Waste Isolation Pilot Plant

Delaware Basin Monitoring Annual Report

DOE/WIPP-22-2308 Rev. 0

Effective Date: December 14, 2022

U.S. Department of Energy
Carlsbad Field Office

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Approved by: MICHAEL GERLE Digitally signed by MICHAEL GERLE Date: 2022.12.13 12:40:09 -07'00'

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Change History Summary

Revision Number	Description of Changes
0	Initial issue.

List of Acronyms and Abbreviations

API	American Petroleum Institute
BLM	Bureau of Land Management
CARD	Compliance Application Review Document
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
CRA	Compliance Recertification Application
DBDSP	Delaware Basin Drilling Surveillance Program
DBWTA	Delaware Basin Well Tracking Application
DOE	U.S. Department of Energy
DPA	Designated Potash Area
EPA	U.S. Environmental Protection Agency
H2S	Hydrogen Sulfide
N/A	Not Applicable
NM	New Mexico
NMOCD	New Mexico Oil Conservation Division
PA	Performance Assessment
PAVT	Performance Assessment Verification Test
SWD	Salt Water Disposal
TX	Texas
WIPP	Waste Isolation Pilot Plant

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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 and throughout the Delaware Basin and to generate a "drilling rate." This program implements key elements of the U.S. Environmental Protection Agency (EPA) criteria in Title 40 Code of Federal Regulations (CFR) §194.33, to consider drilling events in a performance assessment (PA) required by Subpart B of 40 CFR Part 191, EPA Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (EPA 1993). Results from the PA must demonstrate a reasonable expectation that radioactive releases from the WIPP repository will not exceed limits set by the EPA standard. The drilling rate is an input parameter for the PA model. The PA model predicts the likelihood, frequency, and severity of a radioactive release due to future inadvertent drilling into the repository.

Subpart B of 40 CFR Part 191 provides the environmental standards for the disposal of radioactive waste. The PA must consider the impacts 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., 2,104 feet[1]) for natural resources (EPA 1996). The United States Department of Energy (DOE) concluded in the Compliance Certification Application (CCA), Appendix SCR (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 the 2021 Delaware Basin Monitoring Annual Report (DOE 2021).

Title 40 CFR Part 194 (EPA 1996) defines the Delaware Basin as the geographical area for determination of the historical rate of drilling for resources. Title 40 CFR §194.32 requires this area to be monitored for 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,

[1] A deep borehole was previously considered to be any borehole drilled 2,150 feet or deeper, however, due to the 2022 completion of mining in Panel 8, which was completed at 2,104 feet, the definition of a deep borehole was changed to 2,104 feet accordingly.

Culberson, Jeff Davis, Loving, Pecos, Reeves, Ward, and Winkler counties in west Texas (TX), and portions of Eddy and Lea counties in southeastern New Mexico (NM).

The DBDSP identifies deep and shallow, "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," in accordance with the criteria established in Title 40 CFR §194.33. Monitoring drilling activities will continue until the DOE demonstrates to the EPA there are no significant concerns to be addressed by further monitoring. 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 (of the NM Principal Meridian) in southeastern NM. 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 Compliance Recertification Application (CRA) (DOE 2019). The DBDSP provides data to build on the information presented in the CCA, Appendix DEL (DOE 1996), the 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 2022 UPDATES

The reporting period for this report is September 1, 2021, to August 31, 2022. The following items have been changed or updated in this report:

- In the Technical Support Documents accompanying their decision on the 2019 Compliance Recertification Application (CRA-2019), the EPA requested the DBDSP report plugged wells in all of the NM portion of the Delaware Basin. The DBDSP has complied with this request.
- In the Technical Support Documents accompanying their decision on the 2019 Compliance Recertification Application (CRA-2019), the EPA requested that wells classified as "unknown" due to them having a spud date, but no depth or completion information, be moved from a shallow well classification to a deep well classification. The DBDSP has complied with this request.
- Table 8 Plugged Well Summary by Plug Type has been added to this report.
- The definition of a deep borehole has changed from 2,150 feet to 2,104 feet due to shallower mine level at Panel 8.

- A 2018 oil release incident near Mosaic Potash was brought to the attention of the DBDSP by Intrepid Potash. Well American Petroleum Institute (API) number is 30-015-44313. From the Remuda North 25 State 101H gas well summary:

"While pumping stage 40, the production casing failed allowing water to contact and exceed the burst strength of intermediate casing string. Limited amounts of water and later an oil/gas/water mixture flowed from the previously stimulated zones deep in the well through the failed casing strings at 540' and then into the shallow salt formation."

This initial incident occurred on September 30, 2018. On November 27, 2018, the Bureau of Land Management (BLM) observed fluid on the surface approximately one mile northeast of the well. The fluid had traveled to a plugged and abandoned potash core hole (1970s), and from there, migrated to the surface. According to records filed with the New Mexico Oil Conservation Division, remediation efforts at the site have been completed.

In the *2021 Delaware Basin Monitoring Annual Report* (DOE 2021) the deep drilling rate was miscalculated. That miscalculation has been fixed in this report.

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 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 9 feet to 28,133 feet. The

shallowest oil well recorded during the last reporting period was 1,026 feet in Eddy County, NM. The deepest was 24,969 feet in Reeves County, TX. Both wells are located outside the nine-township area.

The DBDSP data set includes the casing size and depth for each section of the borehole drilled during the reporting period within the nine-township area (table 1). Drill bit size is a reportable element, and 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 reporting period. 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 wells currently drilled use horizontal (deviated) drilling techniques for the lower part of the borehole that contacts the targeted zone of production. There were 736 wells spudded, not necessarily completed, in the NM portion of the Delaware Basin from September 1, 2021, through August 31, 2022. This number is derived from the Delaware Basin Well Tracking Application (DBWTA), a Microsoft® SQL server application maintained by the DBDSP. It is assumed, that in reality, the number of new spudded wells is higher; but paperwork on many of the wells has either not yet been filed with the NMOCD or has not yet been processed.

Rotary drilling rigs were used to drill the 469 completed wells (entire basin) in this reporting period. Completions means the period that begins with the initial perforation of the well in the completed interval and concludes at the end of separation flowback. The status of these completed wells include oil wells, gas wells, salt water disposal wells, and injection wells. The 469 wells were conventionally drilled utilizing mud as a medium for circulation. Twenty-seven of these wells were completed in the nine-township area. The total depth of the completed wells in the nine-township area during the reporting period was between 10,550 feet and 24,962 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 27 wells completed during the reporting period in the nine-township area had horizontally drilled components.

2.1.2 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 NM 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 naturally occurring radioactive material 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 Department of the Interior, Secretary's Order 3324 (DOI, 2012) (formerly NMOCD Order R-111-P) regulations to drill with anything but saturated brine through the salt formation in the Designated Potash Area (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, 2021, through August 31, 2022) 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 NM portion of the Delaware Basin.

2.2 Shallow Drilling Events

The criteria in 40 CFR §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 [now 2,104] 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, within the 100-year rolling time-frame up to the end of the current reporting period.

2.3 Deep Drilling Events

The DOE uses 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 2,104 feet that has occurred over the past 100 years in the Delaware Basin. This was chosen because this is the shallowest 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 (in terms of calculating the drilling rate). One combined Microsoft® SQL Server® based well tracking application is maintained on hydrocarbon wells for TX and NM. As information on wells is acquired, it is entered into this well tracking application. The TX 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 TX portion is used only for calculating the drilling rate. The NM portion contains the same basic information as TX, 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, 469 were completed. Most of the completed wells were drilled for hydrocarbon extraction and were deep-drilling events. Twenty-seven of these wells are located in the nine-township area immediately surrounding the WIPP Site. Table 5 shows the number and type of deep wells (2,104 ft. or deeper) located in the Delaware Basin, within the 100-year rolling time-frame up to the end of the current reporting period.

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:

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

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 2022 was derived from the information provided in table 5. There were 32,079 boreholes deeper than 2,104 feet. Applying the Deep Drilling Rate formula presented in section 2.4 results in a deep drilling rate of 138.9 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 many 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.

2.6 Drilling Activities Outside The Nine-Township Area

In the NM portion of the Delaware Basin, outside of the nine-township area, there were 690 new wells spudded during the reporting period.

In the TX portion of the Delaware Basin, 223 new wells were spudded during the reporting period. The DBDSP monitors drilling activities in portions of seven counties and all of one county (Loving).

2.7 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, 38 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 NM 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 NM portion of the Delaware Basin during the reporting period.

In addition, the DBDSP sends out an annual survey, soliciting information pertaining to Castile brine encounter to operators who have completed wells in the NM portion of the Delaware Basin during the reporting period. Historically, the DBDSP has not received very many responses to the annual surveys that go out. As a result, the program has been researching alternative methods for gathering that information. A new method has been proposed, but has not yet been formalized or implemented.

Ten wells drilled since the CCA have encountered Castile brine. Six wells were identified when WIPP Site personnel performing field work talked to area drillers and the information was documented in the DBWTA. These 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) (MacKinnon, 1997), the EPA mandated a range of 1 percent to 60 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.

2.8 Borehole Permeability Assessment-Plugging Practices

Title 40 CFR §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 DPA, Secretary's 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 NM 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.

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 attempted 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."

Because the study found that plugging and abandonment regulations are followed consistently and that no wells in the basin had been left unplugged, 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 2,104 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 2,104 feet.

Type IV Extra plugs, in addition to those of Type II, have been emplaced above 2,104 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 126 wells plugged during the reporting period that lie within the NM portion of the Delaware Basin. The region of data collection for this survey is shown in figure 8 and table 8.

2.9 Seismic Activity in the Delaware Basin

Seismic events occurring within a 300 km radius of the WIPP facility, are recorded in the DBWTA. This information is obtained every quarter from New Mexico Tech Seismological Observatory and entered into the database. While the 300 km radius is what is recorded in the database, the DBDSP reports only those events that occur within the Delaware Basin Boundary.

During this reporting period there were 9,653 seismic events recorded in the counties of the Delaware Basin. In Culberson County, there were 7,533. One hundred seventeen events were recorded in Eddy County. Fifty-three seismic events were recorded in Lea County. Fifty-nine seismic events were recorded in Loving County. Thirty seismic events were recorded in Pecos County. In Reeves County, there were 1,827. Thirty-two seismic events were recorded in Ward County. Two seismic events were recorded in Winkler County. Table 9 provides

information on all recorded seismic events within the Delaware Basin boundary.

2.10 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.

2.11 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 moving from completing SWD wells in the Delaware Mountain Group to completing them deeper, in the Devonian. In 2022, this practice was largely abandoned around the Midland TX portion of the Permian Basin due to a correlation with increased seismic activity. The practice continues in NM. 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.

There are currently 64 active (currently used for water disposal) SWD wells located in the nine-township area surrounding the WIPP Site. Injection depths range from 3,658 feet to 18,398 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.

2.12 Mining

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

2.12.1 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.

2.12.2 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 three active brine mines or wells in the Delaware Basin.

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 NM 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 NMOCD. Corrective action was done in November 2019 to comply with standards imposed by the rules and regulations of the NMOCD. In January 2022, Permian Water Solutions filed Sundry Notices of intent to plug and abandon both wells. The conditions of approval for the plugging and abandonment of Dunaway #1 indicated the work had to be complete by 6/5/2022. The conditions of approval for the plugging and abandonment of Dunaway # 2 indicated the work had to be completed by 3/25/2022. No subsequent reports were filed for either wells. The Carlsbad Brine Well Remediation Authority is a task force responsible for the brine well concern and budget to repair it.

2.13 New Drilling Technology

There are no new technologies that have been employed during the reporting period of which the DBDSP has found evidence. Research of new technologies and their use in the Delaware Basin is an ongoing activity.

2.14 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. SunEdison 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.

2.15 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 survey provides an additional source of information on drilling activities in the NM portion of the Delaware Basin. The most recent responses the DBDSP received were from 2016. No changes were made as a result of those responses.

3.0 REFERENCES

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

MacKinnon, R.J. 1997. Summary of the EPA-Mandated Performance Assessment Verification Test Results for the Individual and Groundwater Protection Requirements. September 15, 1997. ERMS #417309. Albuquerque, NM: Sandia National Laboratories.

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.

Nuclear Waste Partnership LLC. 2021. Delaware Basin Drilling Surveillance Plan, Rev. 10. June 2021. 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. Department of Energy. 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. 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. 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. 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. 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. Department of Energy. 2021. Delaware Basin Monitoring Annual Report. DOE/WIPP-21-2308. Carlsbad, NM: Carlsbad Field Office

U.S. Department of the Interior. 2012. Secretary's Order No. 3324. December 2012. United States Department of the Interior. Washington, D.C.

U.S. Environmental Protection Agency. 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. 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. 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. 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. 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.

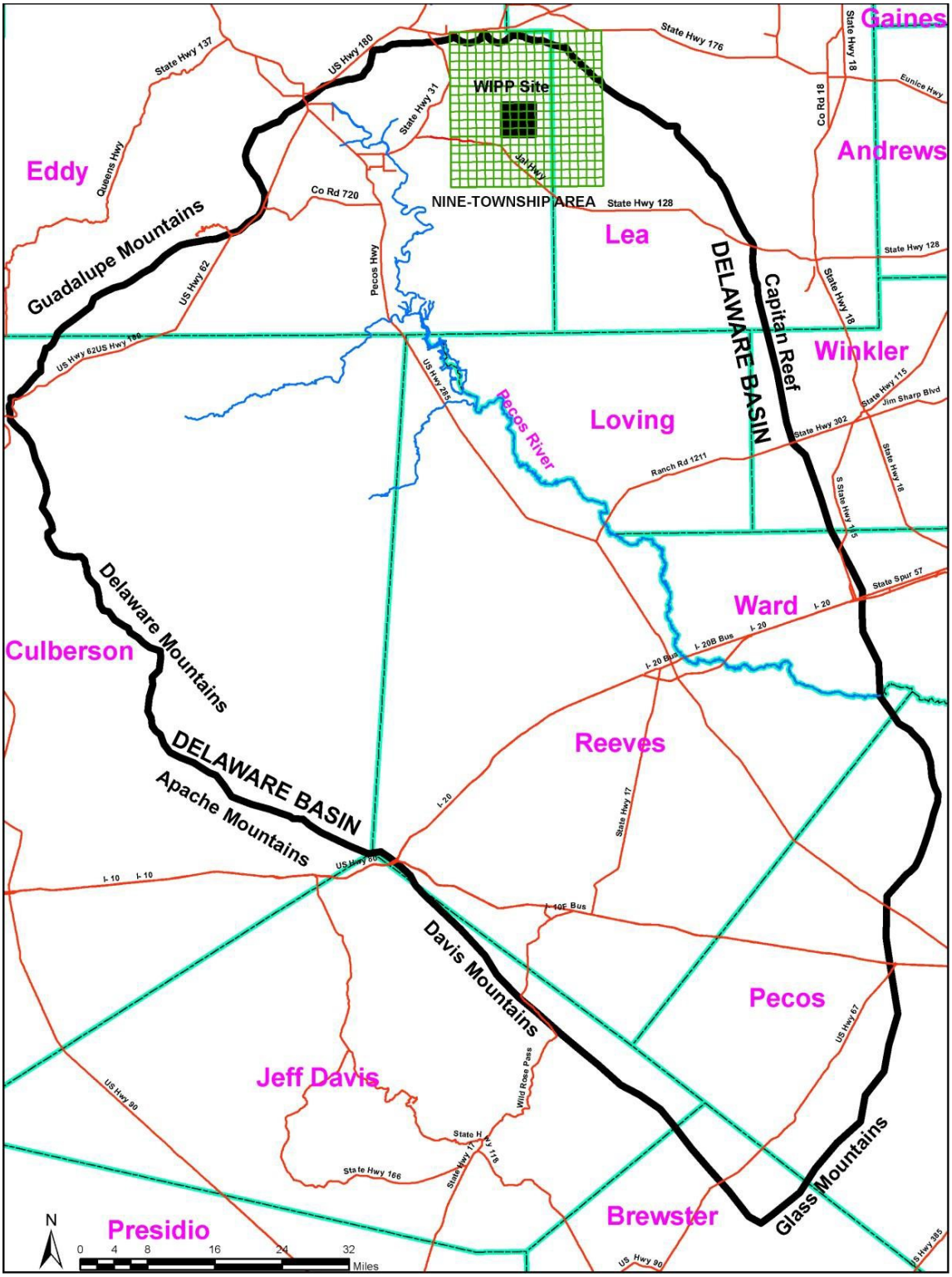

***Figure 1**: WIPP Site, Delaware Basin, and Nine-Township Area*

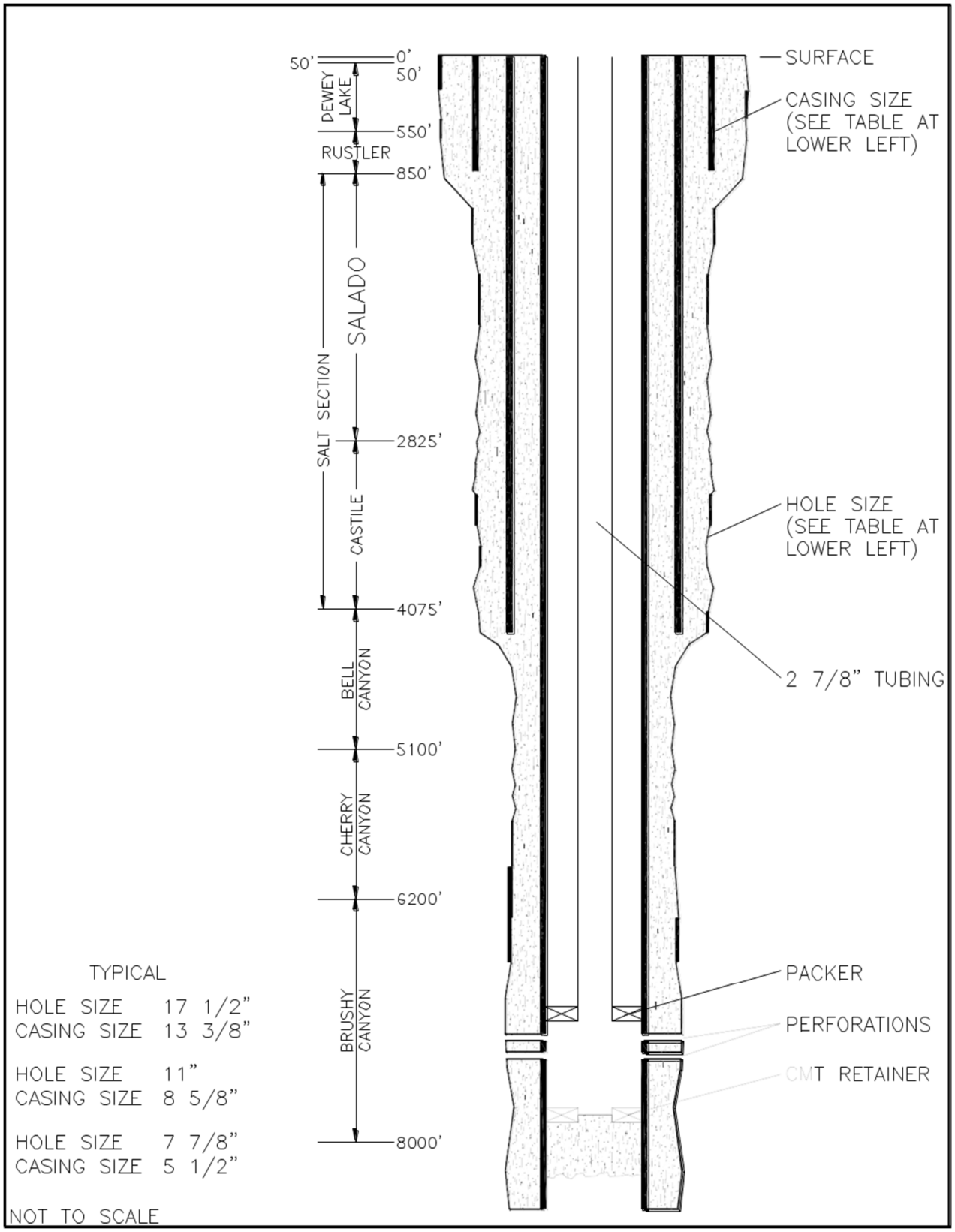

Figure 2: Typical Well Structure and General Stratigraphy Near the WIPP Site

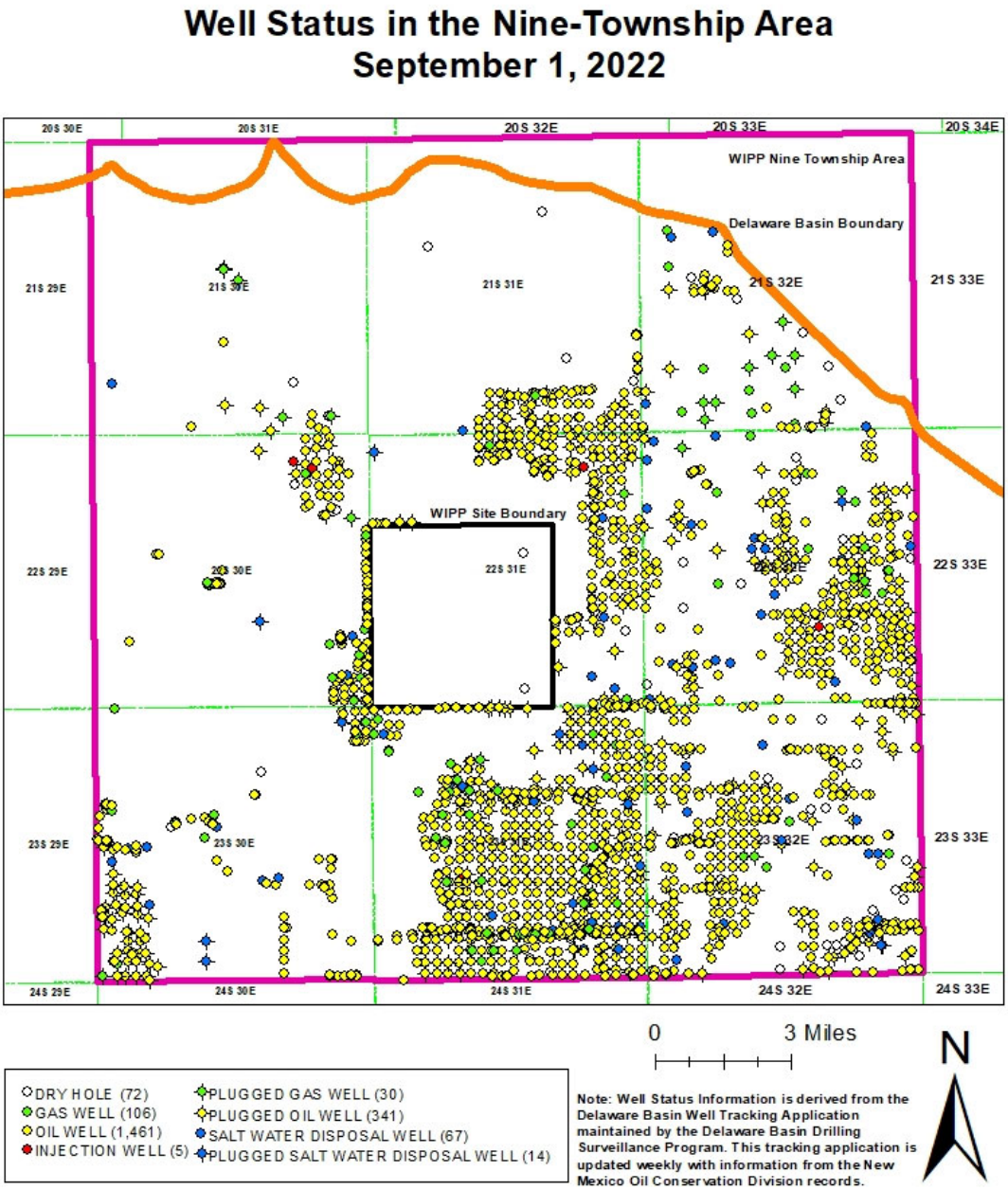

Figure 3: Well Status in the Nine-Township Area

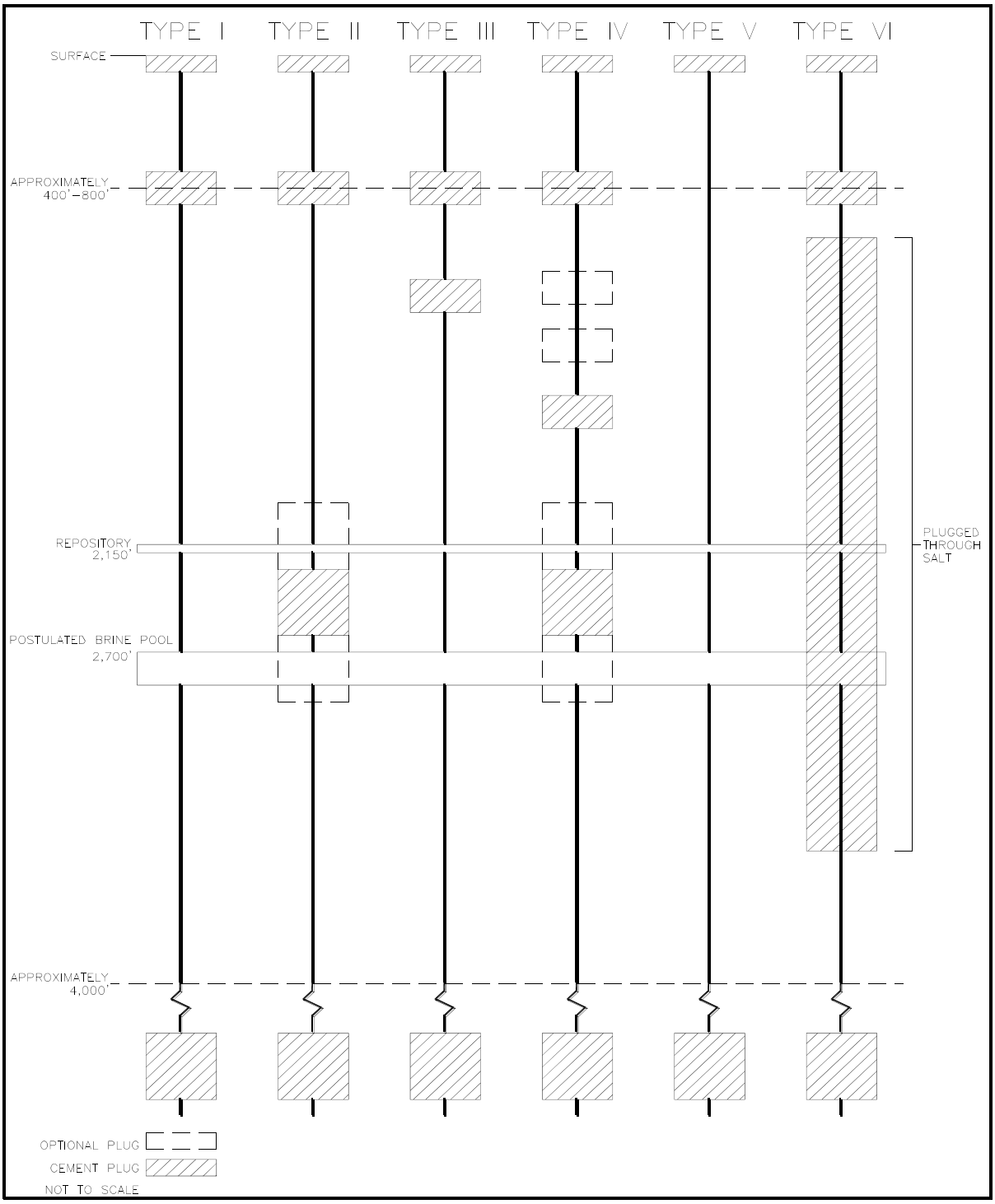

Figure 4: Typical Borehole Plug Configurations in the Delaware Basin

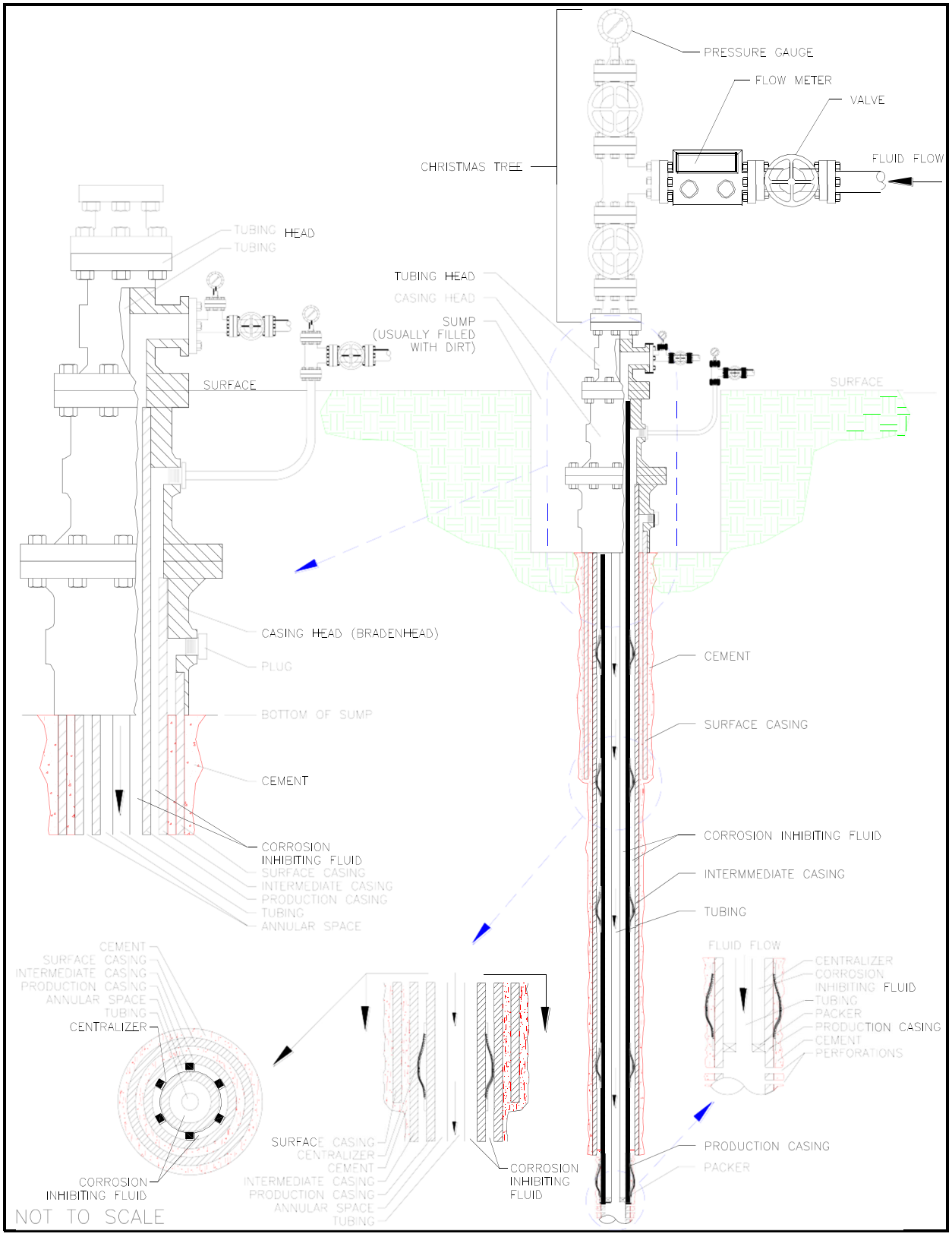

Figure 5: Typical Injection or SWD Well

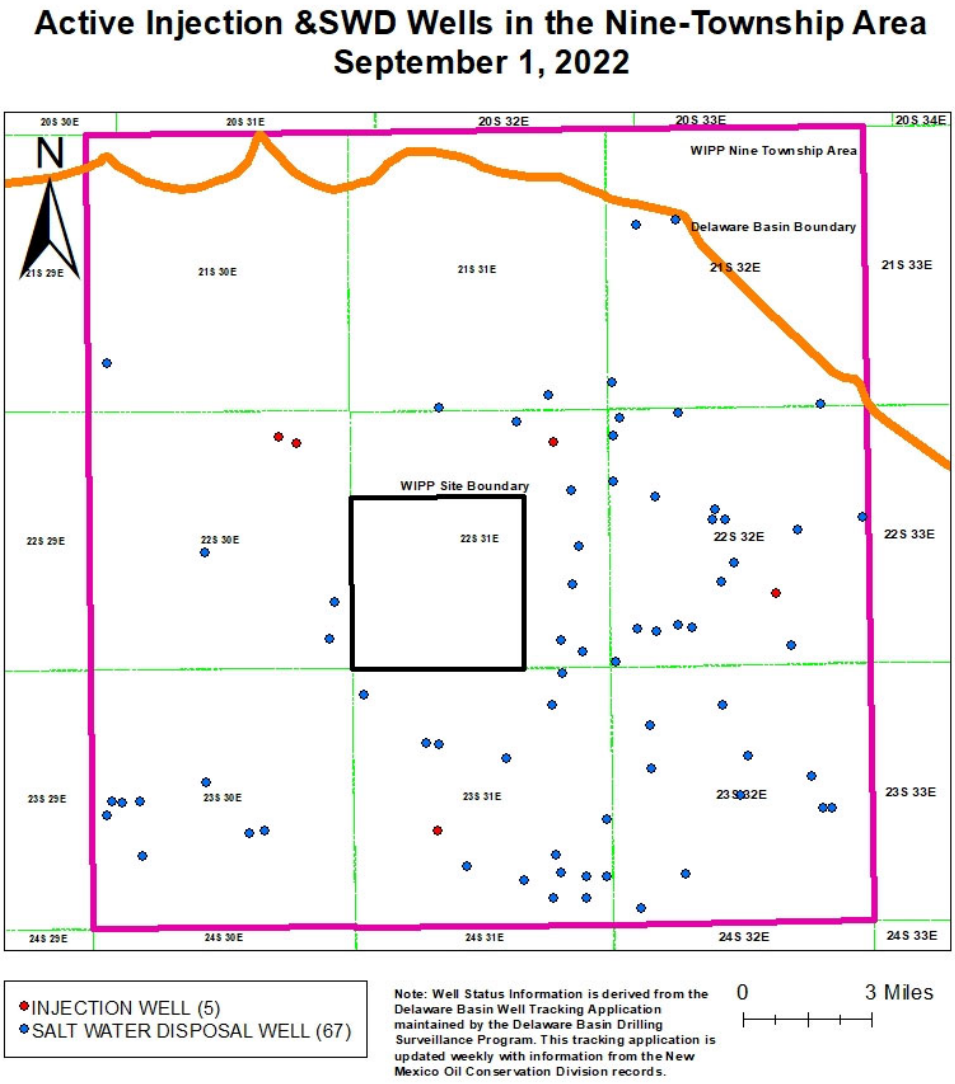

Figure 6: Active Injection and SWD Wells in the Nine-Township Area

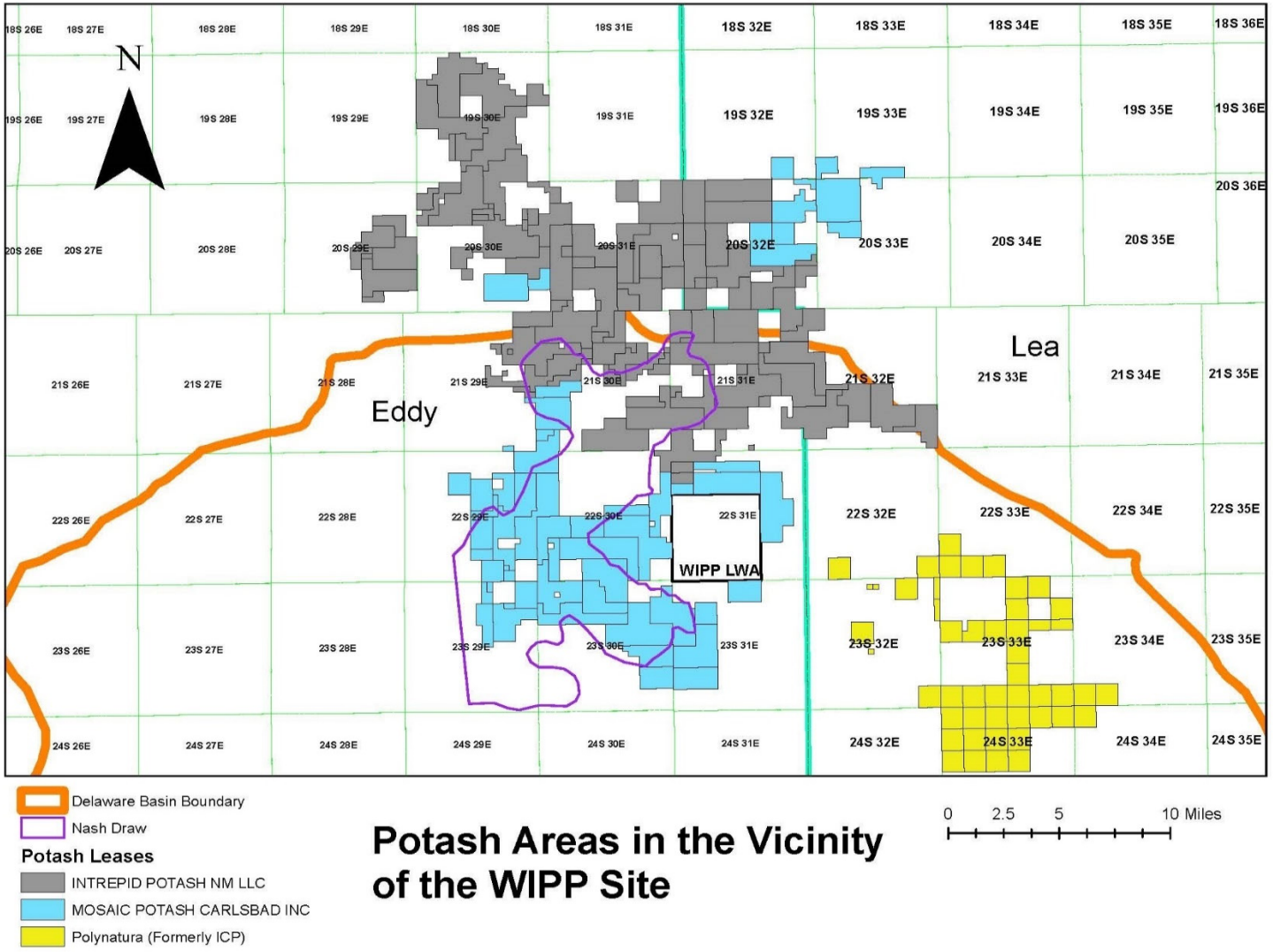

Figure 7: Potash Areas in the Vicinity of the WIPP Site

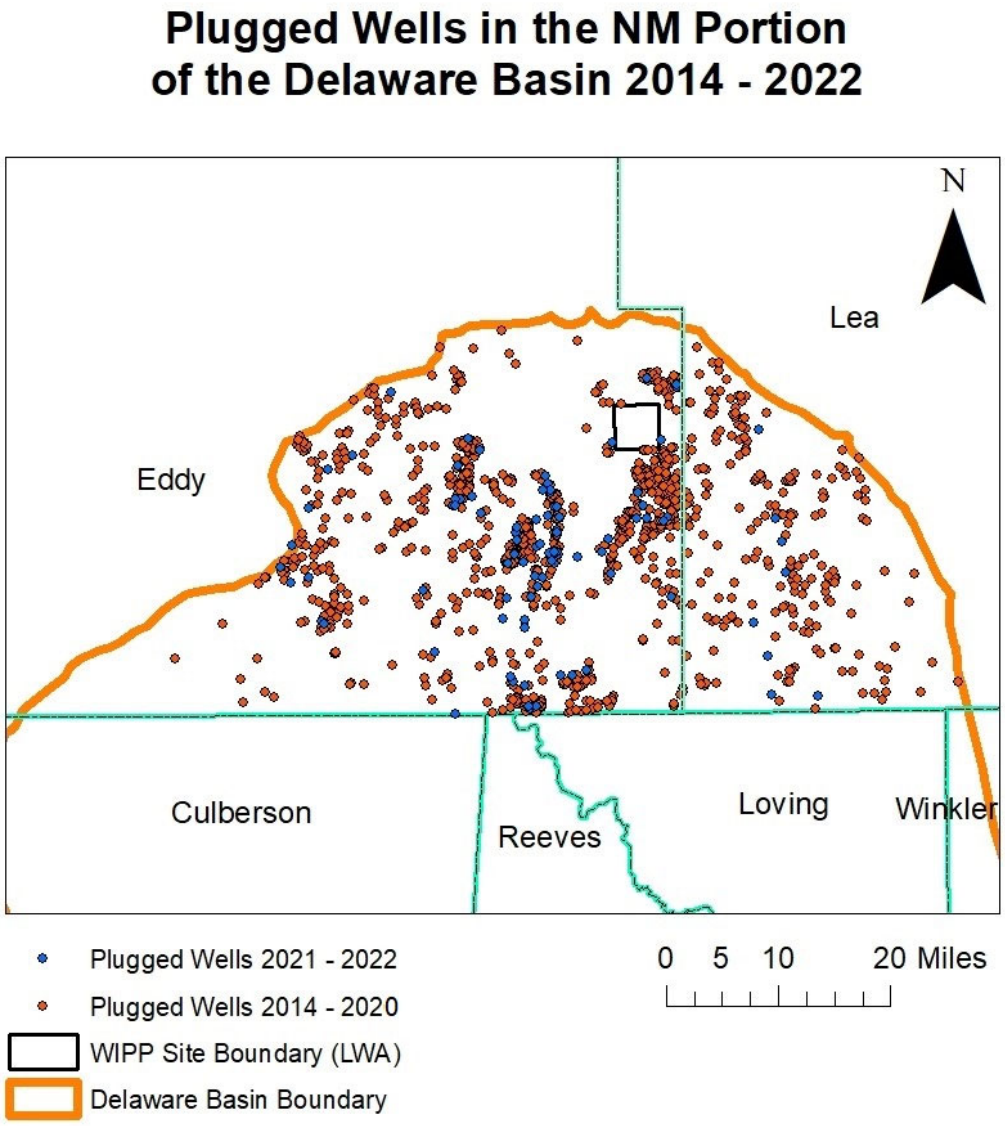

Figure 8: Plugged Wells in the NM Portion of the Delaware Basin 2014-2022

Table 1: Nine-Township Area Casing Sizes

Casing Size (inches)	Surface Casing[1]	Intermediate Casing[2]	Production Casing[3]
	Number of Wells	Number of Wells	Number of Wells
20	0	0	0
18-5/8	0	0	0
16	0	0	0
13-3/8	27	0	0
11-3/4	0	0	0
10-3/4	0	0	0
9-5/8	0	1 9	0
8-5/8	0	4	0
7-5/8	0	4	0
7	0	0	0
5-1/2	0	0	27
4-1/2	0	0	0

NOTE: There were 27 wells completed in the nine-township area between September 1, 2021, and August 31, 2022.

[1] The casing string or strings are used primarily for protecting fresh water or mineralized water resources from potential contamination during the drilling and operation of an oil or gas well, or both.

[2] The string of casing set with cement after the surface casing and before the production casing that is used in the well bore to isolate, stabilize, or provide well control.

[3] A casing string that is set above the reservoir interval and within which the primary completion components are installed.

Table 2: Nine-Township Area Bit Sizes

Bit Size (inches)	Surface Hole[1]	Intermediate Hole[2]	Production Hole[3]
	Number of Wells	Number of Wells	Number of Wells
26	0	0	0
24	0	0	0
20	0	0	0
18-1/2	0	0	0
17-1/2	27	0	0
16	0	0	0
14-3/4	0	0	0
12-3/4	0	0	0
12-1/4	0	19	0
11	0	0	0

10-5/8	0	0	0
9-7/8	0	8	0
8-3/4	0	0	12
8-1/2	0	0	0
7-7/8	0	0	4
7-3/4	0	0	0
7	0	0	0
6-3/4	0	0	11
6-1/8	0	0	0

NOTE: There were 27 wells completed in the nine-township area between September 1, 2021, and August 31, 2022.

[1] The surface hole is the shallowest part of the borehole which starts at the surface. This is where surface casing is installed.

[2] The middle portion of the borehole which is between the surface and the production areas. This is where intermediate casing is installed. There can be several intermediate portions of a borehole.

[3] The portion of the borehole where the production casing and primary completion components are installed.

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

№	API №	Location[1]	Well Name and №	Spud Date	Status	Well Information
1	30-015-04764	21S-28E-33	Richardson & Bass #1	7/27/1961	Plugged Oil Well	Air drilled through the salt. Between 2,545 ft. and 2,685 ft. encountered water and changed from air to mud- based drilling.
2	30-025-31193	21S-32E-26	Lincoln Federal Unit #1	4/1/1991	Plugged Gas Well	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	30-015-26146	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	30-015-02483	23S-28E-11	CP Pardue #1	10/28/1958	Plugged Oil Well	Air drilled through the salt from 390 ft. to 2,620 ft.
5	30-015-22975	23S-28E-11	Amoco Federal 11 #1	8/4/1979	Oil Well	Air drilled from 475 ft. to 9,700 ft.
6	30-015-23084	23S-28E-11	Amoco Federal 11 #3	2/28/1980	Oil Well	Air drilled from 6,271 ft. to 9,692 ft.
7	30-015-22700	23S-28E-23	South Culebra Bluff Unit #3	1/21/1979	Plugged Oil Well	Air drilled from 6,345 ft. to 8,000 ft.
8	30-015-22931	23S-28E-23	South Culebra Bluff Unit #4	8/9/1979	Plugged Oil Well	Air drilled from 450 ft. to 9,802 ft.
9	30-015-27263	24S-31E-03	Lily ALY Federal #2	5/1/1994	Oil Well	Air drilled conductor hole to 40 ft.
10	30-015-27265	24S-31E-03	Lily ALY Federal #4	5/16/1994	Plugged Oil Well	Air drilled conductor hole to 40 ft.
11	30-025-20444	24S-34E-04	Antelope Ridge Unit #2	1/5/1965	Gas Well	Attempted to drill with gas. Had to convert to water at 1,035 ft. Tried again several times at different depths.
12	30-025-20817	24S-34E-09	Federal 9 Com #1	1/23/1974	Gas Well	Hit water while gas drilling at 4,865 ft.
13	30-025-08492	24S-34E-13	Federal Johnson #1	6/23/1958	Plugged Oil Well	Proposed to drill with air, but no information in the records indicate air drilling.
14	30-025-21741	26S-32E-20	Russell Federal #1	3/16/1966	Oil Well	Drilled with air to 1,330 ft.
15	30-025-08314	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	30-015-29532	22S-26E-28	Sheep Draw 28 Federal #13	7/1/1997	Plugged Oil Well	Air drilled the first 358 ft.

[1]"Location" refers to the New Mexico Township, Range, and Section.

Table 4: Shallow Well Type/Status in the Delaware Basin

Well Type/Status	Texas	New Mexico	TOTALS
	Number of Wells	Number of Wells	Number of Wells
Brine Well	4	3	7
Core Hole	30	2	32
Dry Hole	357	148	505
Gas Well	7	9	16
Injection Well	1	0	1
Junked and Abandoned Well	62	0	62
Oil Well	105	10	115
Plugged Brine Well	2	2	4
Plugged Gas Well	2	9	11
Plugged Oil Well	28	80	108
Plugged Salt Water Disposal Well	1	7	8
Plugged Stratigraphic Test Hole	0	18	18
Potash Core Hole	0	1,664	1,664
Salt Water Disposal Well	1	2	3
Service Well	11	0	11
Stratigraphic Test Hole	1,166	1	1,167
Sulfur Core Hole	496	61	557
Water Well	0	1,244	1,244
WIPP Well/Borehole	0	209	209
Other (Mine Shafts, Gnome Project Wells)	0	52	52
TOTALS	2,273	3,521	5,794

Table 5: Deep Well Type/Status in the Delaware Basin

Well Type/Status	Texas	New Mexico	TOTALS
	Number of Wells	Number of Wells	Number of Wells
Brine Well	8	0	8
Core Hole	6	0	6
Drilling or Waiting on Paperwork[1]	382	725	1,107
Dry Hole	2,232	807	3,039
Gas Well	3,662	1,724	5,386
Injection Well	382	36	418
Junked and Abandoned Well	56	0	56
Oil Well	11,369	5,723	17,092
Plugged Brine Well	2	1	3
Plugged Gas Well	351	460	811
Plugged Injection Well	95	82	177
Plugged Oil Well	1,282	1,374	2,656
Plugged Salt Water Disposal Well	6	119	125
Plugged Service Well	7	1	8
Plugged Stratigraphic Test Hole	0	5	5
Potash Core Hole	0	274	274
Salt Water Disposal Well	452	247	699
Service Well	59	0	59
Stratigraphic Test Hole	48	8	56
Sulfur Core Hole	91	0	91
Water Well	3	0	3
WIPP Well/Borehole[2]	0	12	12
Other (Mine Shafts, Gnome Project Wells)[2]	0	8	8
TOTALS	20,493	11,606	32,099

[1]The 1,107 wells under the "Drilling or Waiting on Paperwork" category do not have complete paperwork classifying these wells as oil, gas, or some other type of well. When the appropriate paperwork is posted, the classification of these types of wells will be updated.

[2]WIPP Well/Borehole and Other (Mine Shafts, Gnome Project Wells), while important to track, do not get counted in the overall drilling rate.

Table 6: Drilling Rates for the Delaware Basin

Reporting Period[1] 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	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	29,045 Boreholes Deeper Than 2,150 ft.	125.7[2]
2022	32,079 Boreholes Deeper Than 2,104 ft.	138.9

[1] The data begins in 1996, which was the year the Compliance Certification Application for the WIPP was approved by the EPA.

[2] A drilling rate calculation error was made during the 2021 Delaware Basin Monitoring Annual Report and the correction is reflected in this Delaware Basin Monitoring Annual Report.

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

№	API №	Location[1]	Well Name and Number	Spud Date	Status	Well Information
Original CCA-related Castile Brine Encounters - 1896 Through June 1995						
1	30-015-23045	21S-31E-26	Pogo Federal #1	10/31/1979	Plugged Oil Well	N/A
2	ERDA-6	21S-31E-35	ERDA-6	6/13/1975	Plugged WIPP Well	WIPP well, no API number.
3	30-015-23896	21S-31E-35	Federal FI #1	9/25/1981	Plugged Oil Well	N/A
4	30-015-26584	21S-31E-36	Lost Tank AIS State #1	12/7/1991	Oil Well	N/A
5	30-015-26715	21S-31E-36	Lost Tank AIS State #4	11/19/1991	Oil Well	N/A
6	30-025-31443	21S-32E-31	Lost Tank SWD #1	11/12/1991	SWD Well	N/A
7	30-015-03688	22S-29E-09	Danford Permit #1	5/18/1937	Plugged Oil Well	N/A
8	30-015-26698	22S-31E-01	Unocal AH U Federal #1	4/2/1991	Oil Well	N/A
9	30-015-26815	22S-31E-01	Molly State #1	9/25/1991	Oil Well	N/A
10	30-015-26831	22S-31E-01	Molly State #3	10/20/1991	Oil Well	N/A
11	30-015-26877	22S-31E-02	State 2 #3	11/27/1991	Plugged Oil Well	N/A
12	30-015-26723	22S-31E-11	Martha AIK Federal #3	5/6/1991	Oil Well	N/A
13	30-015-26724	22S-31E-11	Martha "AIK" Federal #4	9/2/1991	Oil Well	N/A
14	30-015-26942	22S-31E-12	Federal 12 #8	3/27/1992	Oil Well	N/A
15	30-015-26487	22S-31E-13	Neff 13 Federal #5	2/4/1991	Oil Well	N/A
16	WIPP-12	22S-31E-17	WIPP-12	11/17/1978	Plugged Monitoring Well	WIPP well, no API number.
17	30-025-27620	22S-32E-05	Bilbrey SWD #1	11/26/1981	SWD Well	N/A
18	30-025-31800	22S-32E-15	Lechuza Federal #4	12/29/1992	Plugged Oil Well	N/A
19	30-025-31576	22S-32E-16	Kiwi AKX State #1	4/28/1992	Oil Well	N/A
20	30-025-24947	22S-32E-25	Covington A Federal #1	2/7/1975	Plugged Oil Well	N/A

21	30-025-08111	22S-32E-26	Culberson #1	12/15/1944	P&A	N/A
22	30-025-31720	22S-32E-34	Red Tank 34 Federal #1	9/3/1992	Oil Well	N/A
23	30-025-08112	22S-32E-36	Richardson State #1	7/20/1962	Plugged Oil Well	N/A
24	30-025-20810	22S-32E-36	Shell State #1	2/27/1964	Oil Well	N/A
25	30-025-01799	22S-33E-20	Cloyd Permit #1	9/7/1937	Plugged Oil Well	N/A
26	30-025-01800	22S-33E-20	Cloyd Permit #2	6/22/1938	Plugged Oil Well	N/A
27	30-015-21052	23S-30E-01	Hudson Federal #1	2/25/1974	Plugged SWD Well	N/A
28	30-025-27772	22S-32E-15	Connally Federal #1	3/5/1991	Gas Well	N/A
29	30-015-26973	22S-31E-2	Flora AKF State #1	3/31/1992	Plugged Oil Well	N/A
30	30-015-28416	22S-31E-2	State 2 #2	3/31/1995	Oil Well	N/A
Castile Brine Encounters Since July 1995						
1	30-015-31275	21S-31E-35	Lost Tank 35 State #4	09/11/2000	Oil Well	Estimated several hundred barrels per hour. Continued drilling.
2	30-015-31926	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	30-015-31913	22S-31E-02	Graham AKB State #8	4/12/2002	Oil Well	Estimated 105 barrels per hour. Continued drilling.
4	30-015-30857	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	30-015-31513	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	30-015-33076	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 the drilling process.
7	30-015-33335	21S-31E-34	Jacque AQJ State #7	3/1/2005	Plugged Oil Well	Encountered water flow of 104 barrels per hour at 2,900 ft. No impact on the drilling process.
8	30-015-34221	22S-30E-13	Apache 13 Fed #8	8/19/2005	Oil Well	Encountered a severe H_2S water flow.
9	30-015-37273	23S-30E-1	James Ranch Unit #108H	12/6/2009	Oil Well	Encountered salt water flow occurred at 2,894 ft.
10	30-015-40890	21S-31E-35	Lost Tank 35 State SWD #1	6/28/2013	SWD Well	Encountered H_2S influx from 2,678-3,004 ft. then shut in on well.

[1] "Location" refers to the New Mexico Township, Range, and Section.

Table 8: Plugged Well Summary by Plug Type

Type	2014 CRA Frequency	CRA-2019 Frequency
I	26.9%	21.7%
II	20.1%	24.3%
III	29.9%	23.8%
IV	16.5%	17.9%
V	2.6%	3.5%
VI	4.0%	8.8%
TOTALS	100.0%	100.0%

Type	Pre-2015 totals	2015	2016	2017	2018	2019	2020	2021	2022	Total	Current Frequency
	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	# of Wells	
I	153	1	9	9	6	27	32	19	17	273	18.3%
II	121	11	20	41	11	50	75	34	35	398	26.8%
III	171	5	9	4	8	32	37	36	10	312	21.0 %
IV	116	11	7	8	26	17	22	14	8	229	15.4%
V	14	0	11	3	0	1	0	0	0	29	2.0%
VI	25	13	11	21	3	47	62	41	22	245	16.5%
TOTALS	600	41	67	86	54	174	228	144	92	1,486	100%

Note: For the sake of simplicity, all years prior to 2015 were rolled into one column on this table. To view those years in detail, please see previous Delaware Basin Monitoring Annual Reports.

Table 9: Seismic Activity within the Delaware Basin Boundary

County and State	№ of Total Recorded Events (all time)	№ of Recorded Events for the Reporting Period	Earliest Event	Latest Event	Smallest Magnitude	Largest Magnitude
Culberson, TX	22,671	7,533	10/27/1992	3/31/2022	0.19	3.93
Eddy, NM	362	117	11/28/1975	3/31/2022	0.25	3.70
Jeff Davis, TX	24	0	9/16/2014	4/19/2020	0.84	2.63
Lea, NM	187	53	6/23/1993	3/31/2022	0.30	2.22
Loving, TX	381	59	2/4/1976	3/30/2022	0.66	2.48
Pecos, TX	429	30	1/30/1975	3/29/2022	0.70	3.00
Reeves, TX	5,408	1,827	10/13/2008	12/31/2021	0.41	3.20
Ward, TX	339	32	9/3/1976	3/30/2022	0.08	2.80
Winkler, TX	23	2	9/24/1971	3/29/2022	1.10	3.00
TOTAL	29,824	9,653				

KEY:

Magnitude

< 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
8.0 or above	Complete destruction; ground moves in waves

Note: A sharp increase in seismic activity in Culberson and Reeves County began in 2018 and continues to increase through the time of this report.

Table 10: Nine-Township Injection and SWD Well Information

№	Location	API №	Type	Injection Zone	First Injection	Last Injection	Cumulative Barrels
1	21S-31E-33	30-015-29330	SWD	4,166-5,160	1998	July 2022	14,291,278
2	21S-31E-35	30-015-40890	SWD	4,355-6,320	2014	July 2022	4,313,135
3	21S-32E-08	30-025-31412	SWD	4,826-5,978	1991	August 2021	20,246,801
4	21S-32E-31	30-025-31443	SWD	4,618-6,012	1992	August 2022	9,843,640
5	21S-32E-35	30-025-44273	SWD	15,900-17,250	2018	August 2022	13,282,811
6	22S-30E-02	30-015-25758	Injection	7,200-7,264	1993	August 2022	29,015,534
7	22S-30E-02	30-015-26761	Injection	5,600-7,400	1991	August 2022	31,525,259
8	22S-30E-21	30-015-41074	SWD	15,291-16,801	2014	July 2022	28,157,840
9	22S-30E-25	30-015-33439	SWD	5,678-5,930	2010	July 2022	5,285,640
10	22S-30E-36	30-015-45691	SWD	15,610-16,730	2019	July 2022	5,942,592
11	22S-31E-02	30-015-32440	Injection	6,989-7,020	2003	October 2021	3,964,371
12	22S-31E-03	30-015-38254	SWD	5,355-6,137	2012	July 2022	6,860,276
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 2022	18,530,666
15	22S-31E-25	30-015-28281	SWD	5,634-5,987	1995	July 2022	15,799,369
16	22S-31E-35	30-015-26629	SWD	4,500-5,670	1991	August 2022	29,938,167
17	22S-31E-36	30-015-26171	SWD	4,500-5,700	1998	July 2022	11,960,822
18	22S-32E-05	30-025-27620	SWD	8,250-8,602	2004	August 2022	12,967,240
19	22S-32E-06	30-025-31227	SWD	4,626-5,730	2012	August 2022	6,721,629
20	22S-32E-06	30-025-43328	SWD	974-4,482	2018	August 2022	12,096,775
21	22S-32E-07	30-025-31076	SWD	4,676-5,814	1991	July 2022	15,266,930
22	22S-32E-14	30-025-08113	SWD	5,750-6,080	1994	July 2022	7,635,509
23	22S-32E-16	30-025-31644	SWD	5,582-6,380	2010	August 2022	2,939,228
24	22S-32E-16	30-025-31889	SWD	5,240-8,710	1995	August 2022	12,273,726
25	22S-32E-16	30-025-36006	SWD	5,850-6,450	2010	October 2021	3,166,992
26	22S-32E-17	30-025-31926	SWD	6,807-6,828	2007	August 2022	2,992,064
27	22S-32E-21	30-025-08109	SWD	4,755-5,110	1994	July 2022	5,011,163
28	22S-32E-27	30-025-32436	Injection	6,831-8,388	1994	July 2022	16,529,615
29	22S-32E-28	30-025-31754	SWD	4,674-5,672	1993	July 2022	8,562,075
30	22S-32E-30	30-025-44106	SWD	3,395-4,528	2017	August 2022	26,761,148
31	22S-32E-31	30-025-20423	SWD	4,734-5,590	1993	June 2022	9,128,013
32	22S-32E-31	30-025-32093	SWD	4,590-5,626	2004	November 2021	1,577,376
33	22S-32E-32	30-025-36004	SWD	6,744-8,518	2010	August 2022	6,876,617
34	22S-32E-32	30-025-36135	SWD	5,850-6,450	2013	August 2022	4,108,935
35	22S-32E-32	30-025-37799	SWD	5,750-6,500	2010	August 2022	5,895,068
36	22S-32E-35	30-025-33149	SWD	4,950-6,252	1995	July 2022	13,357,201
37	23S-30E-16	30-015-20899	SWD	4,433-5,952	2003	July 2022	17,259,086
38	23S-30E-19	30-015-28901	SWD	3,402-3,912	1997	November 2019	3,886,405
39	23S-30E-19	30-015-45072	SWD	3,032-3,283	2018	August 2022	19,169,971

40	23S-30E-20	30-015-29549	SWD	4,124-4,774	2006	July 2022	4,243,355
41	23S-30E-22	30-015-33637	SWD	4,510-5,780	2012	July 2022	3,648,986
42	23S-30E-29	30-015-28808	SWD	5,370-6,380	1996	July 2022	8,596,349
43	23S-31E-02	30-015-05840	SWD	4,500-5,700	1997	July 2022	10,814,729
44	23S-31E-02	30-015-35749	SWD	4,600-5,880	2010	February 2018	4,361,719
45	23S-31E-06	30-015-46432	SWD	15,610-16,980	2020	July 2022	6,075,962
46	23S-31E-08	30-015-32619	SWD	7,900-7,933	2004	July 2022	5,895,976
47	23S-31E-09	30-015-33368	SWD	7,744-7,952	2005	July 2022	7,157,060
48	23S-31E-13	30-015-28904	SWD	5,760-5,862	2005	September 2018	1,103,924
49	23S-31E-15	30-015-43805	SWD	1,180-3,300	2018	August 2022	16,994,978
50	23S-31E-20	30-015-30605	Injection	7,740-7,774	2001	July 2022	14,804,413
51	23S-31E-24	30-015-43806	SWD	16,390-17,500	2018	August 2022	22,670,873
52	23S-31E-25	30-015-28817	SWD	5,776-5,920	2008	February 2022	2,223,148
53	23S-31E-25	30-015-28859	SWD	5,236-5,498	2008	January 2022	1,167,784
54	23S-31E-26	30-015-20277	SWD	4,460-5,134	1992	July 2022	5,681,878
55	23S-31E-26	30-015-20302	SWD	4,390-6,048	1971	October 2020	7,561,352
56	23S-31E-27	30-015-27106	SWD	4,750-5,720	1998	July 2022	7,118,558
57	23S-31E-28	30-015-26194	SWD	4,295-5,570	1993	July 2022	10,374,090
58	23S-31E-35	30-015-25640	SWD	4,484-5,780	1993	June 2022	11,761,511
59	23S-31E-36	30-015-20341	SWD	5,980-6,560	1994	July 2022	41,137,688
60	23S-32E-01	30-025-36192	SWD	5,468-6,092	2013	May 2019	3,152,490
61	23S-32E-04	30-025-31650	SWD	4,884-5,886	2003	July 2022	6,474,256
62	23S-32E-07	30-025-33398	SWD	4,660-6,270	2009	July 2022	3,627,072
63	23S-32E-14	30-025-26844	SWD	5,496-6,014	1991	July 2022	2,755,459
64	23S-32E-15	30-025-35524	SWD	5,786-5,942	2008	July 2022	1,772,104
65	23S-32E-18	30-025-25017	SWD	16,700-18,000	1975	May 2019	0
66	23S-32E-21	30-025-45029	SWD	1,210-4,757	2019	August 2022	4,339,228
67	23S-32E-23	30-025-33653	SWD	5,950-6,065	2000	July 2022	3,253,444
68	23S-32E-24	30-025-33521	SWD	5,925-6,042	2001	July 2022	2,427,129
69	23S-32E-29	30-025-31515	SWD	4,844-6,160	1992	July 2022	18,537,934
70	23S-32E-31	30-025-32868	SWD	5,150-5,700	1996	July 2022	5,929,984
71	23S-30E-01	30-015-21052	SWD	4,040-4,825	2001	December 2016	4,129,954
72	23S-31E-11	30-015-25419	SWD	5,210-5,800	2004	June 2021	1,364,087
73	23S-30E-33	30-015-26084	SWD	4,470-7,558	2005	December 2016	6,819,768
74	23S-31E-02	30-015-29792	SWD	4,500-5,850	2000	July 2022	11,096,966
75	23S-30E-33	30-015-31744	SWD (Now a monitoring well)	4,227-6,770	2002	December 2016	6,384,163
76	23S-31E-26	30-015-45235	SWD	16,513-17,894	2019	August 2022	16,568,172
77	22S-32E-11	30-025-31716	SWD	5,220-8,706	2000	December 2017	4,274,168
78	23S-32E-36	30-025-31929	SWD	5,364-6,138	2001	March 2018	5,940,770

Table 11: Brine Well Status/Type in the Delaware Basin

County	Location	API №	Well Name and Number	Operator	Status/Type
Eddy	22S-27E-17	30-015-22574	Eugenie # 1	I & W Inc.	Active Brine Well
Eddy	22S-27E-23	30-015-28083	Dunaway #1	Permian Water Solutions, LLC	Active Brine Well
Eddy	22S-27E-23	30-015-28084	Dunaway #2	Permian Water Solutions, LLC	Active Brine Well
Eddy	22S-26E-36	30-015-21842	City Of Carlsbad # 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	30-015-23031	Eugenie #WS-2	I & W Inc.	Plugged Brine Well