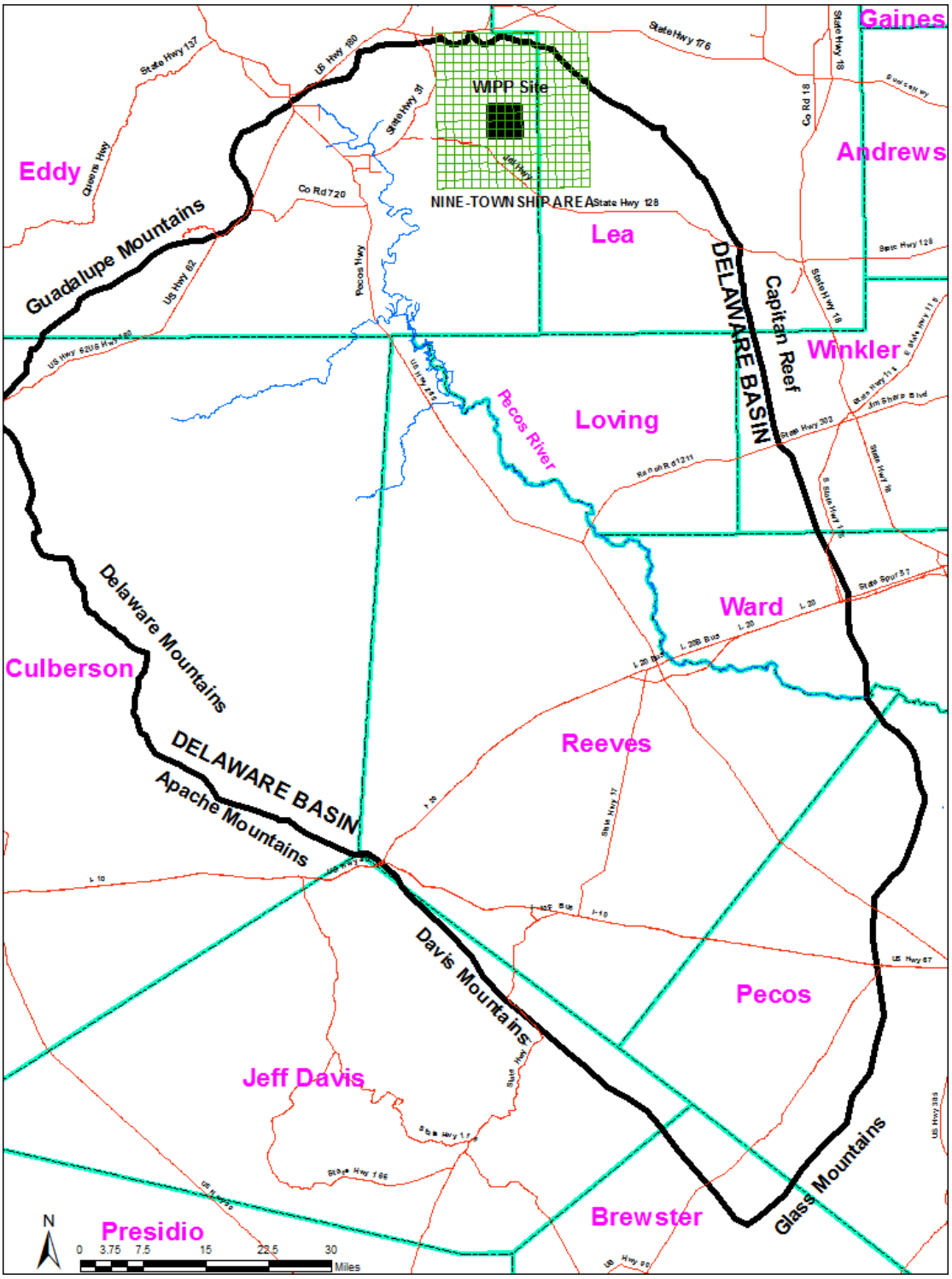


Figure 1: WIPP Site, Delaware Basin, and Surrounding Area

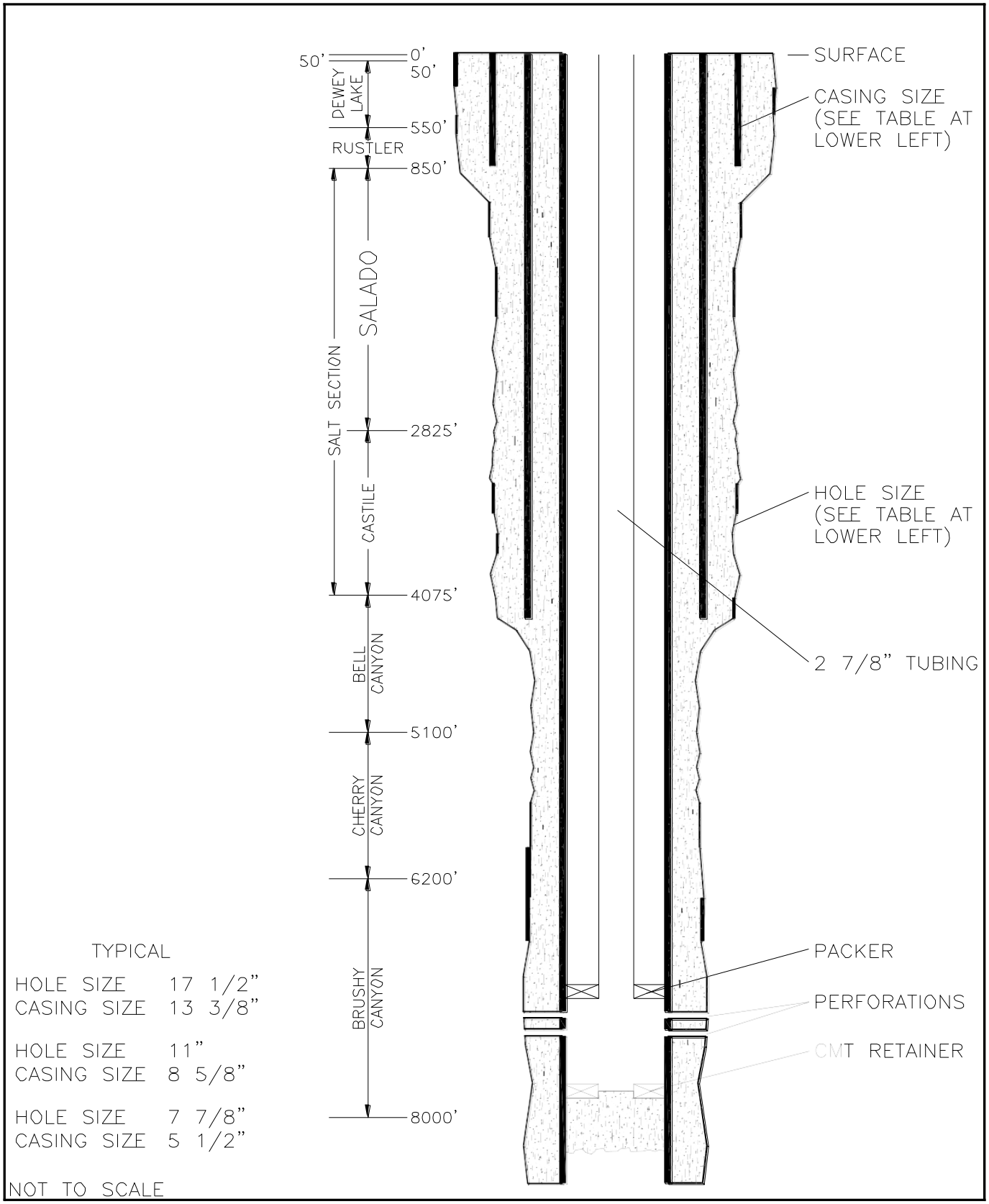


Figure 2: Typical Well Structure and General Stratigraphy Near the WIPP Site

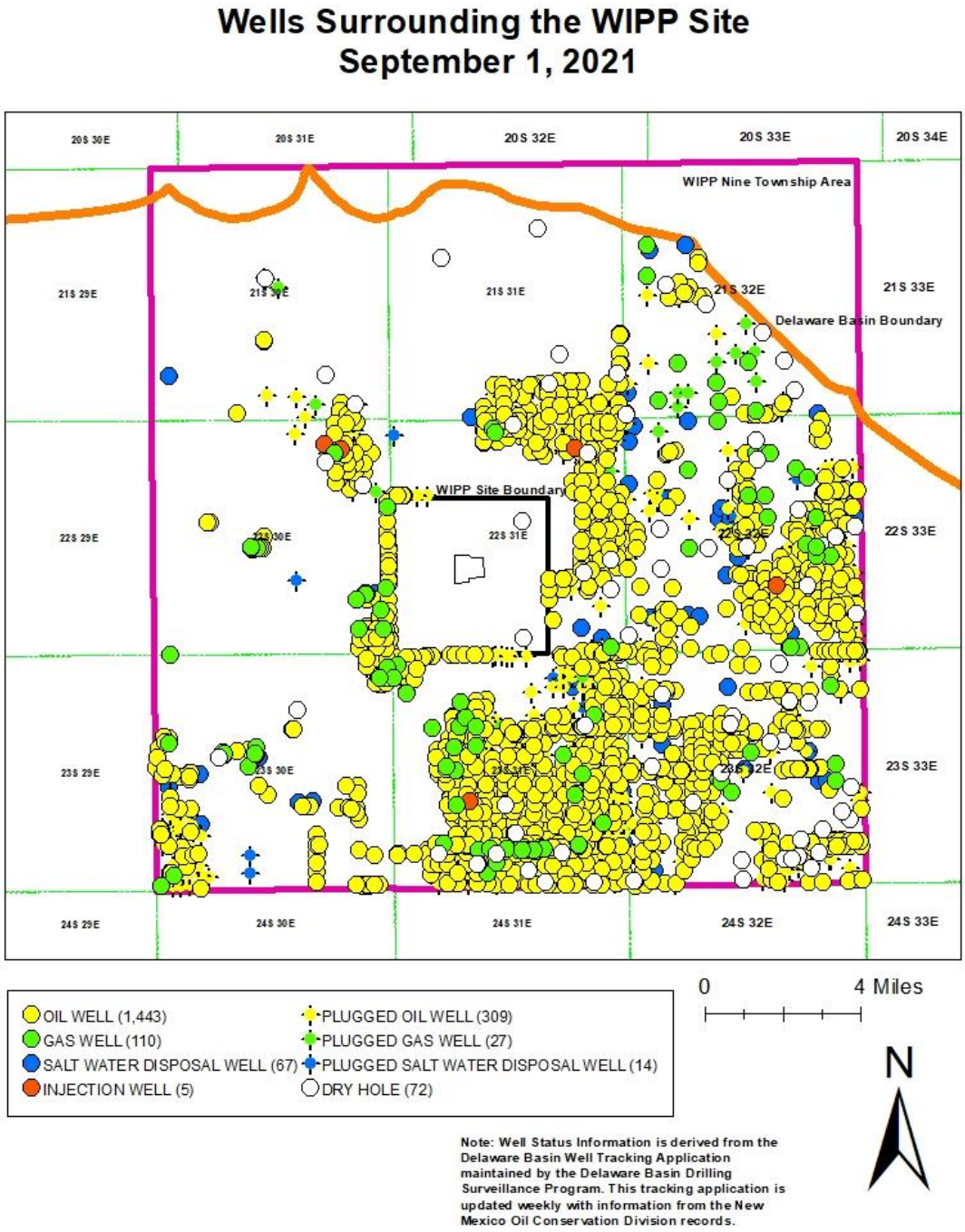


Figure 3: Well Activity in the Nine-Township Area

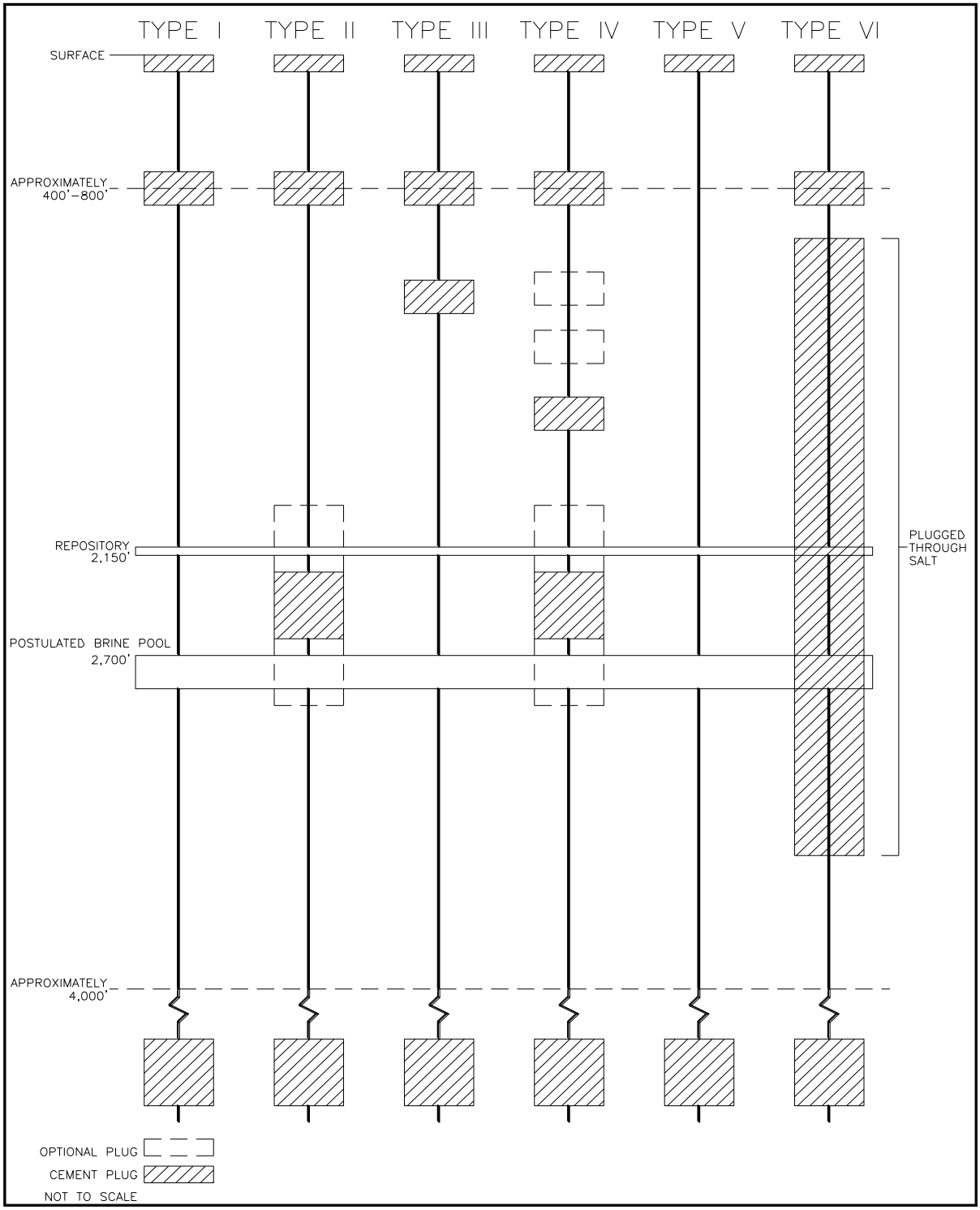


Figure 4: Typical Borehole Plug Configurations in the Delaware Basin

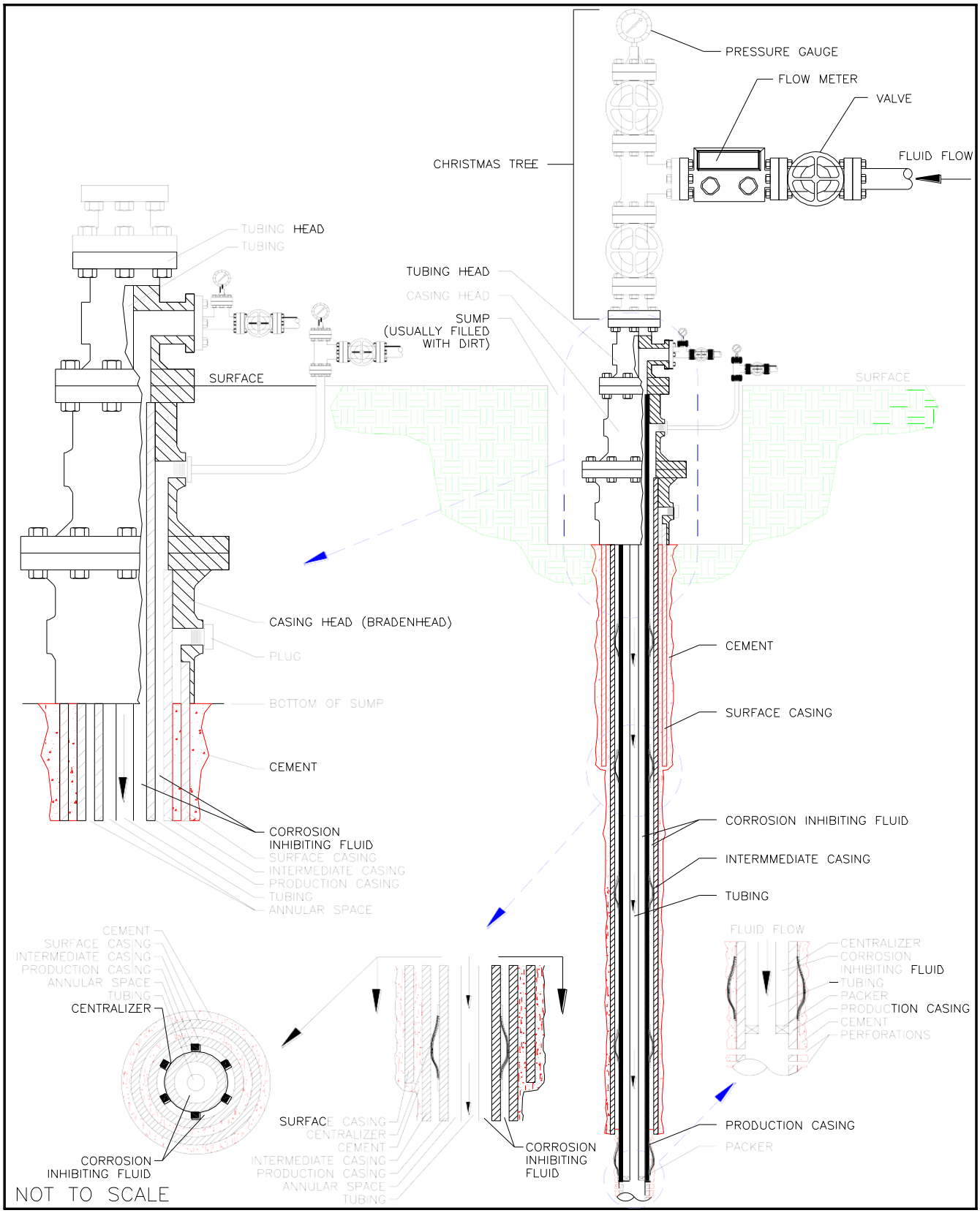


Figure 5: Typical Injection or SWD Well

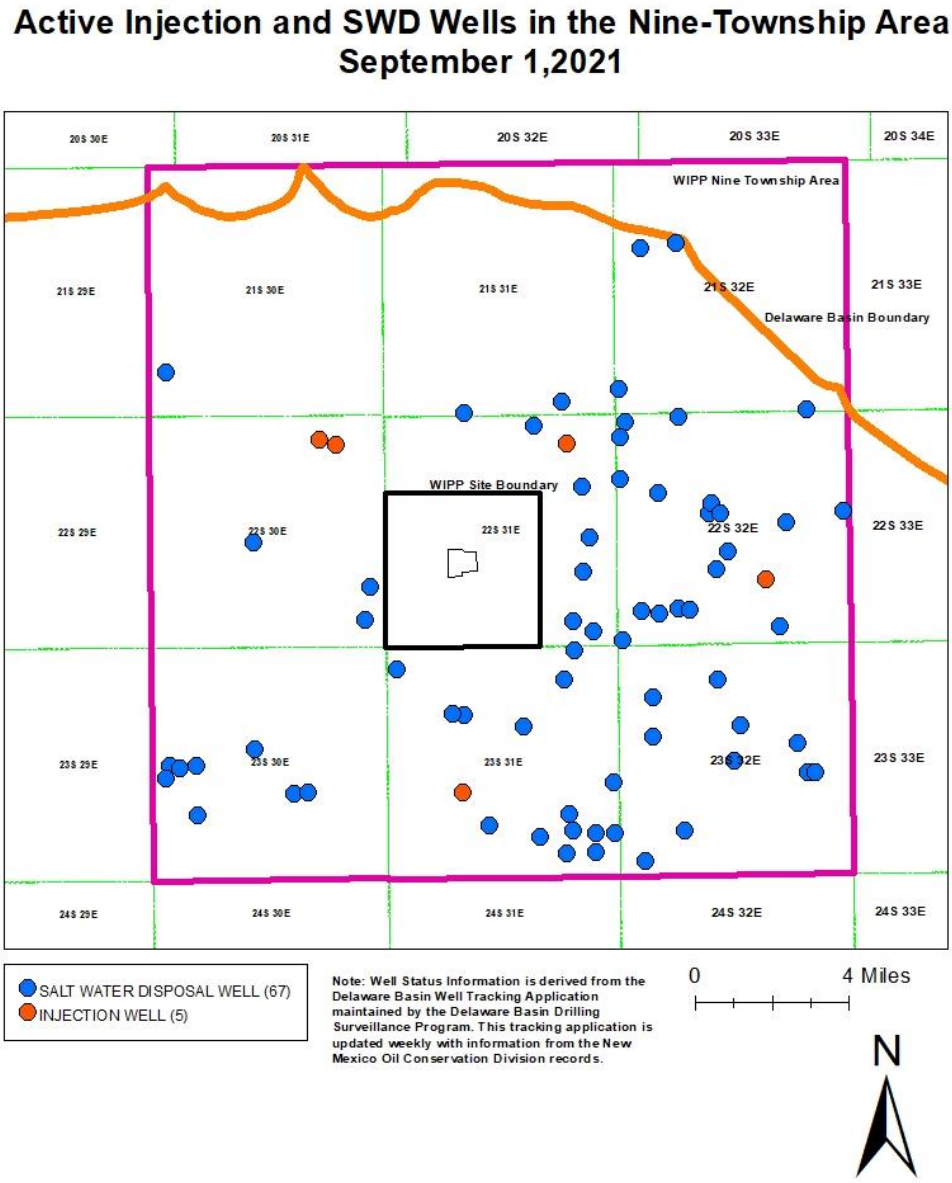


Figure 6: Active Injection and SWD Wells in the Nine-Township Area

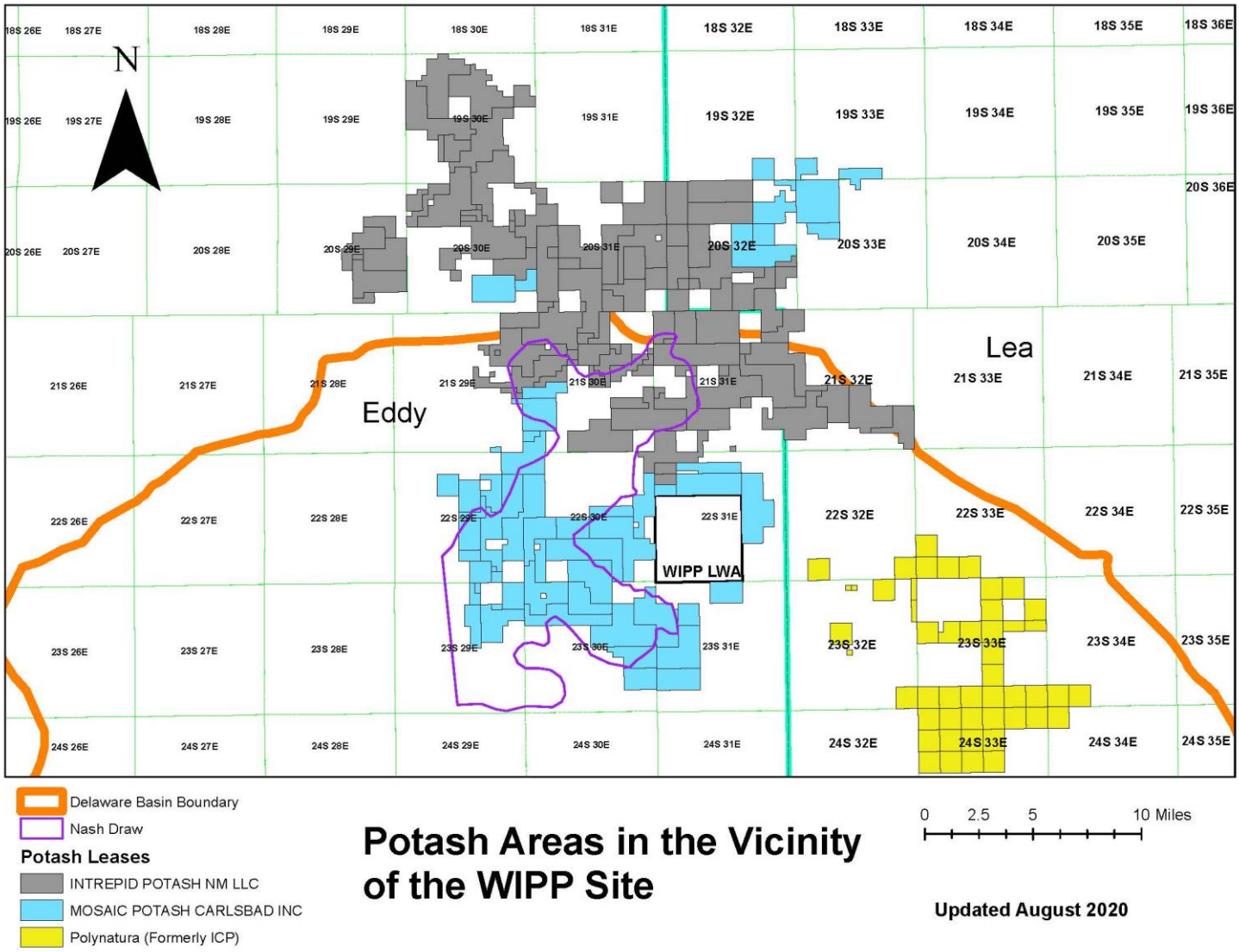


Figure 7: Potash Areas in the Vicinity of the WIPP Site

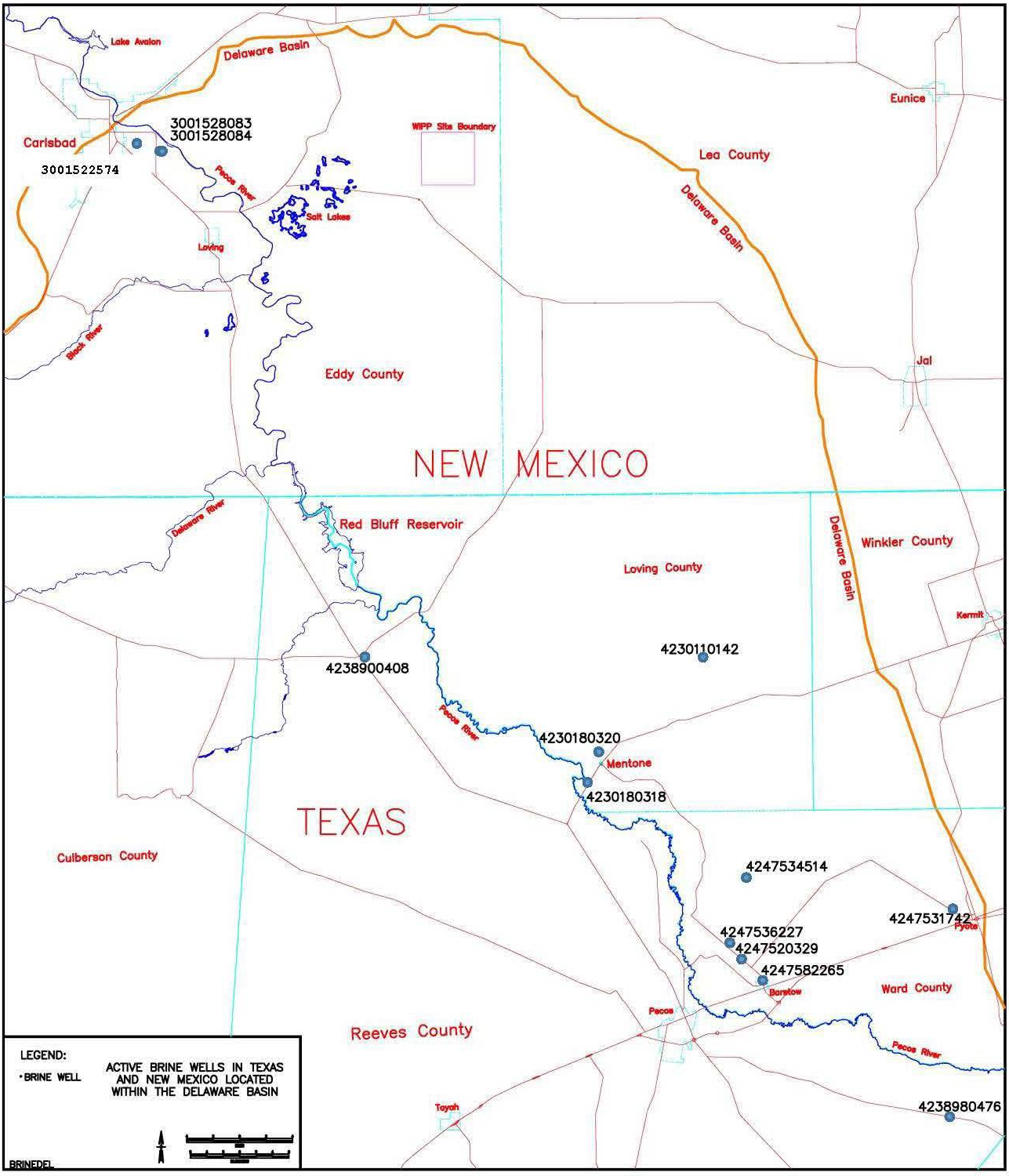


Figure 8: Active Brine Well Locations in the Delaware Basin

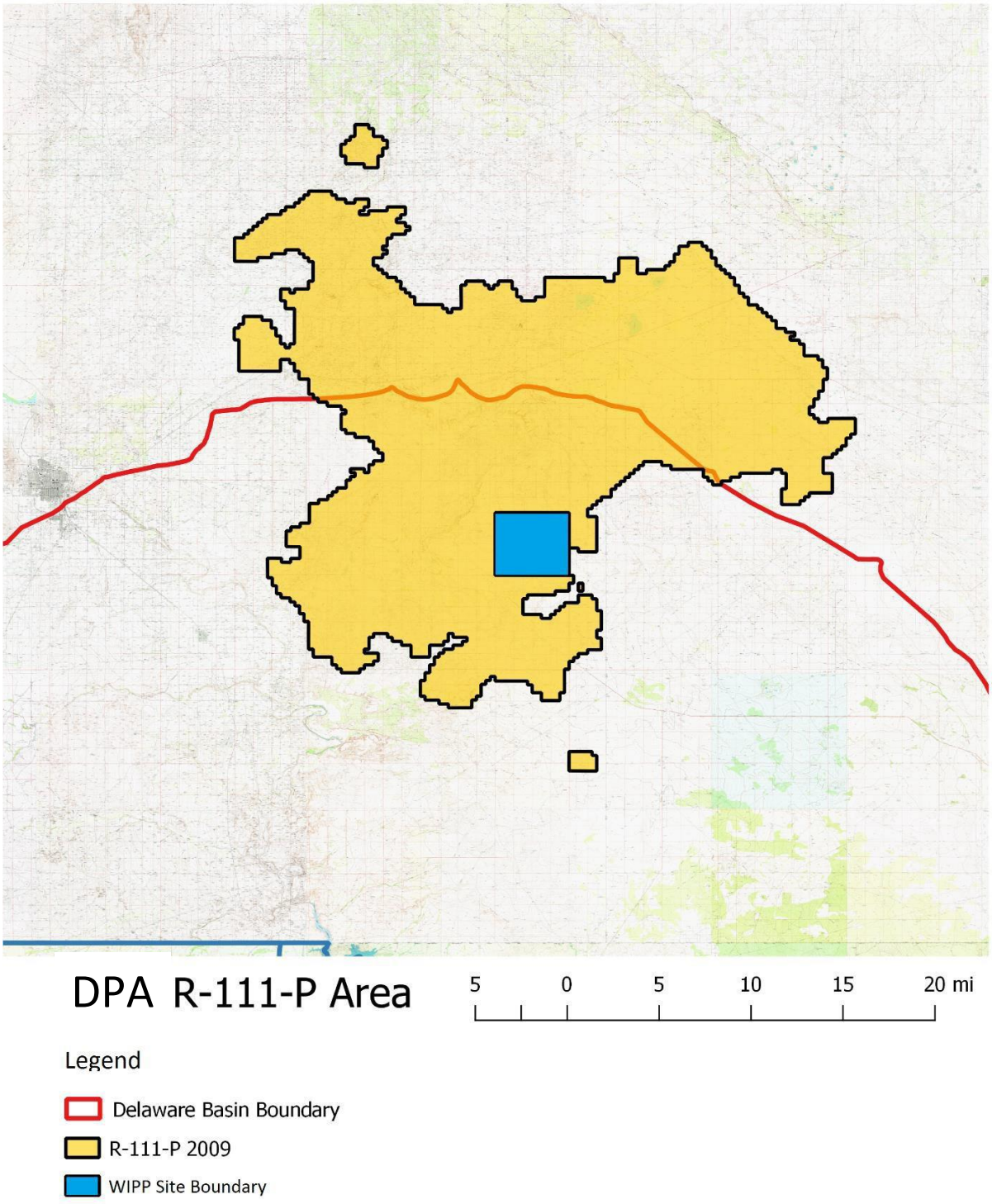


Figure 9: Designated Potash Area – R-111

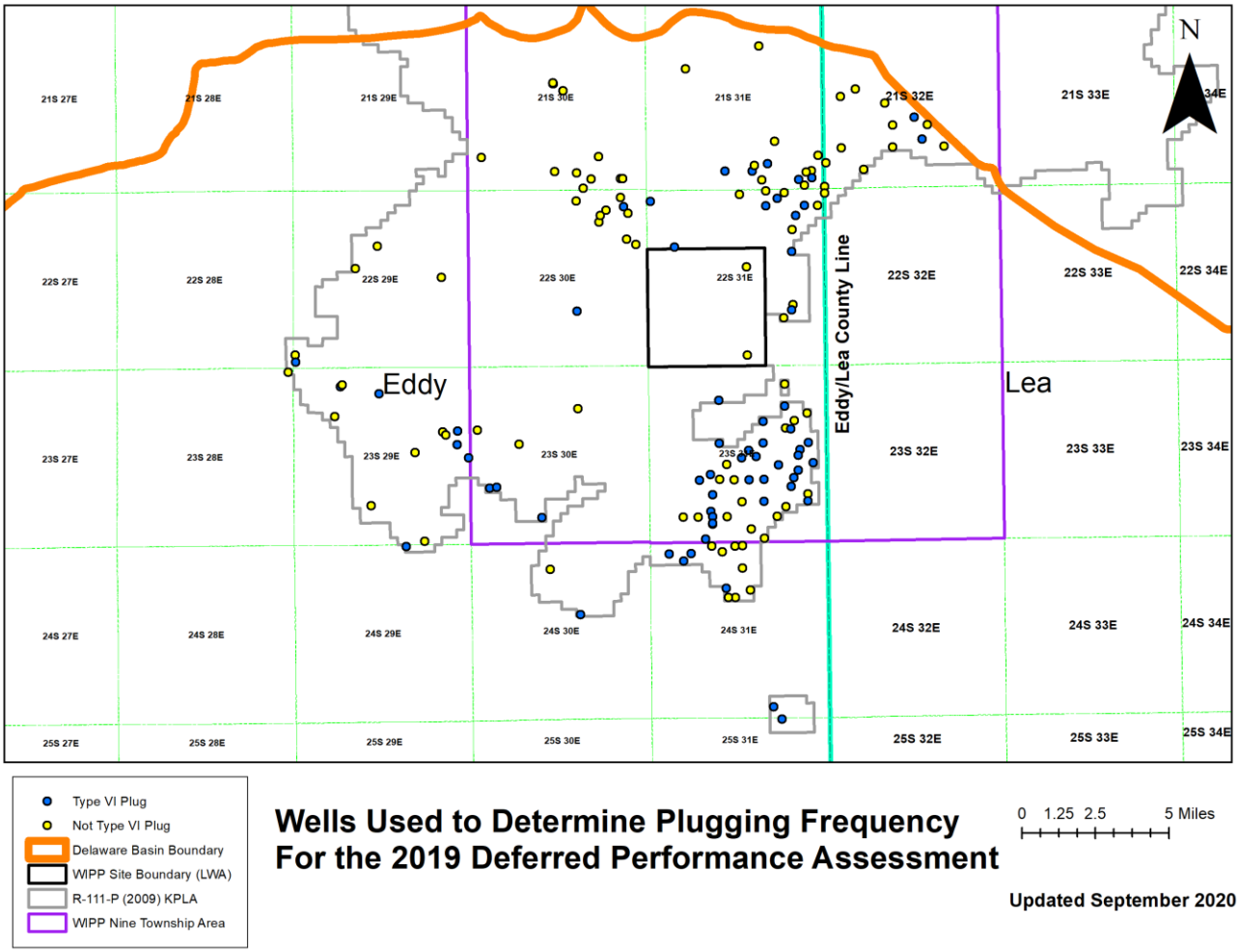


Figure 10: Wells Used to Determine Plugging Frequency for the 2019 Deferred PA

Table 1: Nine-Township Area Casing Sizes

Casing Size	Surface Casing	Intermediate Casing	Production Casing
20	0	0	0
18-5/8	0	0	0
16	1	0	0
13-3/8	6	0	0
11-3/4	0	1	0
10-3/4	0	6	0
9-5/8	1	8	0
8-5/8	0	0	1
7-5/8	0	0	0
7	0	1	0
5-1/2	0	0	14
4-1/2	0	0	1

NOTE: There were 17 wells drilled in the nine-township area between September 1, 2020, and August 31, 2021. Two of the wells did not have complete records available on casing sizes.

Table 2: Nine-Township Area Bit Sizes

Bit Size	Surface Hole	Intermediate Hole	Production Hole
26	0	0	0
24	0	0	0
20	1	0	0
18 1/2	0	0	0
17 1/2	6	0	0
16	0	0	0
14 3/4	0	1	0
12 3/4	0	0	0
12 1/4	1	5	0
11	0	0	0
10 5/8	0	0	1
9 7/8	0	0	0
8 3/4	0	0	7
8 1/2	0	0	2
7 7/8	0	0	5
7 3/4	0	1	0
7	0	0	1
6 3/4	0	0	0
6 1/8	0	0	1

NOTE: There were 17 wells drilled in the nine-township area between September 1, 2020, and August 31, 2021. Two of the wells did not have complete records available on bit sizes.

Table 3: Air-Drilled Wells in the New Mexico Portion of the Delaware Basin

#	Location	Well Name and No.	Spud Date	Status	Well Information
1	21S-28E-33	Richardson & Bass #1	7/27/1961	P&A	Air drilled through the salt. Between 2,545 ft and 2,685 ft encountered water and changed from air to mud-based drilling.
2	21S-32E-26	Lincoln Federal Unit #1	4/1/1991	P&A	Lost circulation at 1,290 ft hole was dry drilled to 1,792 ft supposedly, air drilled from 2,984 ft to 4,725ft.
3	23S-26E-17	Exxon "17" Federal #1	8/1/1989	Gas Well	Air drilled through the salt from 575 ft to 2,707 ft.
4	23S-28E-11	CP Pardue #1	10/28/1958	P&A	Air drilled through the salt from 390 ft to 2,620 ft.
5	23S-28E-11	Amoco Federal #1	8/4/1979	Oil Well	Air drilled from 475 ft to 9,700 ft.
6	23S-28E-11	Amoco Federal #3	2/28/1980	Oil Well	Air drilled from 6,271 ft to 9,692 ft.
7	23S-28E-23	South Culebra Bluff Unit #3	1/21/1979	Oil Well	Air drilled from 6,345 ft to 8,000 ft.
8	23S-28E-23	South Culebra Bluff Unit #4	8/9/1979	Oil Well	Air drilled from 450 ft to 9,802 ft.
9	24S-31E-03	Lilly "ALY" Federal #2	5/1/1994	Oil Well	Air drilled conductor hole to 40 ft.
10	24S-31E-03	Lilly "ALY" Federal #4	5/16/1994	Oil Well	Air drilled conductor hole to 40 ft.
11	24S-34E-04	Antelope Ridge Unit #2	9/13/1962	Gas Well	Attempted to drill with gas. Had to convert to water at 1,035 ft. Tried again several times at different depths.
12	24S-34E-09	Federal "9" Com #1	12/3/1963	Gas Well	Hit water while gas drilling at 4,865 ft.
13	24S-34E-13	Federal Johnson #1	6/23/1958	P&A	Proposed to drill with air, but no information in the records indicate air drilling.
14	26S-32E-20	Russell Federal #1	3/16/1966	Oil Well	Drilled with air to 1,330 ft.
15	26S-32E-36	North El Mar Unit #44	2/19/1959	Oil Well	Proposed to drill with air, but no information in the records indicate air drilling.
Wells Drilled after Supplemental Information Provided to the EPA Docket in 1997.					
16	22S-26E-28	Sheep Draw "28" Federal #13	7/1/1997	Oil Well	Air drilled the first 358 ft.

Table 4: Shallow Well Status in the Delaware Basin

Well Type	Texas	New Mexico	Totals
Brine Well	4	3	7
Core Hole	31	2	33
Drilling or Waiting on Paperwork	0	0	0
Dry Hole	378	153	531
Gas Well	15	0	15
Injection Well	1	0	1
Junked and Abandoned Well	63	0	63
Oil Well	127	14	141
Oil and Gas Well	6	0	6
Plugged Brine Well	2	2	4
Plugged Gas Well	2	8	10
Plugged Oil	27	75	102
Plugged Oil and Gas Well	1	0	1
Plugged Salt Water Disposal Well	1	7	8
Potash Core Hole	0	951	951
Salt Water Disposal Well	1	1	2
Service Well	1	0	1
Stratigraphic Test Hole	1,170	0	1,170
Sulfur Core Hole	502	61	563
Water Well		1,244	1,244
WIPP Well/Boring	0	207	207
Other (Mine Shafts, Gnome Project Wells)	0	0	0
TOTALS	2,332	2,728	5,060

Table 5: Deep Well Status in the Delaware Basin

Well Type	Texas	New Mexico	Totals
Brine Well	13	0	13
Core Hole	36	0	36
Drilling or Waiting on Paperwork	26	0	26
Dry Hole	2,224	803	3,027
Gas Well	4,122	2,070	6,192
Injection Well	1,081	37	1,118
Junked and Abandoned Well	56	0	56
Oil Well	10,595	7,273	17,868
Oil and Gas Well	1,174	0	1,174
Plugged Brine Well	3	2	5
Plugged Gas Well	1,139	420	1,559
Plugged Injection Well	95	80	175
Plugged Oil Well	1,202	1,226	2,428
Plugged Oil and Gas Well	61	0	61
Plugged Salt Water Disposal Well	6	114	120
Potash Core Hole	0	137	137
Salt Water Disposal Well	447	305	752
Service Well	59	0	59
Stratigraphic Test Hole	44	13	57
Sulfur Core Hole	85	0	85
Water Well	3	0	3
WIPP Well	0	13	13
Other (Mine Shafts, Gnome Project Wells)	0	0	0
TOTALS	22,471	12,492	34,964

NOTE: The 26 Texas wells under the “Drilling or Waiting on Paperwork” category have a depth associated with them which classifies them as deep wells, but the paperwork classifying these wells as oil, gas, or some other type of well have yet to be posted. When posted, the classification of these types of wells will be changed.

Table 6: Drilling Rates for the Delaware Basin

Reporting Period September 1 – August 31	Number of Deep Boreholes	Drilling Rate Boreholes/km^2
1996	10,804 Boreholes Deeper Than 2,150 ft.	46.8
1997	11,444 Boreholes Deeper Than 2,150 ft.	49.5
1998	11,616 Boreholes Deeper Than 2,150 ft.	50.3
1999	11,684 Boreholes Deeper Than 2,150 ft.	50.6
2000	11,828 Boreholes Deeper Than 2,150 ft.	51.2
2001	12,056 Boreholes Deeper Than 2,150 ft.	52.2
2002[1]	12,139 Boreholes Deeper Than 2,150 ft.	52.5
2003	12,316 Boreholes Deeper Than 2,150 ft.	53.3
2004	12,531 Boreholes Deeper Than 2,150 ft.	54.2
2005	12,819 Boreholes Deeper Than 2,150 ft.	55.5
2006	13,171 Boreholes Deeper Than 2,150 ft.	57.0
2007	13,520 Boreholes Deeper Than 2,150 ft.	58.5
2008	13,824 Boreholes Deeper Than 2,150 ft.	59.8
2009	14,173 Boreholes Deeper Than 2,150 ft.	61.3
2010	14,403 Boreholes Deeper Than 2,150 ft.	62.3
2011	14,816 Boreholes Deeper Than 2,150 ft.	64.1
2012	15,558 Boreholes Deeper Than 2,150 ft.	67.3
2013	16,633 Boreholes Deeper Than 2,150 ft.	72.0
2014	17,937 Boreholes Deeper Than 2,150 ft.	77.6
2015	19,424 Boreholes Deeper Than 2,150 ft.	84.1
2016	20,429 Boreholes Deeper Than 2,150 ft.	88.4
2017	21,581 Boreholes Deeper Than 2,150 ft.	93.4
2018	22,886 Boreholes Deeper Than 2,150 ft.	99.1
2019	24,408 Boreholes Deeper Than 2,150 ft.	105.7
2020	28,669 Boreholes Deeper Than 2,150 ft.	124.1
2021	34,839 Boreholes Deeper Than 2,150 ft.	151.3

Table 7: Castile Brine Encounters in the Vicinity of the WIPP Site

No.	Location	Well Name and No.	Spud Date	Status	Well Information
Original CCA-related Castile Brine Encounters - 1896 Through June 1995					
1	21S-31E-26	Federal #1	10/31/1979	P&A	Identified as encountering Castile Brine.
2	21S-31E-35	ERDA-6	6/13/1975	P&A	Identified as encountering Castile Brine.
3	21S-31E-35	Federal "FT" #1	9/25/1981	P&A	Identified as encountering Castile Brine.
4	21S-31E-36	Lost Tank "AIS" State #1	12/7/1991	Oil Well	Identified as encountering Castile Brine.
5	21S-31E-36	Lost Tank "AIS" State #4	11/19/1991	Oil Well	Identified as encountering Castile Brine.
6	21S-32E-31	Lost Tank SWD #1	11/12/1991	SWD	Identified as encountering Castile Brine.
7	22S-29E-09	Danford Permit #1	5/18/1937	P&A	Identified as encountering Castile Brine.
8	22S-31E-01	Unocal "AHU" Federal #1	4/2/1991	Oil Well	Identified as encountering Castile Brine.
9	22S-31E-01	Molly State #1	9/25/1991	Oil Well	Identified as encountering Castile Brine.
10	22S-31E-01	Molly State #3	10/20/1991	Oil Well	Identified as encountering Castile Brine.
11	22S-31E-02	State "2" #3	11/28/1991	Oil Well	Identified as encountering Castile Brine.
12	22S-31E-11	Martha "AIK" Federal #3	5/6/1991	Oil Well	Identified as encountering Castile Brine.
13	22S-31E-11	Martha "AIK" Federal #4	9/2/1991	Oil Well	Identified as encountering Castile Brine.
14	22S-31E-12	Federal "12" #8	3/28/1992	Oil Well	Identified as encountering Castile Brine.
15	22S-31E-13	Neff "13" Federal #5	2/4/1991	Oil Well	Identified as encountering Castile Brine.
16	22S-31E-17	WIPP-12	11/17/1978	Monitoring	Identified as encountering Castile Brine.
17	22S-32E-05	Bilbrey "5" Federal #1	11/26/1981	Oil Well	Identified as encountering Castile Brine.
18	22S-32E-15	Lechuza Federal #4	12/29/1992	Oil Well	Identified as encountering Castile Brine.
19	22S-32E-16	Kiwi "AKX" State #1	4/28/1992	Oil Well	Identified as encountering Castile Brine.
20	22S-32E-25	Covington "A" Federal #1	2/7/1975	Oil Well	Identified as encountering Castile Brine.
21	22S-32E-26	Culberson #1	12/15/1944	P&A	Identified as encountering Castile Brine.
22	22S-32E-34	Red Tank "34" Federal #1	9/23/1992	Oil Well	Identified as encountering Castile Brine.
23	22S-32E-36	Richardson State #1	7/20/1962	P&A	Identified as encountering Castile Brine.
24	22S-32E-36	Shell State #1	2/22/1964	Oil Well	Identified as encountering Castile Brine.

No.	Location	Well Name and No.	Spud Date	Status	Well Information
25	22S-33E-20	Cloyd Permit #1	9/7/1937	P&A	Identified as encountering Castile Brine.
26	22S-33E-20	Cloyd Permit #2	6/22/1938	P&A	Identified as encountering Castile Brine.
27	23S-30E-01	Hudson Federal #1	2/25/1974	SWD	Identified as encountering Castile Brine.
28	22S-32E-15	Connally Federal 1	4/1/1982	Gas	Identified as encountering Castile Brine.
29	22S-31E-2	Flora AKF State 1	6/14/1995	Oil Well	Identified as encountering Castile Brine.
30	22S-31E-2	Pogo State “2” #2	3/31/1995	Oil Well	Identified as encountering Castile Brine.
Castile Brine Encounters Since July 1995					
1	21S-31E-35	Lost Tank "35" State #4	09/11/2000	Oil Well	Estimated several hundred barrels per hour. Continued drilling.
2	21S-31E-35	Lost Tank "35" State #16	2/6/2002	Oil Well	At 2,705 ft, encountered 1,000 barrels per hour. Shut-in to get room in reserve pit with pressure of 180 psi and water flow of 450 B/H. Two days later no water flow and full returns.
3	22S-31E-02	Graham "AKB" State #8	4/12/2002	Oil Well	Estimated 105 barrels per hour. Continued drilling
4	23S-30E-01	James Ranch Unit #63	12/23/1999	Oil Well	Sulfur water encountered at 2,900 ft. H_2S of 35 ppm was reported in the sulfur water but quickly dissipated to 3 ppm in a matter of minutes. Continued drilling.
5	23S-30E-01	Hudson "1" Federal #7	1/6/2001	Oil Well	Estimated initial flow at 400 to 500 barrels per hour with a total volume of 600 to 800 barrels. Continued drilling.
6	22S-30E-13	Apache "13" Federal #3	11/26/2003	Oil Well	Encountered strong water flow with blowing air at 2,850-3,315 ft. No impact on drilling process.
7	21S-31E-34	Jacque "AQJ" State #7	3/4/2005	Oil Well	Encountered water flow of 104 barrel per hour at 2,900 ft. No impact on drilling process.
8	22S-30E-13	Apache 13 Fed 8H	8/19/2005	Oil Well	Encountered a severe H_2S water flow.
9	23S-30E-1	James Ranch Unit 108H	12/6/2009	Oil Well	Encountered salt water flow occurred at 2,894 ft.
10	21S-31E-35	Lost Tank 36 Stae SWD #1	6/28/2013	SWD	Encountered H_2S influx from 2,678-3,004 ft then shut in on well.

Table 8: Plugged Well Information

DPA Plugged Well Information for Reporting Period 9/1/2020 through 8/31/2021							
No.	**Location**	**API#**	**Plug Date**	**Type**	**Well Depth**	**Plug Depth**	**Plug Length**
1	660 FS-660 FW 23S-31E-11	30-015-37580	5/1/2020	II	8,400	CIBP @ 8,110-4,910 4,910-1,980 1,950-725 140 – SURFACE	3,200 ft. 2,930 ft. 1,225 ft. 140 ft.
2	2310 FS – 1650 FW 23S-31E-36	30-015-28521	3/17/2020	I	8,672	CIBP @ 6,750-6,500 5,287-4,540 1,200-838 160 - SURFACE	250 ft. 747 ft. 362 ft. 160 ft.
3	660 FN-1980 FW 23S-31E-02	30-015-35674	2/18/2020	VI	8,515	CISP @ 6,207-4,500 4,393-2,900 2,602-750 612-100 100-SURFACE	1,707 ft. 1,493 ft. 1,852 ft. 512 ft.

Table 9: Seismic Activity in the Counties of the Delaware Basin

County	No. of Total Events	Earliest Event	Latest Event	Smallest Magnitude	Largest Magnitude
Brewster	100	7/06/1983	5/10/2020	1.10	3.80
Culberson	5,541	3/06/1962	12/31/2020	0.19	4.07
Eddy	511	7/17/1926	12/27/2020	0.07	4.00
Jeff Davis	97	8/16/1931	5/17/2020	0.59	4.00
Lea	262	9/19/1976	12/27/2020	0.20	3.10
Loving	182	2/4/1976	12/25/2020	0.66	2.48
Pecos	419	1/30/1975	12/09/2020	0.70	3.20
Reeves	2,158	2/19/1976	12/31/2020	0.46	3.20
Ward	304	8/05/1976	12/17/2020	0.08	3.60
Winkler	107	8/14/1964	12/03/2020	0.86	3.80
TOTAL	9,681				

KEY:

Magnitude

Less than 2 Very seldom ever felt
2.0 to 3.4 Barely felt
3.5 to 4.2 Felt as a rumble
4.3 to 4.9 Shakes furniture; can break dishes
5.0 to 5.9 Dislodges heavy objects; cracks walls
6.0 to 6.9 Considerable damage to buildings
7.0 to 7.3 Major damage to buildings; breaks underground pipes
7.4 to 7.9 Great damage; destroys masonry and frame buildings
Above 8.0 Complete destruction; ground moves in waves

Table 10: Nine-Township Injection and SWD Well Information

#	Location	API#	Status	Injection Zone	First Injection	Last Injection	Cumulative Bbl
1	21S-31E-33	30-015-29330	SWD	4,166-5,160	1998	July 2021	13,785,914
2	21S-31E-35	30-015-40890	SWD	4,355-6,320	2014	July 2021	4,185,015
3	21S-32E-08	30-025-31412	SWD	4,826-5,978	1991	July 2021	20,068,804
4	21S-32E-31	30-025-31443	SWD	4,618-6,012	1992	July 2021	9,332,534
5	21S-32E-35	30-025-44273	SWD	15,900-17,250	2018	August 2021	11,227,154
6	22S-30E-02	30-015-25758	Injection	7,200-7,264	1993	July 2021	28,630,375
7	22S-30E-02	30-015-26761	Injection	5,600-7,400	1991	July 2021	29,444,791
8	22S-30E-21	30-015-41074	SWD	15,291-16,801	2014	July 2021	26,482,973
9	22S-30E-25	30-015-33439	SWD	5,678-5,930	2010	March 2021	4,846,091
10	22S-30E-36	30-015-45691	SWD	15,610-16,730	2019	July 2021	2,911,278
11	22S-31E-02	30-015-32440	Injection	6,989-7,020	2003	March 2021	3,964,338
12	22S-31E-03	30-015-38254	SWD	5,355-6,137	2012	July 2021	6,959,950
13	22S-31E-12	30-015-26742	SWD	4,574-4,963	2014	June 2019	1,687,410
14	22S-31E-24	30-015-26848	SWD	4,519-5,110	1991	July 2021	17,970,195
15	22S-31E-25	30-015-28281	SWD	5,634-5,987	1995	July 2021	15,555,899
16	22S-31E-35	30-015-26629	SWD	4,500-5,670	1991	August 2021	29,661,089
17	22S-31E-36	30-015-26171	SWD	4,500-5,700	1998	June 2021	11,730,973
18	22S-32E-05	30-025-27620	SWD	8,250-8,602	2004	August 2021	12,396,673
19	22S-32E-06	30-025-31227	SWD	4,626-5,730	2012	August 2021	6,370,366
20	22S-32E-06	30-025-43328	SWD	974-4,482	2018	August 2021	8,806,070
21	22S-32E-07	30-025-31076	SWD	4,676-5,814	1991	July 2021	15,137,508
22	22S-32E-14	30-025-08113	SWD	5,750-6,080	1994	July 2021	7,578,979
23	22S-32E-16	30-025-31644	SWD	5,582-6,380	2010	August 2021	2,500,282
24	22S-32E-16	30-025-31889	SWD	5,240-8,710	1995	August 2021	12,199,507
25	22S-32E-16	30-025-36006	SWD	5,850-6,450	2010	August 2021	3,162,863
26	22S-32E-17	30-025-31926	SWD	6,807-6,828	2007	August 2021	1,918,249
27	22S-32E-21	30-025-08109	SWD	4,755-5,110	1994	July 2021	4,936964
28	22S-32E-27	30-025-32436	Injection	6,831-8,388	1994	July 2021	16,317,001
29	22S-32E-28	30-025-31754	SWD	4,674-5,672	1993	July 2021	8,443,711
30	22S-32E-30	30-025-44106	SWD	3,395-4,528	2017	August 2021	19,907,906
31	22S-32E-31	30-025-20423	SWD	4,734-5,590	1993	June 2021	9,046,338
32	22S-32E-31	30-025-32093	SWD	4,590-5,626	2004	July 2021	1,366,655
33	22S-32E-32	30-025-36004	SWD	6,744-8,518	2010	August 2021	6,552,743
34	22S-32E-32	30-025-36135	SWD	5,850-6,450	2013	August 2021	3,647,563
35	22S-32E-32	30-025-37799	SWD	5,750-6,500	2010	August 2021	5,512,315
36	22S-32E-35	30-025-33149	SWD	4,950-6,252	1995	July 2021	13,338,812
37	23S-30E-16	30-015-20899	SWD	4,433-5,952	2003	July 2021	15,784,789
38	23S-30E-19	30-015-28901	SWD	3,402-3,912	1997	November 2019	3,886405
39	23S-30E-19	30-015-45072	SWD	3,032-3,283	2018	August 2021	14,283,963
40	23S-30E-20	30-015-29549	SWD	4,124-4,774	2006	July 2021	4,148,741
41	23S-30E-22	30-015-33637	SWD	4,510-5,780	2012	July 2021	3,590,627

#	Location	API#	Status	Injection Zone	First Injection	Last Injection	Cumulative Bbl
42	23S-30E-29	30-015-28808	SWD	5,370-6,380	1996	July 2021	8,291,411
43	23S-31E-02	30-015-05840	SWD	4,500-5,700	1997	June 2021	10,564,859
44	23S-31E-02	30-015-29792	SWD	4,500-5,850	1998	June 2021	11,078,607
45	23S-31E-02	30-015-35749	SWD	4,600-5,880	2010	February 2018	4,361,719
46	23S-31E-06	30-015-46432	SWD	N/A	2019	July 2020	N/A
47	23S-31E-08	30-015-32619	SWD	7,900-7,933	2004	May 2021	5,504,717
48	23S-31E-09	30-015-33368	SWD	7,744-7,952	2005	May 2021	6,795,633
49	23S-31E-13	30-015-28904	SWD	5,760-5,862	2005	September 2018	1,103,924
50	23S-31E-15	30-015-43805	SWD	1,180-3,300	2018	August 2021	9,509,637
51	23S-31E-20	30-015-30605	Injection	7,740-7,774	2001	July 2021	14,297,454
52	23S-31E-24	30-015-43806	SWD	16,390-17,500	2018	August 2021	13,449,980
53	23S-31E-25	30-015-28817	SWD	5,776-5,920	2008	December 2020	2,223,461
54	23S-31E-25	30-015-28859	SWD	5,236-5,498	2008	July 2021	1,157,559
55	23S-31E-26	30-015-20277	SWD	4,460-5,134	1992	May 2021	5,562,801
56	23S-31E-26	30-015-20302	SWD	4,390-6,048	1971	October 2020	7,561,352
57	23S-31E-26	30-015-45235	SWD	1,065-4,543	2018	August 2021	5,371,944
58	23S-31E-27	30-015-27106	SWD	4,750-5,720	1998	March 2021	6,999,711
59	23S-31E-28	30-015-26194	SWD	4,295-5,570	1993	July 2021	10,182,596
60	23S-31E-35	30-015-25640	SWD	4,484-5,780	1993	June 2021	11,659,663
61	23S-31E-36	30-015-20341	SWD	5,980-6,560	1994	May 2021	39,606,459
62	23S-32E-01	30-025-36192	SWD	5,468-6,092	2013	May 2019	3,152,490
63	23S-32E-04	30-025-31650	SWD	4,884-5,886	2003	June 2021	6,317,964
64	23S-32E-07	30-025-33398	SWD	4,660-6,270	2009	July 2021	3,489,135
65	23S-32E-14	30-025-26844	SWD	5,496-6,014	1991	July 2021	3,289,135
66	23S-32E-15	30-025-35524	SWD	5,786-5,942	2008	May 2021	1,609,710
67	23S-32E-18	30-025-25017	SWD	16,700-18,000	1975	May 2019	N/A
68	23S-32E-21	30-025-45029	SWD	1,210-4,757	2019	August 2021	801,612
69	23S-32E-23	30-025-33653	SWD	5,950-6,065	2000	May 2021	3,139,759
70	23S-32E-24	30-025-33521	SWD	5,925-6,042	2001	May 2021	2,318,322
71	23S-32E-29	30-025-31515	SWD	4,844-6,160	1992	May 2021	17,990,303
72	23S-32E-31	30-025-32868	SWD	5,150-5,700	1996	November 2020	5,664,376

NOTE: Information collected from New Mexico Oil Conservation Division (OCD) offices in Artesia and Hobbs, New Mexico. Also, cumulative barrels information is collected from the internet site maintained by the New Mexico Institute of Mining and Technology (NMIMT) on behalf of the New Mexico OCD.

Table 11: Brine Well Status in the Delaware Basin

County	Location	API#	Well Name and No.	Operator	Status
Eddy	22S-26E-36	30-015-21842	City Of Carlsbad #WS-1	Key Energy Services, LLC	Plugged Brine Well
Eddy	22S-27E-03	30-015-20331	Tracy #3	Ray Westall	Plugged Brine Well
Eddy	22S-27E-17	30-015-22574	Eugenie #WS-1	I & W Inc.	Active Brine Well
Eddy	22S-27E-17	30-015-23031	Eugenie #WS-2	I & W Inc.	Plugged Brine Well
Eddy	22S-27E-23	30-015-28083	Dunaway #1	Pyote Well Service, LLC	Active Brine Well
Eddy	22S-27E-23	30-015-28084	Dunaway #2	Pyote Well Service, LLC	Active Brine Well
Loving	Blk 29-03	42-301-10142	Lineberry Brine Station #1	Chance Properties Company	Active Brine Well
Loving	Blk 01-82	42-301-30680	Chapman Ford #BR1	Herricks & Son Co.	Plugged Brine Well
Loving	Blk 33-80	42-301-80318	Mentone Brine Station #1D	Basic Energy Services, LP	Active Brine Well
Loving	Blk 29-28	42-301-80319	East Mentone Brine Station #1	Permian Brine Sales, Inc.	Plugged Brine Well
Loving	Blk 01-83	42-301-80320	North Mentone Brine Station #1	Chance Properties Company	Active Brine Well
Reeves	Blk 04-08	42-389-20100	North Pecos Brine Station #WD-1	Chance Properties Company	Plugged Brine Well
Reeves	Blk 07-21	42-389-80476	Coyanosa Brine Station #1	Chance Properties Company	Active Brine Well
Ward	Blk 17-20	42-475-31742	Pyote Brine Station #WD-1	Chance Properties Company	Active Brine Well
Ward	Blk 01-13	42-475-34514	Quito West Unit #207	Seaboard Oil Co.	Active Brine Well
Ward	Blk 34-200	42-475-20329	Barstow Brine Station #1	Basic Energy Services, LP	Active Brine Well
Ward	Blk 34-174	42-475-82265	Barstow Brine Station #1	Energy Equity Company	Active Brine Well
Ward	Blk 34-214	42-475-36227	Brine #1	Mesquite SWD, Inc.	Active Brine Well
Reeves	Blk 56-T2S	42-389-00408	Orla Brine Station	Mesquite SWD, Inc.	Active Brine Well