DOE/WIPP-19-2308

Delaware Basin Monitoring Annual Report

September 2019

United States Department of Energy
Waste Isolation Pilot Plant

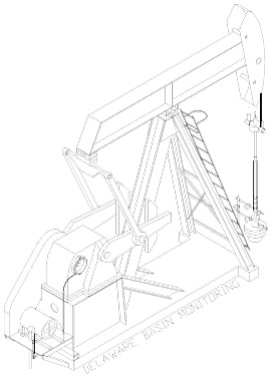
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United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

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

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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 is based on the U.S. Environmental Protection Agency (EPA) criteria in Title 40 Code of Federal Regulations (CFR) Part 194.33. 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). The results of the PA must show the expected long-term repository performance will not result in the release of radioactive material above EPA limits. The PA includes the consideration of inadvertent human intrusion into the repository.

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 definition of the Delaware Basin in 40 CFR § 194.2 is:

"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 DOE continues to provide surveillance of mining and drilling activities in the Delaware Basin in accordance with the criteria established in 40 CFR Part 194. This will continue until the DOE and the EPA mutually agree no further benefit can be gained from continued surveillance. The results of the ongoing surveillance will be used to determine if a substantial and detrimental deviation has occurred that would affect the long-term performance of the disposal system.

The *Delaware Basin Drilling Surveillance Plan* (WP 02-PC.02; NWP 2019) 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. 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 2019 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 future 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. While the presence of pressurized brine under the repository is speculative, it cannot be completely ruled out based on available information. 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 scenario models 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, 2018, to August 31, 2019. 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. 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
- Fraction of each borehole that is plugged
- 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 9 feet to 26,150 feet. The 9-foot hole is a dry hole located outside the nine-township area and the 26,150 foot hole is an oil well located in the New Mexico portion of the Delaware Basin. Borehole depths in the immediate vicinity of the WIPP site have a depth of 846 ft. to 26,150 ft. for oil wells and 8,408 to 25,210 ft. for gas wells.

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 not a reportable element, although hole sizes are reported on Sundry notices (miscellaneous forms) maintained by the New Mexico Oil Conservation Division (NMOCD). The casing size or hole size is used to determine the diameter of the bit used to drill that particular section of the well. In previous years, the most common bit sizes were 17 ½ inches for the surface section, 12 ¼ inches for the intermediate 7 section, and 7 $^{7}/_{8}$ inches for the production section of the hole. This year the common pattern was observed from the surface and intermediate sections, however, 8 ¾ inches bit size was prevalent production section. 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, for a three-string well in the vicinity of the WIPP site, are shown in Figure 2.

2.1.1 DRILLING TECHNIQUES

The drilling techniques reported since the CCA, Appendix DEL are still being implemented by area drillers. There were 384 hydrocarbon wells spudded, not necessarily completed, in the New Mexico portion of the Delaware Basin from September 1, 2018, through August 31, 2019. 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 572 completed wells in this reporting period. The status of these completed wells include oil wells, gas wells, and salt water disposal wells. The 572 wells were conventionally drilled utilizing mud as a medium for circulation. Ninety 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 11,930 feet to 25,210 feet. Outside of the nine-township area the depths of the completed wells range from 5,470 feet to 23,745 feet.

A technique used by operators to increase production is to drill a well horizontally after a target depth for lateral kick-off point is reached, which allows for more of the wellbore area to be in the production zone. 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. The DBDSP monitors directional and horizontally drilled wells only in the nine-township area. All 55 new wells spudded during the reporting period in the nine-township area had horizontally drilled components.

2.1.2 DRILLING FLUIDS

Employing a rotary rig for drilling involves the use of 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 Known Potash Leasing Area (KPLA) 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 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 a common 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 KPLA; (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, 2018, through August 31, 2019) 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.

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, 2019).

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 the the reporting period, there were 2,369 new wells added to the well tracking application. Most of the completed wells were drilled for hydrocarbon extraction and were deep-drilling events. Fifty-five 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 – August 31) drilling rates since the submittal of the CCA in 1996 are shown in Table 6. The large increase between 1996 and 1997 was the result of updating the databases with information from June 1995 through August 1997. 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 2019 was derived from the information provided in Table 5. There were 24,408 boreholes deeper than 2,150 feet. Wells were removed from the count because they were no longer within the 100-year interval. Applying the Deep Drilling Rate formula results in the following:

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

This results in a deep drilling rate of 105.7 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 NINE-TOWNSHIP AREA DRILLING ACTIVITIES

From September 1, 2018, to August 31, 2019, there were 54 new wells spudded in the nine-township area immediately surrounding the WIPP site. Figure 3 shows the status of known hydrocarbon wells drilled within the nine township area.

2.5.2 DRILLING ACTIVITIES OUTSIDE THE NINE-TOWNSHIP AREA

In the New Mexico portion of the Delaware Basin outside of the nine-township area, there were 340 new wells spudded during the reporting period of September 1, 2018, through August 31, 2019. Of the 340 wells, 132 are located in Eddy County and 208 are in Lea County.

In the Texas portion of the Delaware Basin, 21 new wells were spudded during the reporting period. The DBDSP monitors drilling activities in portions of seven counties and all of one county (Loving). The number of spudded wells during the last reporting period in the Texas portion of the Delaware Basin is abnormally low. The DBDSP is behind in gathering these data.

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. DBDSP records indicated that 27 wells encountered pressurized brine in the Castile Formation; of these, 25 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 search of the records performed in 1999 looked for instances of pressurized brine. Although the search of the records noted a number of instances of encounters with sulfur water and brine water, only the original 27 were found to have been pressurized brine encounters in the Castile Formation.

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, 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, 2018, and August 31, 2019.

Seven 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 other encounter was reported by an operator in the Annual Survey of area drillers. 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 8 percent with 27 Castile Brine encounters out of 345 boreholes. In the Performance Assessment Verification Test (PAVT), the EPA mandated a range of 1 percent to 60 percent. These higher values did not influence the predicted performance of the repository. The CRA-2004 continued to use the higher values and a probability for encountering a Castile Brine reservoir was not calculated. The CRA-2009 uses the values from the PAVT. However, due to the increased drilling in the area it was necessary to verify that the original value was still valid. The same parameters were used and the rate was calculated at 5 percent with 34 Castile Brine encounters out of 678 boreholes. For 2019, the same parameters were used and the rate was calculated at 1.4 percent with 34 Castile Brine encounters out of 2,493 boreholes.

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 Known Potash Leasing Area (KPLA), NMOCD R-111-P 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 KPLA and plugging in the vicinity

generally follows this plugging technique, although there are cases in which exemptions to this technique have been granted to the operator by the regulator. Additionally, older plugged wells that pre-date the NMOCD R-111-P regulation may not be plugged in this manner.

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, 2018, to August 31, 2019. For analyzing plugging types, data from the KPLA portion of the 9-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 KPLA.

There were 23 wells plugged during the reporting period that lie within the KPLA 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 2,021 seismic events recorded in the counties of the Delaware Basin. Thirteen hundred thirty-four seismic events occurred in Culberson County with magnitudes between 0.36 and 2.64. Twenty-one events were recorded in Eddy County with magnitudes from 0 .25 to 1.77. One seismic event was recorded in Jeff Davis County with a magnitude of 1.72. Sixteen seismic events were recorded in Lea County with magnitudes from 0.64 to 1.77. Twenty-eight seismic events were recorded in Loving with a magnitude range from 1.01 to 1.78. Forty-one seismic events were recorded in Pecos County with a magnitude range from 1.31 to 2.47. Five Hundred fifteen seismic events occurred in Reeves County with a magnitude range from 0.64 to 2.54. Sixty-three seismic events were recorded in Ward County with a magnitude of 1.17 to 2.43. One seismic event was recorded in Winkler with a magnitude of 1.48. 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. Operators of SWD wells generally seek to maintain low injectivity pressure and thereby minimize pumping costs. Such preferred lower pressures further reduce the potential for fracturing and migration out-of-zone (Hall 2018).

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, 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 nearby CO_2 flooding potential to 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 six injection wells located in the nine-township area surrounding the WIPP site.

ConocoPhillips Company operates two injection wells northwest of the site in the Cabin Lake field. The other four injection wells are operated by *OXY USA INC* and are located south and east of the site. The six wells are injecting into the Brushy Canyon Formation of the Delaware

Mountain Group at a depth of approximately 7,200 feet. 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.

There are currently 64 SWD 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. During the last year, based on injection records, the three companies operated within their maximum permitted injection pressure. 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, and halite (NMBMMR 1995).

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.

In August 1996, *Mississippi Potash* (a subsidiary of *Mississippi Chemical Corporation*) purchased the assets of *New Mexico Potash Corporation* and *Eddy Potash, Inc.* These plants were renamed Mississippi East and Mississippi North, respectively. In early 2004, *Mississippi Potash* sold its Carlsbad properties to *Intrepid Mining LLC*, a Denver based mining company. Recently the company changed the name to *Intrepid Potash – New Mexico, LLC.* The former *Eddy Potash, Inc.* mine (Mississippi North) has been shut down. In July 2016 *Intrepid Potash –New Mexico, LLC* idled their west location and transitioned it into "maintenance mode". In addition, they have relinquished their mineral easements below the Eddy-Lea County Consortium.

The other potash producer in the area is *The Mosaic Company*, formerly known as *IMC Kalium Potash*, which was a wholly-owned subsidiary of *IMC Global*. *Western Ag-Minerals* was purchased by *IMC Global* in September 1997. This acquisition doubled the potash reserves for *IMC Kalium*. *IMC Global* merged with *Freeport-McMoRan*, a major world potash producer, in December 1997 with *IMC Global* as the surviving entity in the transaction. In 2004, *IMC Global* and *Cargill, Inc.* merged to form *The Mosaic Company.*

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 several brine mines or wells in the area, 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.

A moratorium on new brine wells was enacted by the NMOCD in mid-November 2008 due to the collapse of two brine wells in the vicinity of Loco Hills, New Mexico, neither of which are located in the Delaware Basin. One well was in an isolated area and was actively producing brine for sale. This well collapsed in July 2008. The second well that collapsed was located just outside of Loco Hills and was plugged and abandoned. This well collapsed in early November. 2008.

Brine wells are being monitored by the NMOCD as they fit the geological profile of the two collapsed wells. 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 is due by 11/6/2019 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.

In early 1997, *Mississippi Potash, Inc.* proposed to set up a pilot potash solution mining project at the former *Eddy Potash, Inc.* mine located north of the WIPP site and outside of the Delaware Basin. In March 2002, *Mississippi Potash, Inc.* applied for a permit to operate a pilot in-situ potash solution mining project. In May 2002, the project was given approval to proceed by the BLM. *Intrepid Potash*, formerly *Mississippi Potash, Inc.*, has continued with the project by developing a required EIS, which was approved by the BLM on March 19, 2012. The in-situ solution mining project is currently extracting potash enriched brine from the former *Eddy Potash, Inc.* mine and evaporating the brine in surface ponds. After evaporation of potash enriched brine occurs, the ponds will be ready for potash production.

In the late 1960s, *Conoco Minerals* installed a pilot solution mining project on leases it held on the former *AMAX* property north of the Delaware Basin and the WIPP site. The project was designed to test solution mining of potassium minerals and consisted of one injection well and three withdrawal wells, but the potash ore zone was deemed too thin to make this method viable at this location.

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. Horizontal development accounts for nearly all new well drilling in the Delaware and Bone Spring formations. The rate of drilling for the Delaware Mountain Group (Cherry Canyon, Brushy Canyon) oil wells is delayed for several years as horizontal wells offer more favorable economic returns (Hall 2018). In the Delaware Basin, oil producers are moving from completing SWD wells in the Delaware Mountain Group, to completing them deeper, in the Devonian.

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 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 - 2019 DELAWARE BASIN DRILLING SURVEILLANCE PROGRAM

- No new instances of air drilling.
- No Castile Brine encounters reported.
- The drilling rate increased to 105.7 boreholes per square kilometer from 99.0 boreholes per square kilometer reported in the 2018 annual report (DOE 2018).
- Two new SWD wells were completed in the nine-township area compared to twenty-nine SWD wells reported in the 2018 annual report (DOE 2018).
- Fifty-four wells were spudded in the nine-township area compared to four wells in the 2018 annual report (DOE 2018).
- Two hundred sixty-two wells were spudded outside the nine-township area in the Delaware Basin compared to 157 wells in the 2018 annual report (DOE 2018).
- In the Texas portion of the Delaware Basin 21 wells were spudded. The number of reported spudded wells in the Texas portion of the Delaware Basin is abnormally low. The DBDSP is behind in gathering these data.

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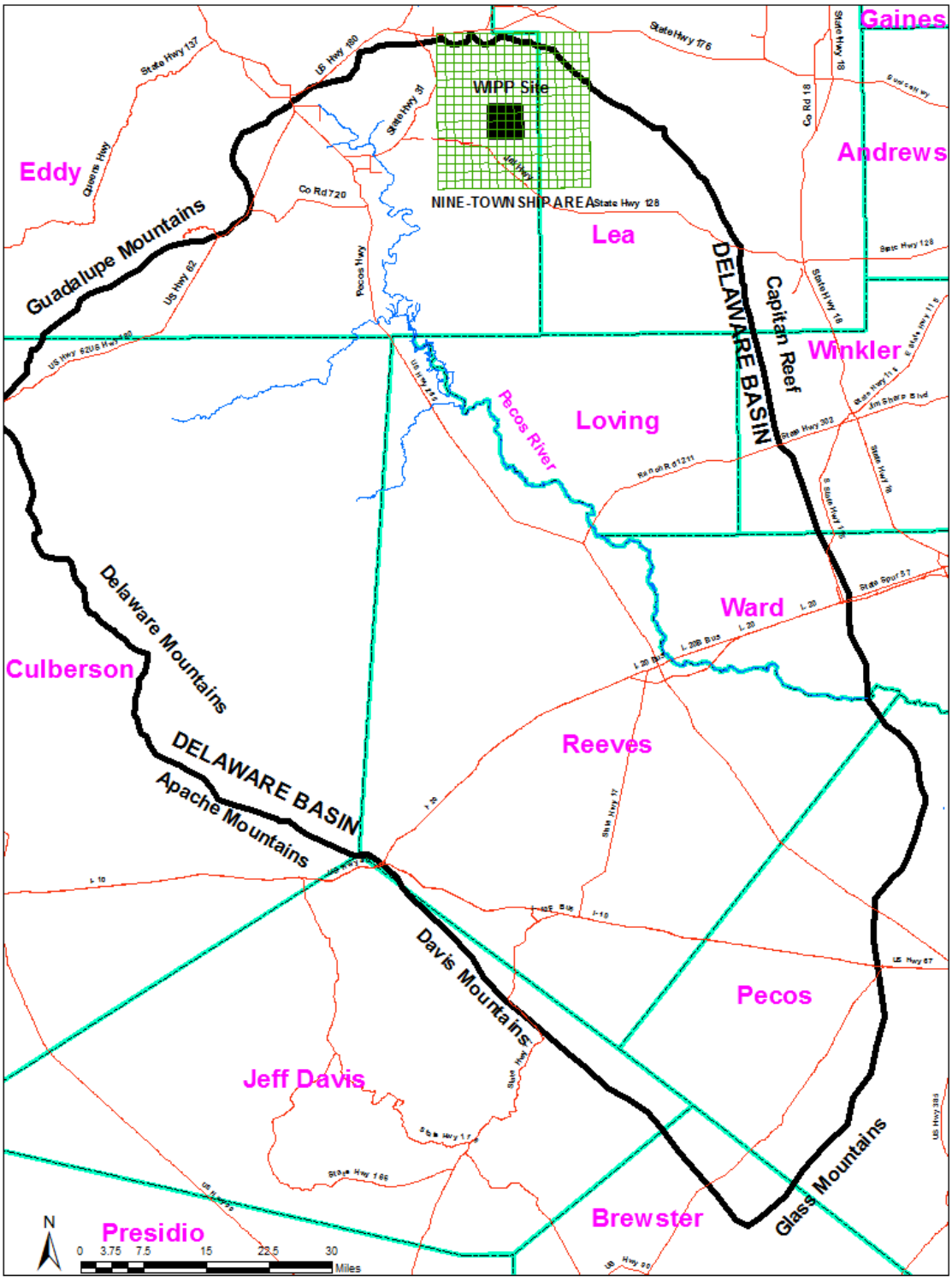


Figure 1: WIPP Site, Delaware Basin, and Surrounding Area

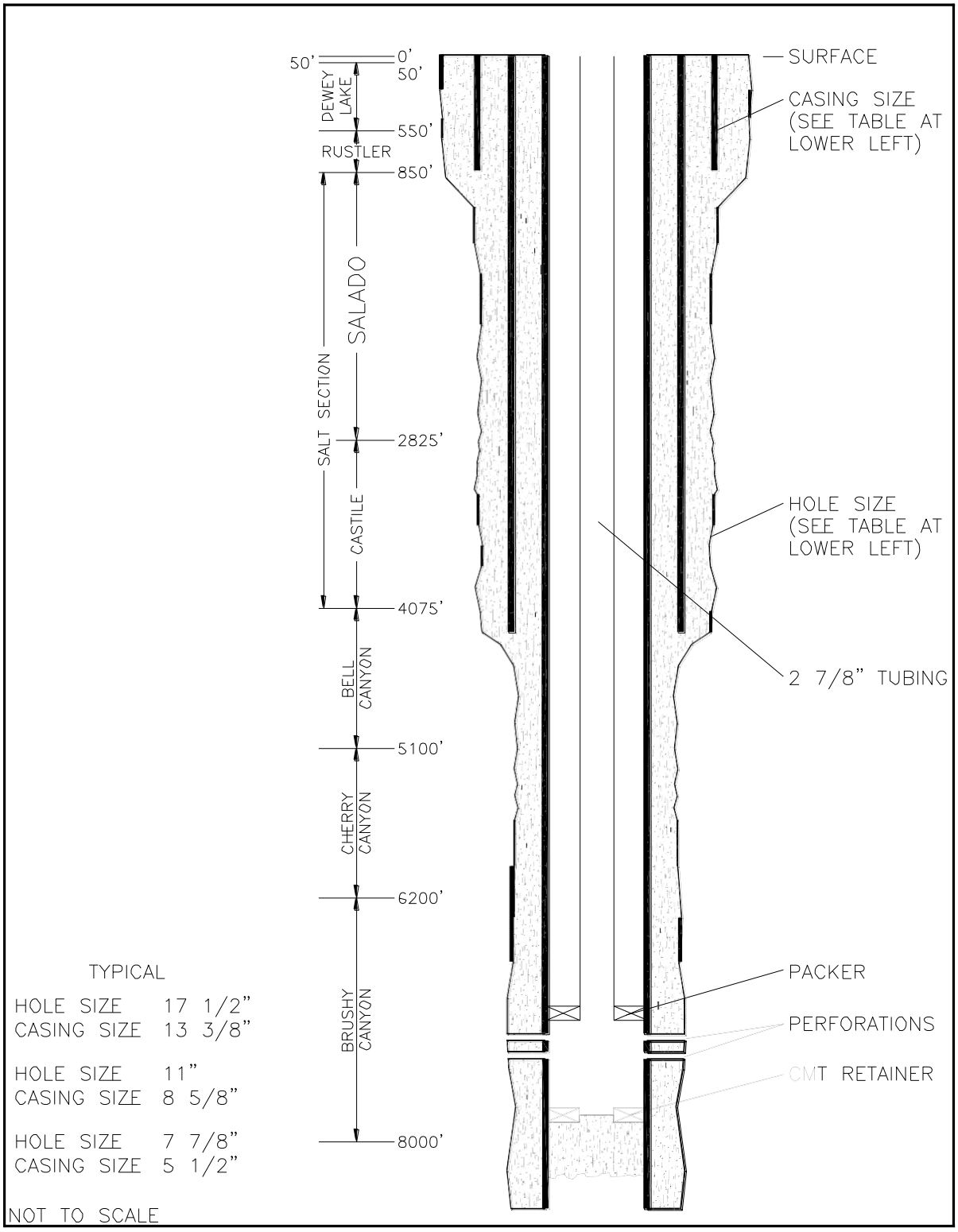


Figure 2: Typical Well Structure and General Stratigraphy Near the WIPP Site

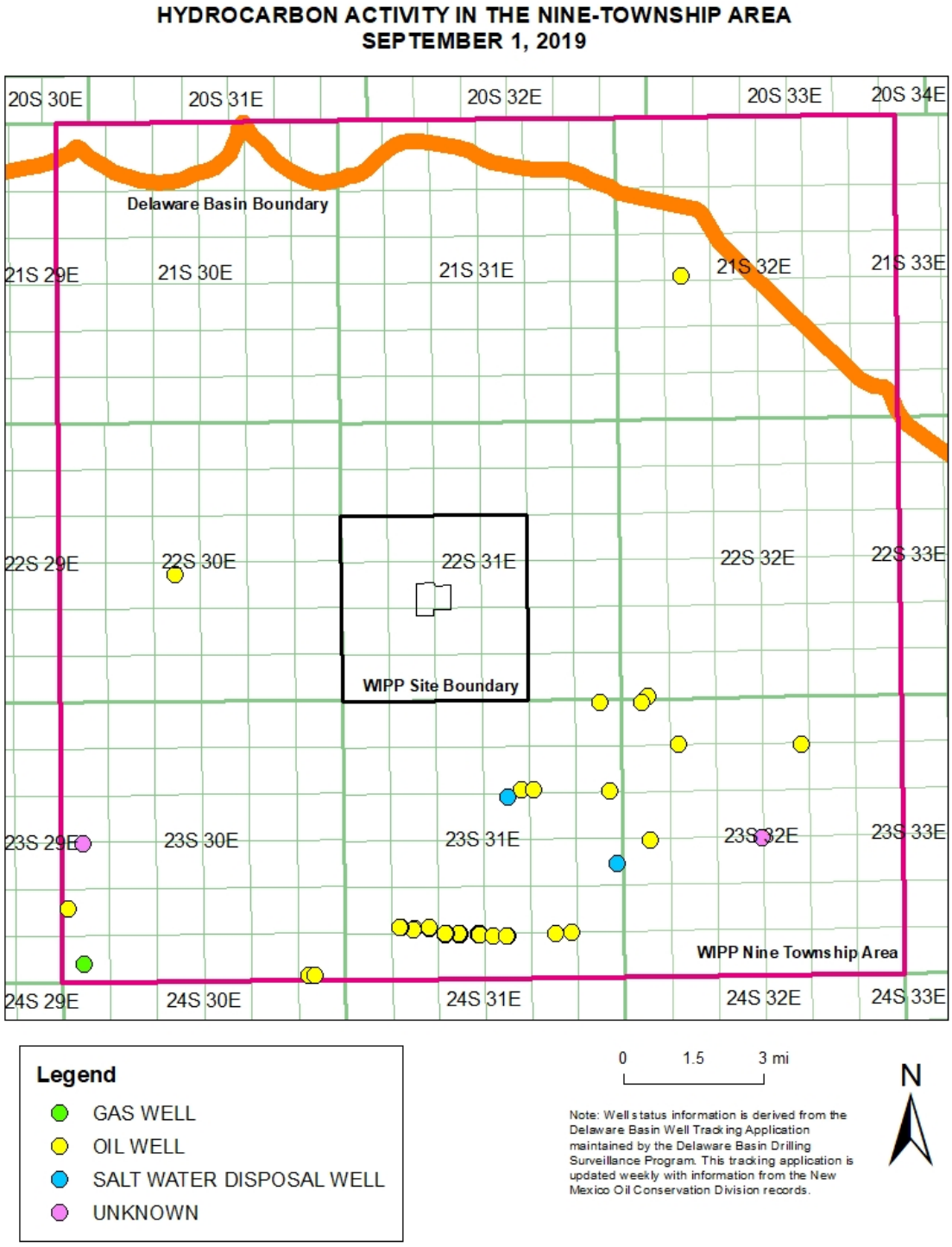


Figure 3: Hydrocarbon Activity in the Nine-Township Area

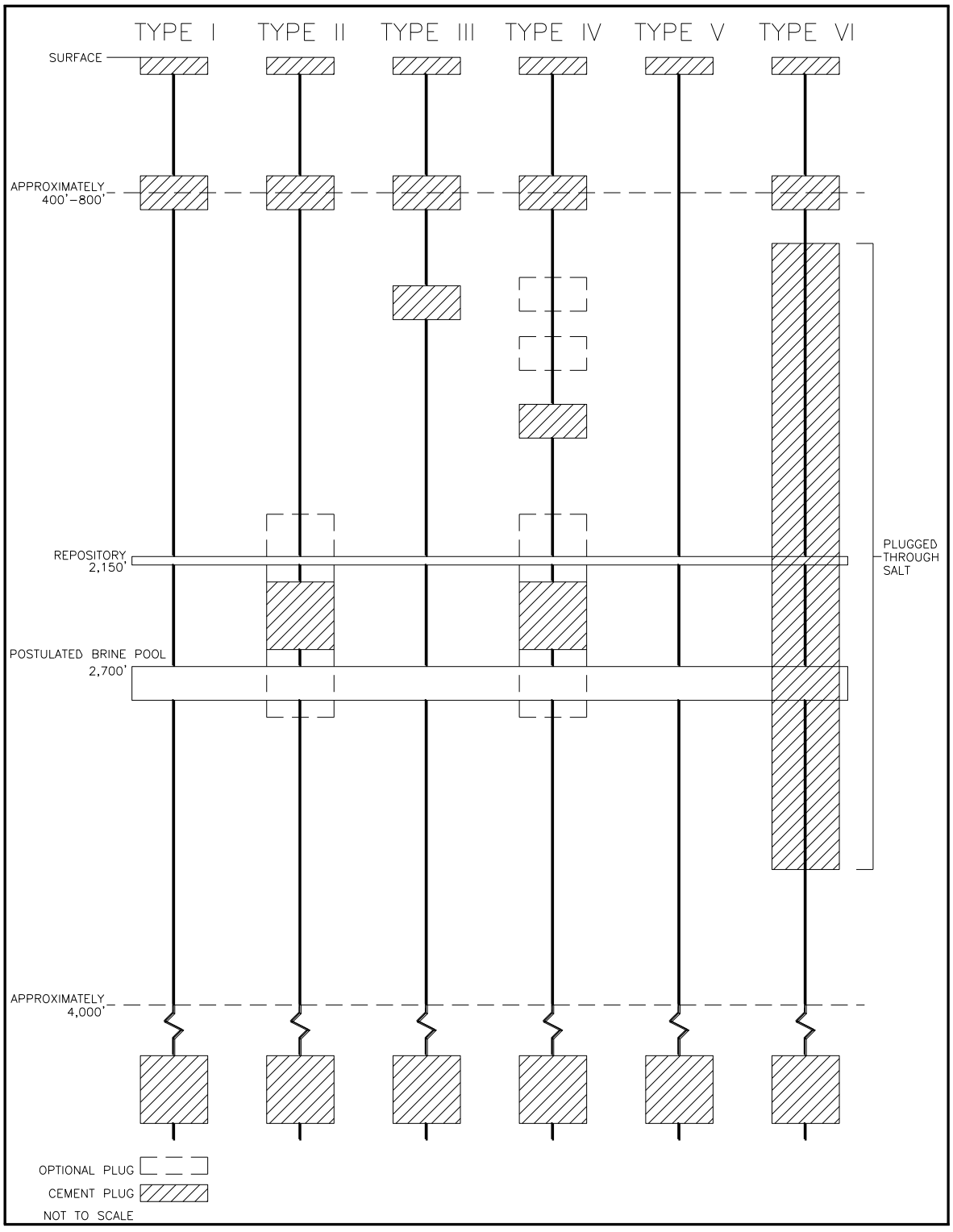


Figure 4: Typical Borehole Plug Configurations in the Delaware Basin

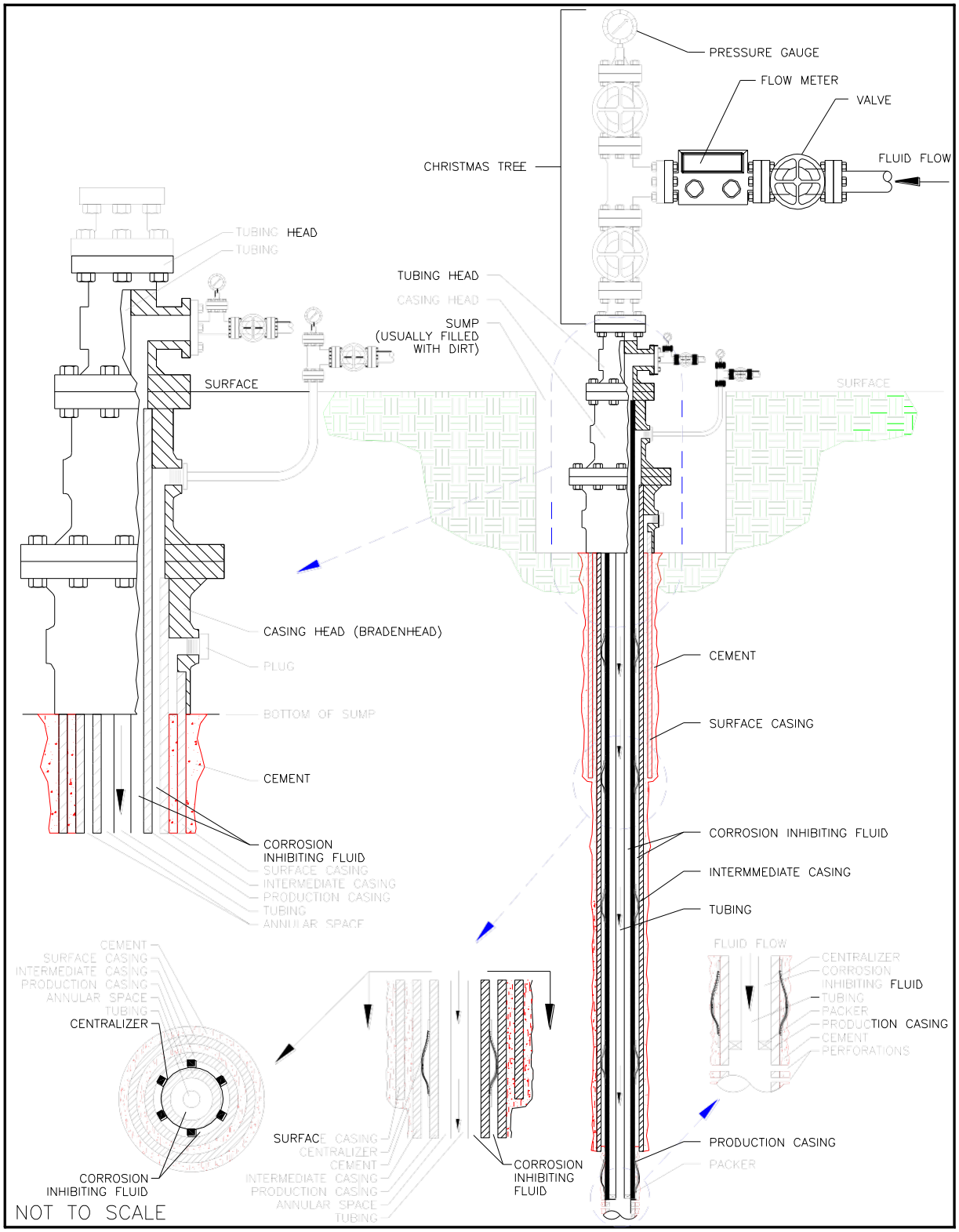


Figure 5: Typical Injection or SWD Well

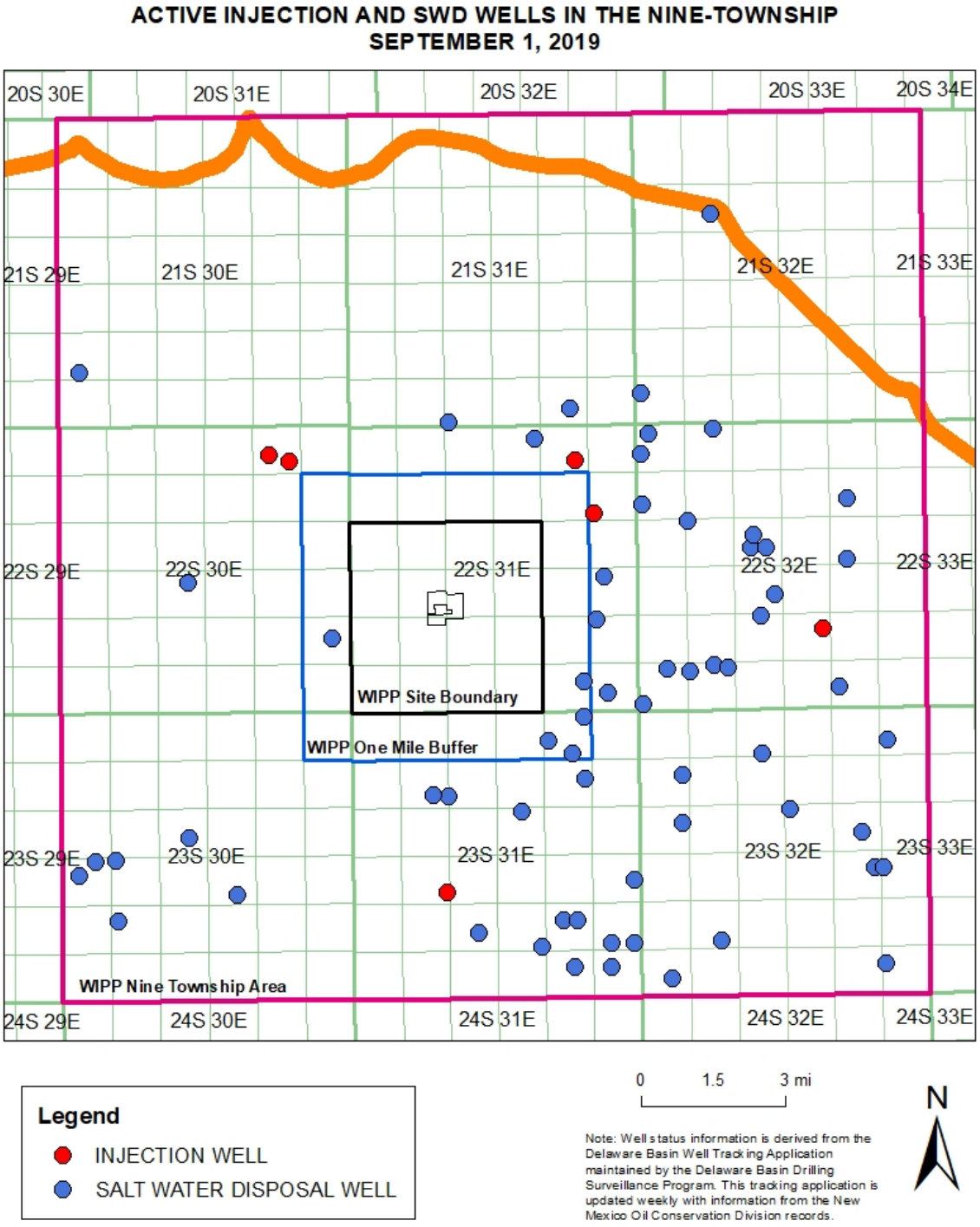


Figure 6: Active Injection and SWD Wells in the Nine-Township Area

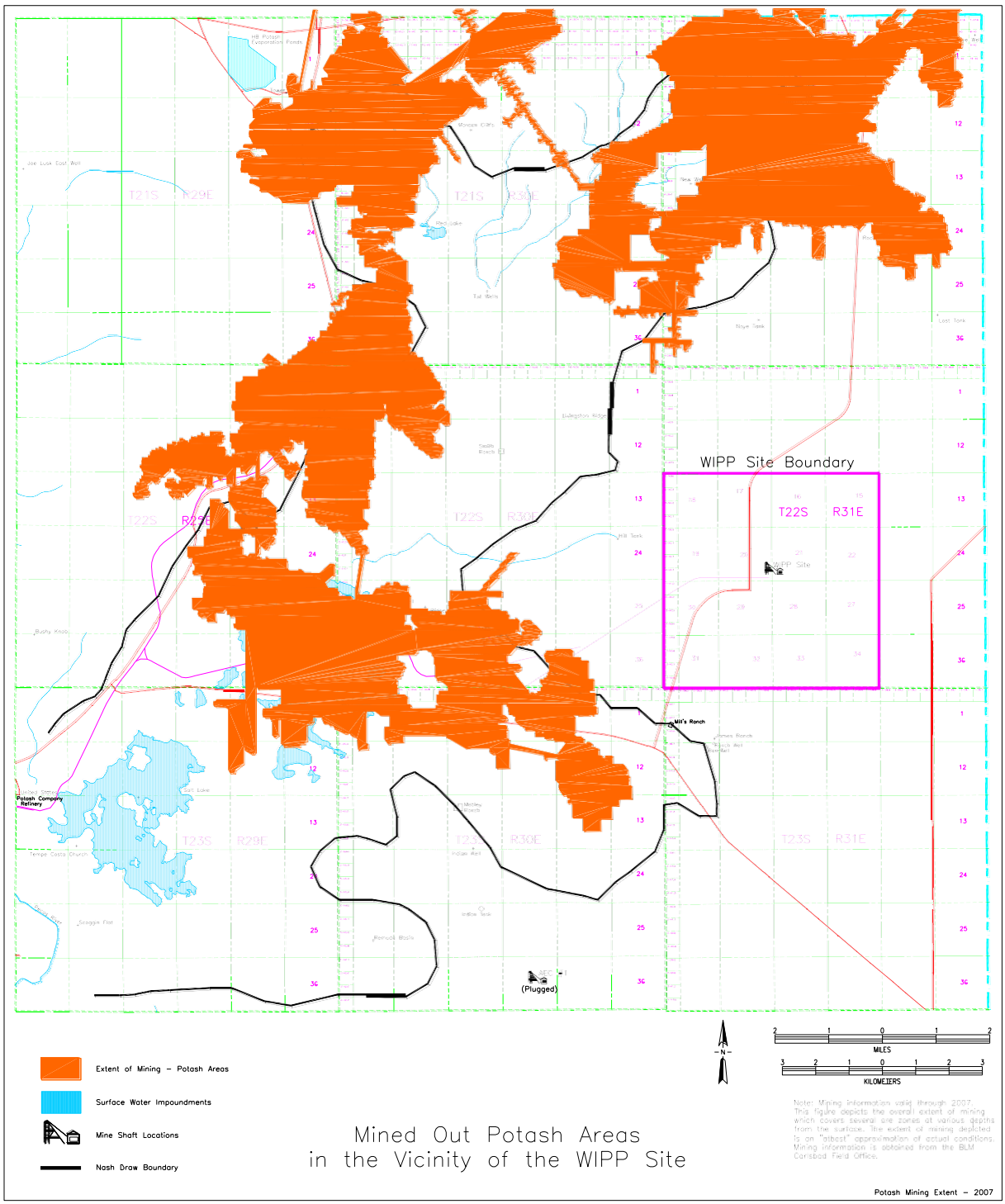


Figure 7: Potash Mining in the Vicinity of the WIPP Site

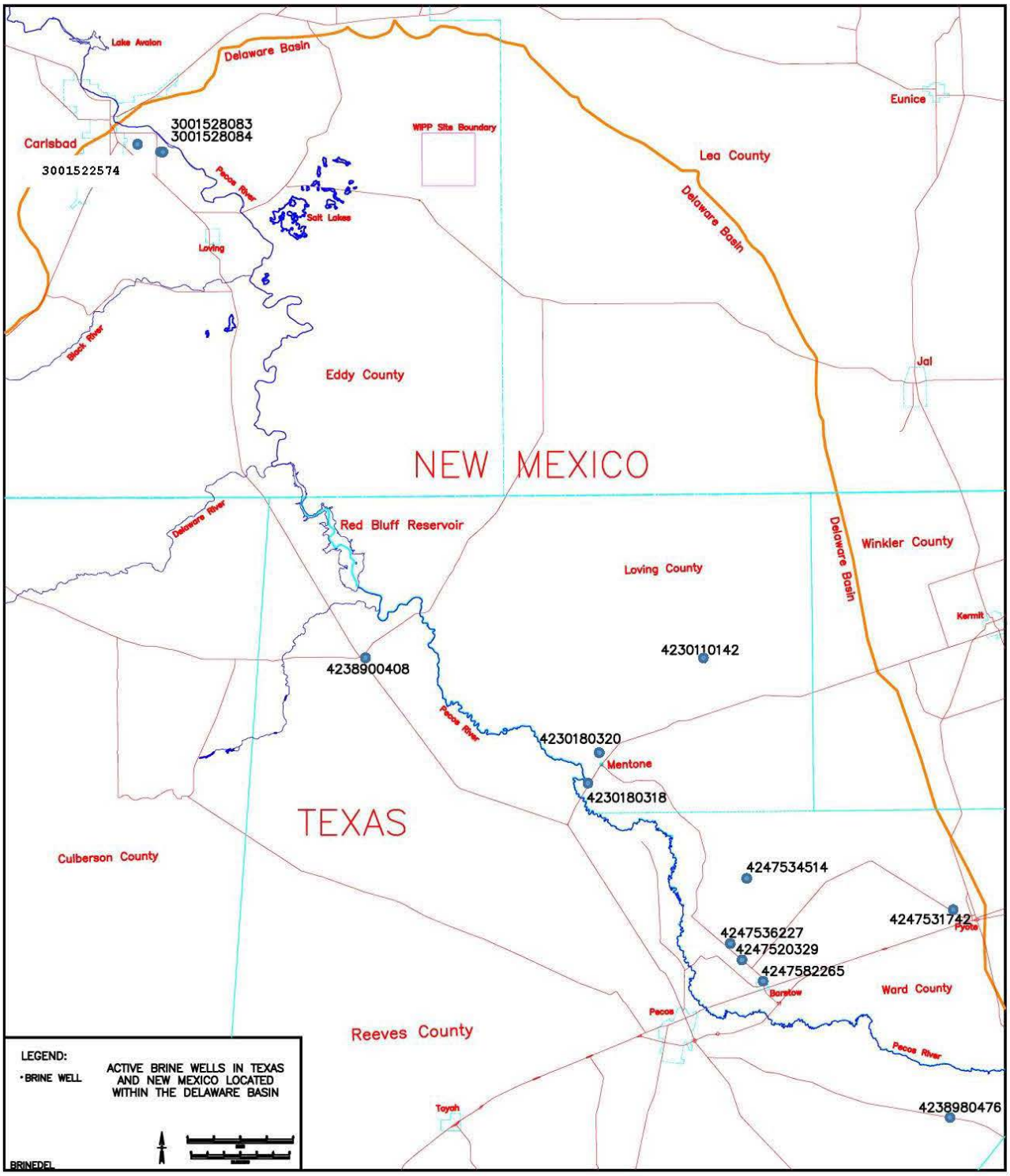


Figure 8: Active Brine Well Locations in the Delaware Basin

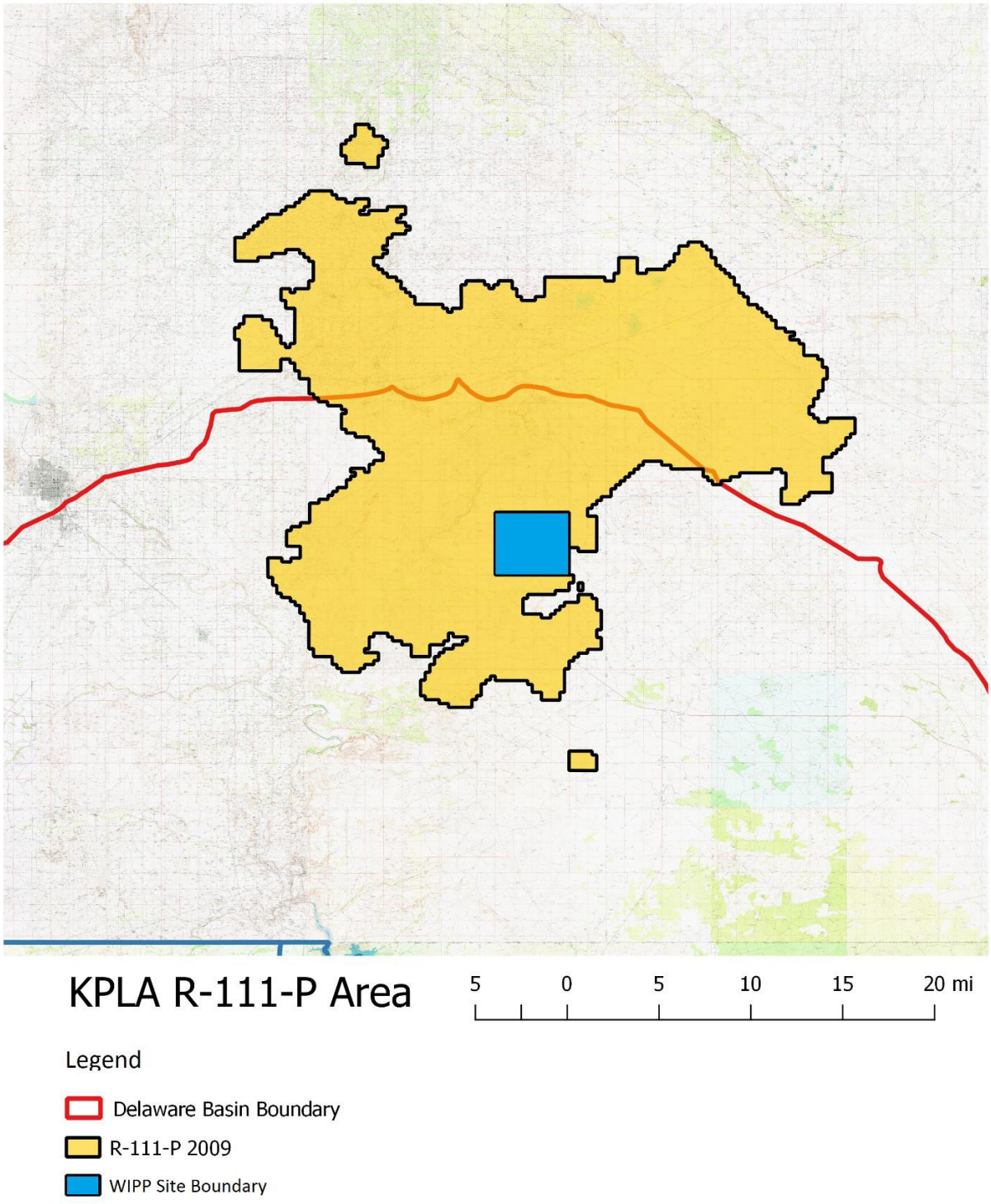


Figure 9: Known Potash Leasing Area – R-111-P

Table 1: Nine-Township Area Casing Sizes

Casing Size	Surface Casing	Intermediate Casing	Production Casing
20	2	0	0
18 5/8	1	0	0
16	3	0	0
13 3/8	45	3	0
11 3/4	0	3	0
10 3/4	4	0	0
9 5/8	0	45	3
8 5/8	0	0	3
7 5/8	0	4	20
7	0	0	4
5 1/2	0	0	25

NOTE: There were 55 wells drilled in the nine-township area between September 1, 2018, and August 31, 2019.

Table 2: Nine-Township Area Bit Sizes

Bit Size	Surface Hole	Intermediate Hole	Production Hole
26	2	0	0
24	1	0	0
20	0	0	0
18 1/2	3	0	0
17 1/2	45	3	0
16	0	0	0
14 3/4	4	3	0
12 3/4	0	0	0
12 1/4	0	45	3
11	0	0	0
10 5/8	0	0	3
9 7/8	0	4	0
8 3/4	0	0	25
8 1/2	20	0	20
7 7/8	0	0	0
7 3/4	0	0	0
7	0	0	0
6 3/4	0	0	4
6 1/8	0	0	0

NOTE: There were 55 wells drilled in the nine-township area between September 1, 2018, and August 31, 2019. All of the wells had 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 4,725 ft.
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	1	3	4
Core Hole	31	2	33
Drilling or Waiting on Paperwork	1,853	52	1,905
Dry Hole	397	159	556
Gas Well	19	34	53
Injection Well	3	0	3
Junked and Abandoned Well	64	34	98
Oil Well	153	21	174
Oil and Gas Well	49	0	49
Plugged Brine Well	2	2	4
Plugged Gas Well	1	6	7
Plugged Oil	30	47	77
Plugged Oil and Gas Well	2	0	2
Plugged Salt Water Disposal Well	0	5	5
Potash Core Hole	0	1,791	1,791
Salt Water Disposal Well	6	2	8
Service Well	12	0	12
Stratigraphic Test Hole	1,170	0	1,170
Sulfur Core Hole	502	0	502
Water Well	1,706	1,244	2,950
WIPP Well	0	210	210
Other (Mine Shafts, Gnome Project Wells)	0	31	31
TOTALS	6,001	3,643	9,644

NOTE: Only the known holes that occur in the Delaware Basin are listed in the above table. The 1,905 wells under the "Drilling or Waiting on Paperwork" category do not have an associated depth until one has been reported on paperwork. These are listed as shallow wells but may eventually be placed in the deep classification when a depth has been listed in the paperwork.

Table 5: Deep Well Status in the Delaware Basin

Well Type	Texas	New Mexico	Totals
Brine Well	9	0	9
Core Hole	4	0	4
Drilling or Waiting on Paperwork	30	9	39
Dry Hole	2,186	803	2,989
Gas Well	2,023	1,194	3,217
Injection Well	393	44	437
Junked and Abandoned Well	56	20	76
Oil Well	8,174	4,810	12,984
Oil and Gas Well	722	0	722
Plugged Brine Well	1	1	2
Plugged Gas Well	339	323	662
Plugged Injection Well	95	73	168
Plugged Oil Well	1,204	914	2,118
Plugged Oil and Gas Well	61	0	61
Plugged Salt Water Disposal Well	6	74	80
Potash Core Hole	0	108	108
Salt Water Disposal Well	281	243	524
Service Well	58	0	58
Stratigraphic Test Hole	44	2	46
Sulfur Core Hole	85	0	85
Water Well	4	0	4
WIPP Well	0	11	11
Other (Mine Shafts, Gnome Project Wells)	0	4	4
TOTALS	15,775	8,633	24,408

NOTE: The 39 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	19,313 Boreholes Deeper Than 2,150 ft.	83.6
2016	20,425 Boreholes Deeper Than 2,150 ft.	88.4
2017	21,580 Boreholes Deeper Than 2,150 ft.	93.4
2018	22,886 Boreholes Deeper Than 2,150 ft.	99.0
2019	24,408 Boreholes Deeper Than 2,150 ft.	105.7

NOTE: The increase in the drilling rate between 1996 and 1997 was not due to the drilling of wells, but to the fact that the Delaware Basin Drilling Surveillance Program did not begin until 1997 when a review of the records from July 1995 through 1997 was necessary to bring the databases up to date.

1 In Rev. 3 of this report dated September 2002, the drilling rate for 2002 was shown as 52.9 with 12,219 deep holes. While reviewing the databases to develop reports for the Compliance Recertification Application, it was noticed that 80 shallow wells in Texas were listed as being deep. The classification of the 80 holes to shallow resulted in a reduction in the drilling rate from 52.9 to 52.5. This was reported in December 2002.

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

#	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.
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.

#	Location	Well Name and No.	Spud Date	Status	Well Information
27	23S-30E-01	Hudson Federal #1	2/25/1974	SWD	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. 35 ppm was reported 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.

Table 8: Plugged Well Information

KPLA Plugged Well Information for Reporting Period 9/1/18 – 8/31/19							
#	**Location**	**API#**	**Plug Date**	**Type**	**Well Depth**	**Plug Depth**	**Plug Length**
1	660 FS-2310 FW	30015269730000	8/2/2019	VI	8,325	CIBP @ 6715 – 6087 4362 – 3010 2785 – 1673 100 – SURFACE	628 ft. 1352 ft. 1112 ft. 100 ft.
2	1980 FS-1650 FE	30015301670000	7/17/2019	VI	8,150	CIBP @ 6826 – 6369 5860 – 5392 4130 - SURFACE	457 ft. 468 ft. 4130 ft.
3	1140 FN-990 FW	30015279140000	7/8/2019	VI	8,150	CIBP @ 7818 – 7783 4604 – 3623 3600 – 938 938 - SURFACE	35 ft. 981 ft. 2662 ft. 938 ft.
4	760 FS-330 FE	30015296910000	6/21/2019	VI	8,100	3600 – 3500 3000 - SURFACE	100 ft. 3000 ft.
5	330 FN-330 FE	30015353160000	6/19/2019	II	8,290	CIBP @ 7830 – 7604 5838 – 5535 4300 – 3213 2101 – 330 100 - SURFACE	226 ft. 303 ft. 1087 ft. 1771 ft. 100 ft.
6	200 FN-1830 FE	30015363680000	6/13/2019	VI	12,402	CIBP @ 7500 – 7248 6153 – 5850 4250 - SURFACE	252 ft. 303 ft. 4250 ft.
7	1980 FN-760 FE	30015300430000	6/7/2019	III	8,400	CIBP @ 8100 – 7901 6560 – 6316 4440 – 3926 970	199 ft. 244 ft. 514 ft. 970 ft.
8	330 FN-330 FW	30015353140000	6/7/2019	VI	8,254	CIBP @ 7800 – 7605 4900 – 4648 4300 – 3934 3934 – 664 100 - SURFACE	195 ft. 252 ft. 366 ft. 3270 ft. 100 ft.
9	1980 FN-1651 FE	30015353570000	6/1/2019	VI	8,300	8240 – 7334 4471 – 3240 3240 - SURFACE	906 ft. 1231 ft. 3240 ft.
10	1980 FN-660 FW	30015257730000	5/9/2019	VI	15,220	13583 – 12609 12050 – 10915 9953 – 9644 8198 – 7888 5979 – 5716 4407 – 4200 2383 – 2115 1040 - SURFACE	974 ft. 1135 ft. 309 ft. 310 ft. 263 ft. 207 ft. 268 ft. 1040 ft.
11	1650 FS-330 FE	30015272680000	5/1/2019	VI	8,380	CIBP @ 6845 – 6581 6071 – 5778 4790 – 4533 CIBP @ 4393 - SURFACE	264 ft. 293 ft. 257 ft. 4393 ft.

KPLA Plugged Well Information for Reporting Period 9/1/18 – 8/31/19							
#	**Location**	**API#**	**Plug Date**	**Type**	**Well Depth**	**Plug Depth**	**Plug Length**
12	1980 FN-1980 FE	30015332130000	4/19/2019	VI	8,400	CIBP @ 7100 – 6850 4610 – 4350 4278 – 3383 3370 – 999 980 – 706 160 - SURFACE	250 ft. 260 ft. 895 ft. 2371 ft. 274 ft. 160 ft.
13	1650 FN-660 FE	30015263040000	4/2/2019	I	7,500	CIBP @ 5610 – 5305 3611 – 3214 450 - SURFACE	305 ft. 397 ft. 450 ft.
14	2310 FS-1980 FE	30015209860000	2/26/2019	VI	6,100	CIBP @ 5783 – 5543 4400 – 3865 3865 – 511 245 - SURFACE	240 ft. 535 ft. 3336 ft. 245 ft.
15	960 FS-1800 FE	30015339230000	1/3/2019	VI	6,750	CIBP @ 4555 – 4342 3562 – 3352 2750 – 325 100 - SURFACE	213 ft. 210 ft. 2425 ft. 100 ft.
16	660 FN-330 FE	30015320020000	12/2/2018	VI	8,300	*CIBP @ 6460 4195 – 700 100 – Surface	15 ft. 3495 ft. 100 ft.
17	1980 FS-1980 FE	30015258660000	12/2/2018	II	15,034	CIBP @ 7980 – 7460 CIBP @ 7420 3800 – 3650 700 – 650 435 – Surface	520 ft. 35 ft. 150 ft. 50 ft. 435 ft.
18	1800 FS-660 FW	30015368970000	11/10/2018	VI	8,400	4590 – 800 780 – 640 140 - SURFACE	3790 ft. 140 ft. 140 ft.
19	330 FS-2180 FW	30015271040000	11/1/2018	VI	8,400	CIBP @ 5980 – 5580 4465 – 3849 3815 – 2715 2705 – 1278 1255 – 766 140-SURFACE	400 ft. 616 ft. 1100 ft. 1427 ft. 489 ft. 140 ft.
20	1980 FS-1650 FE	30015224730000	10/24/2018	VI	6,159	CIBP @ 5988 – 5788 4445 - SURFACE	200 ft. 4445 ft.
21	1980 FS-1980 FW	30015331070000	10/9/2018	VI	8,225	CIBP @ 6370 – 6120 4600 – 3165 3155 – 2023 2013 – 732 140 - SURFACE	250 ft. 1435 ft. 1132 ft. 1281 ft. 140 ft.
22	990 FS-330 FW	30015320280000	9/27/2018	II	8,350	CIBP @ 6875 – 6610 5406 – 5119 4304 – 3912 1000 – 569 200 - SURFACE	265 ft. 287 ft. 392 ft. 431 ft. 200 ft.

KPLA Plugged Well Information for Reporting Period 9/1/18 – 8/31/19							
#	**Location**	**API#**	**Plug Date**	**Type**	**Well Depth**	**Plug Depth**	**Plug Length**
23	1980 FS-1830 FE	30015315740000	9/19/2018	VI	8,160	CIBP @ 6560 - 6525 4154 – 678 60 - SURFACE	35 ft. 3476 ft. 60 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	98	7/06/1983	4/07/2018	1.10	3.80
Culberson	1,849	3/06/1962	7/12/2019	0.35	3.50
Eddy	380	7/17/1926	3/29/2019	0.09	4.00
Jeff Davis	84	8/16/1931	11/13/2018	0.59	4.00
Lea	84	9/19/1976	3/15/2019	0.20	3.10
Loving	47	2/4/1976	3/26/2019	0.66	1.80
Pecos	337	1/30/1975	3/29/2019	0.70	3.20
Reeves	1,345	2/19/1976	3/31/2019	0.87	3.20
Ward	222	8/05/1976	3/31/2019	0.08	3.60
Winkler	71	8/14/1964	1/14/2019	0.86	3.80
TOTAL	4,517				

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	March 2018	11,337,653
2	21S-31E-35	30-015-40890	SWD	4,355-6,320	2014	March 2018	2,857,837
3	21S-32E-08	30-025-31412	SWD	4,826-5,978	1991	May 2018	18,584,638
4	21S-32E-31	30-025-31443	SWD	4,618-6,012	1992	April 2018	7,922,555
5	22S-30E-02	30-015-25758	Injection	7,200-7,264	1993	April 2018	26,315,613
6	22S-30E-02	30-015-26761	Injection	5,600-7,400	1991	April 2018	29,106,120
7	22S-30E-21	30-015-41074	SWD	15,291-16,801	2014	April 2018	15,391,198
8	22S-30E-25	30-015-33439	SWD	5,678-5,930	2010	April 2018	3,864,090
9	22S-30E-27	30-015-04734	SWD	3,820-4,620	1981	Feb 2015	6,166,342
10	22S-31E-02	30-015-32440	Injection	6,989-7,020	2003	May 2018	3,964,168
11	22S-31E-03	30-015-38254	SWD	5,355-6,137	2012	March 2018	4,807,567
12	22S-31E-12	30-015-26742	Injection	4,574-4,963	2014	June 2016	1,433,100
13	22S-31E-24	30-015-26848	SWD	4,519-5,110	1991	April 2018	16,361,035
14	22S-31E-25	30-015-28281	Injection	5,634-5,987	1995	March 2018	14,553,984
15	22S-31E-35	30-015-26629	SWD	4,500-5,670	1991	May 2018	27,900,414
16	22S-31E-36	30-015-26171	SWD	4,500-5,700	1998	March 2018	10,721,543
17	22S-32E-05	30-025-27620	SWD	8,250-8,602	2004	May 2018	11,187,113
18	22S-32E-06	30-025-31227	SWD	4,626-5,730	2012	May 2018	4,774,585
19	22S-32E-07	30-025-31076	SWD	4,676-5,814	1991	April 2018	13,942,431
20	22S-32E-11	30-025-31716	SWD	5,220-8,706	1994	December 2017	4,274,166
21	22S-32E-14	30-025-08113	SWD	5,750-6,080	1994	April 2018	7,183,152
22	22S-32E-16	30-025-31644	SWD	5,582-6,380	2010	May 2018	1,935,140
23	22S-32E-16	30-025-31889	SWD	5,240-8,710	1995	May 2018	12,146,165
24	22S-32E-16	30-025-36006	SWD	5,850-6,450	2010	May 2018	2,554,873
25	22S-32E-17	30-025-31926	SWD	6,807-6,828	2007	July 2018	2,830,819
26	22S-32E-21	30-025-08109	SWD	4,755-5,110	1992	April 2018	4,616,174
27	22S-32E-27	30-025-32436	Injection	6,831-8,388	1998	July 2016	14,357,708
28	22S-32E-28	30-025-31754	SWD	4,674-5,672	1993	April 2018	7,714,020
29	22S-32E-31	30-025-20423	SWD	4,734-5,590	1993	March 2018	8,481,002
30	22S-32E-31	30-025-32093	SWD	4,590-5,626	2004	May 2018	1,147,301
31	22S-32E-32	30-025-36004	SWD	6,744-8,518	2010	May 2018	5,079,279
32	22S-32E-32	30-025-36135	SWD	5,850-6,450	2013	May 2018	2,885,801
33	22S-32E-32	30-025-37799	SWD	5,750-6,500	2010	May 2018	4,434,746
34	22S-32E-35	30-025-33149	SWD	4,950-6,252	1995	March 2018	12,242,090
35	23S-30E-01	30-015-21052	SWD	4,040-4,825	2001	Oct 2015	4,129,914
36	23S-30E-16	30-015-20899	SWD	4,433-5,952	2003	April 2018	8,699,699
37	23S-30E-19	30-015-28901	SWD	3,402-3,912	1997	March 2018	3,765,757
38	23S-30E-20	30-015-29549	SWD	4,124-4,774	2006	April 2018	3,850,405
39	23S-30E-22	30-015-33637	SWD	4,510-5,780	2012	April 2018	2,848,031
40	23S-30E-29	30-015-28808	SWD	5,370-6,380	1996	April 2018	6,101,973

#	Location	API#	Status	Injection Zone	First Injection	Last Injection	Cumulative Bbl
41	23S-30E-33	30-015-26084	SWD	4,470-7,558	2005	Oct 2015	6,819,768
42	23S-30E-33	30-015-31744	SWD	4,227-6,770	2002	January 2014	6,384,163
43	23S-31E-02	30-015-05840	SWD	4,500-5,700	1997	April 2018	10,379,380
44	23S-31E-02	30-015-29792	SWD	4,500-5,850	1998	April 2018	10,873,559
45	23S-31E-02	30-015-35749	SWD	4,600-5,880	2010	February 2018	4,361,719
46	23S-31E-08	30-015-32619	SWD	7,900-7,933	2004	April 2018	4,578,652
47	23S-31E-09	30-015-33368	SWD	7,744-7,952	2005	April 2018	5,981,485
48	23S-31E-11	30-015-25419	SWD	5,210-5,800	2005	April 2018	1,338,632
49	23S-31E-13	30-015-28904	SWD	5,760-5,862	2005	April 2018	1,083,533
50	23S-31E-20	30-015-30605	Injection	7,740-7,774	2001	March 2018	19,929,465
51	23S-31E-24	30-015-43806	SWD	16,390-17,500	2018	January 2019	1,800
52	23S-31E-25	30-015-28817	SWD	5,776-5,920	2008	March 2018	2,205,262
53	23S-31E-25	30-015-28859	SWD	5,236-5,498	2008	March 2018	1,155,547
54	23S-31E-26	30-015-20277	SWD	4,460-5,134	1992	April 2018	5,469,203
55	23S-31E-26	30-015-20302	SWD	4,390-6,048	1971	April 2018	7,522,736
56	23S-31E-27	30-015-27106	SWD	4,750-5,720	1998	April 2018	6,704,795
57	23S-31E-28	30-015-26194	SWD	4,295-5,570	1993	March 2018	9,750,1925
58	23S-31E-35	30-015-25640	SWD	4,484-5,780	1993	March 2018	11,466,439
59	23S-31E-36	30-015-20341	SWD	5,980-6,560	1994	April 2018	36,421,923
60	23S-32E-01	30-025-36192	SWD	5,468-6,092	2013	April 2018	3,145,258
61	23S-32E-04	30-025-31650	SWD	4,884-5,886	2003	April 2018	6,093,283
62	23S-32E-07	30-025-33398	SWD	4,660-6,270	2009	April 2018	3,763,759
63	23S-32E-14	30-025-26844	SWD	5,496-6,014	1991	April 2018	2,500,133
64	23S-32E-15	30-025-35524	SWD	5,786-5,942	2008	March 2018	1,189,243
65	23S-32E-18	30-025-25017	SWD	16,700-18,000	1975	May 2019	N/A
66	23S-32E-23	30-025-33653	SWD	5,950-6,065	2000	April 2018	2,761,742
67	23S-32E-24	30-025-33521	SWD	5,925-6,042	2001	April 2018	2,159,752
68	23S-32E-29	30-025-31515	SWD	4,844-6,160	1992	May 2018	15,768,459
69	23S-32E-31	30-025-32868	SWD	5,150-5,700	1996	March 2018	5,140,296
70	23S-32E-36	30-025-31929	SWD	5,364-6,138	1995	March 2018	5,801,046

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 56-30	42-389-00408	Orla Brine Station #1D	Mesquite SWD, Inc.	Plugged 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