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Delaware Basin Monitoring Annual Report

September 2013

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

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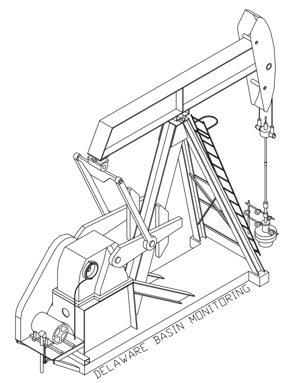

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United States Department of Energy
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Prepared for
the Department of Energy by
Nuclear Waste Partnership LLC, Regulatory Environmental Services
Delaware Basin Drilling Surveillance Program

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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 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 Department of Energy (DOE) to demonstrate the expected performance of the disposal system using a probabilistic risk assessment or performance assessment (PA). The results of the PA must show the expected 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 significant and detrimental change has occurred that would affect the performance of the disposal system.

The *Delaware Basin Drilling Surveillance Plan* (WP 02-PC.02) 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), and the Compliance Recertification Application-2009 (CRA-2009), Appendix DATA (DOE 2009).

2.0 2013 Updates

The 40 CFR §194.33 standards 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: (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, 2012 to August 31, 2013. 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 19 feet to 25,201 feet. The 19-foot hole is an exhaust shaft monitoring well located on the WIPP site, and the 25,201-foot hole is a gas well located in the

Texas portion of the Delaware Basin. Borehole depths in the immediate vicinity of the WIPP site typically range from 7,750 feet to 9,000 feet for oil wells and 13,000 feet to 16,000 feet 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 in 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 1/2 inches for the surface section, 12 1/4 inches for the intermediate section, and 7 7/8 inches for the production section of the hole. This year this common pattern was observed. Table 2 shows the documented bit sizes used in drilling wells in the nine-township area during the past 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 in CCA, Appendix DEL, CRA-2004, Appendix DATA, and CRA-2009, Appendix DATA are still being implemented by area drillers. There were 209 hydrocarbon wells spudded, not necessarily completed, in the New Mexico portion of the Delaware Basin from September 1, 2012 through August 31, 2013. This number is derived from the Delaware Basin Well Tracking Application (DBWTA) maintained by the DBDSP. In reality, the number of new wells is higher; but the 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 209 wells. Some have been completed as oil wells, others as gas wells, while the rest are still in the process of being completed. The 209 wells were conventionally drilled utilizing mud as a medium for circulation. Fourteen of these wells were in the nine-township area. The depths of the completed wells in the nine-township area range from 707 feet to 15,277 feet. Outside of the nine-township area the depths of the completed wells range from 653 feet to 17,319 feet.

A technique used by operators to increase production is to drill a well horizontally after a target depth is reached, which allows for more of the wellbore area to be in the production zone. As reported in CCA, Appendix DEL, this technique is not often used in this area because of the increased costs due to the additional drilling time needed. The DBDSP monitors directional and horizontally drilled wells only in the nine-township area. Eight of the fourteen new wells spudded during the last year 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 (RK 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 mitigative 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, 2012 through August 31, 2013) 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 the PA.

Although the EPA has agreed, in CARD 33, shallow drilling is of low consequence and could be eliminated from the 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 it is the depth of the repository, and the repository is not 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. 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.

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 last year, there were 943 new wells added to the well tracking application. Most of the wells were drilled for hydrocarbon extraction and were deep-drilling events. Fourteen 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:

$$\text{Deep Drilling Rate} = \frac{(\text{\# of deep boreholes}) \times 10{,}000 \text{ years}}{23{,}102.1 \text{ km}^2} \times \frac{1}{100 \text{ years}}$$

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

The 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. Also, the 100-year period is considered a moving period; in which 100 years worth of data are used each time the calculation is performed. As each new year of data is added, the oldest year of data 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 2013 was derived from the information provided in Table 5. There were 16,634 boreholes deeper than 2,150 feet. One well was removed from the count because it is no longer within the 100-year interval. This brings the total deep well count to 16,633 boreholes for 2013. Applying the formula results in the following:

$$\text{Deep Drilling Rate} = \frac{(16{,}633 \text{ boreholes}) \times 10{,}000 \text{ years}}{23{,}102.1 \text{ km}^2} \times \frac{1}{100 \text{ years}}$$

This results in a deep drilling rate of 72.0 boreholes per km^2 over 10,000 years. This is currently the largest consecutive year increase since reporting began and is due to increased drilling activity during the reporting period of September 1, 2012 to August 31, 2013.

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 of the 100-year moving time frame used for drilling results. As new wells are added to the count, wells older than 100 years are dropped.

2.5.1 Nine-Township Area Drilling Activities

From September 1, 2012 to August 31, 2013, there were fourteen new wells spudded in the nine-township area immediately surrounding the WIPP site. Five new wells were drilled within one mile of the WIPP site boundary with four to the northeast and one to the southwest of the site. Figure 3 shows the status of known hydrocarbon wells drilled within one mile of the WIPP site boundary. Of the fourteen new wells spudded in the nine-township, eleven were drilled in Eddy County and three in Lea County. Eight of the wells are to the northeast of the site, three wells are to the southeast, and three wells are to the southwest of the WIPP site. During the reporting period, the Department of Interior published Secretary's Order 3324. This new order supersedes the 1986 Secretary's Order and authorizes the BLM to establish development areas for oil and gas drilling in the Designated Potash Area. Each development area will have at least one corresponding drilling island from which oil and gas operators may drill extended reach horizontal wells to access oil and gas resources.

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 195 new wells spudded during the reporting period of September 1, 2012 through August 31, 2013. Of the 195 wells, 120 are located in Eddy County and 75 are in Lea County.

In the Texas portion of the Delaware Basin, 734 new wells were spudded during the reporting period. The DBDSP monitors drilling activities in portions of seven counties and all of one county (Loving). A majority of the wells were drilled in Loving, Reeves, Ward, and Culberson counties.

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. Research was performed in an attempt to verify this assumption. Studies recorded that 27 out of 620 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.

As indicated earlier, the search of the records performed in 1999 for instances of air drilling also 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 looking for instances of encounters with pressurized brine. The program also sends out an annual survey to operators of new wells asking if they encountered pressurized brine during the drilling process. As of this report, none of the records reviewed indicated encounters with pressurized brine during the drilling of new wells spudded in the New Mexico portion of the Delaware Basin between September 1, 2012 and August 31, 2013.

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 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 hits out of 345 possibilities. 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 brine encounters out of 678 possibilities. For 2013, the same parameters were used and the rate was calculated at 4.4 percent with 34 brine encounters out of 771 possibilities.

2.7 Borehole Permeability Assessment - Plugging Practices

The hydrocarbon well plugging assumptions used for the borehole permeability assessment remain valid. The regulations in place during the submittal of the CCA, the CRA-2004, and the CRA-2009 have not changed. The assessment will not change unless the regulations change to allow a different method of plugging. Regulations require the well be plugged in a manner that will permanently confine oil, gas, and water in the separate strata in which they were originally found. These regulations require a notice of intent to plug from the operator to the regulating agency. This notice includes a diagram of the well bore and the placement of the plugs. A 24-hour notice to the NMOCD or to the Bureau of Land Management (BLM) is required before plugging may commence.

Approximately 900 wells in the vicinity of the WIPP site are in the KPLA. Under NMOCD R-111-P regulations, the operator is required to provide a solid cement plug through the salt section and any water-bearing horizon in addition to installing a bridge plug above the perforations. The above requirement 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.

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, should the regulations change and the plugging methods differ from what is now occurring, a trend would be noticed and the borehole permeability assessment revisited. Table 8 shows plugging information on the wells plugged and abandoned within the New Mexico portion of the Delaware Basin in the last year.

Compliance Certification Application, Appendix MASS, Attachment 16-1 describes the development of a conceptual model for long-term performance of plugged boreholes. The study did not attempt to predict the effectiveness of plugs, but to identify the location and physical characteristics of plugs, which might be important to performance assessment. Guidance in 40 CFR Part 194.33 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 criteria also state that "...drilling practices will remain as those of today." Only wells plugged in the New Mexico portion of the Delaware Basin and drilled after 1988, when the current plugging regulation went into effect, were used for the study. The results of this study indicated the PA should assume a 100 percent plugging frequency.

To determine the typical configuration and composition of a borehole plug, the study considered plugging practices 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.

There were 20 wells plugged during the reporting period. Four wells are in the nine-township area and 16 are outside the nine-township area. Two of the 20 wells are in the KPLA. Three wells have total depth of less than 300 feet. These three wells will not be considered in the permeability assessment update. Therefore, 17 of the 20 wells will be used in the permeability assessment update (see Table 9 and Table 10).

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 a Microsoft® SQL server application. This information is obtained every quarter in a report from the New Mexico Institute of Mining and Technology, Socorro, New Mexico, utilizing data from an array of nine seismographs in the vicinity of the WIPP site (NMIMT 2012, NMIMT 2013a, NMIMT 2013b, NMIMT 2013c).

During the reporting period there were five seismic events recorded in the Delaware Basin. Four seismic events occurred in Reeves County with magnitudes of 0.8, 1.5, 1.7, and 2.0. One seismic event occurred in Pecos County with a magnitude of 1.1. Table 11 provides information on recorded seismic events, which have occurred in 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.

In the New Mexico portion of the Delaware Basin, there are three major waterflood projects and several one and two 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 Paduca waterflood project, located in T25S-R32E, has six permitted injection wells with five 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 six 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 CO_2.

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 12 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 brine 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 producing oil and gas wells produce 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 companies now dispose of this water by injecting it into approved SWD wells.

There are currently 57 SWD wells located in the nine-township area surrounding the WIPP site. Three operators, *Devon Energy Production Company LP*, *OXY USA INC*, and *Yates Petroleum Corporation*, operate the majority of the SWD wells. Injection depths range from 3,400 feet to 8,500 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 12 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 in CCA, Appendix DEL, CRA-2004, Appendix DATA, and CRA-2009, Appendix DATA. 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; however, a new company, *Intercontinental Potash Corporation*, has procured leases to the east of the WIPP site and is proposing to develop a new underground mine in order to extract polyhalite ore (a type of potash). The draft environmental impact statement was made available for public comment on August 9, 2013.

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) is currently shut down.

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 then pumped back to the surface where the minerals are removed from the water, usually by evaporation. There are several brine mines or wells in the area, two 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. These are shallow wells using injected fresh water to dissolve salt into a brine solution.

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 13 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 is located in the Delaware Basin. One 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 had been recently plugged and abandoned. This well collapsed in early November 2008.

One brine well, Eugenie #1, is closely being monitored by the NMOCD as it fits the geological profile of the two collapsed wells. This well is located within the Carlsbad city limits and is within the New Mexico portion of the Delaware Basin. It was voluntarily plugged and abandoned by the operator in October 2008.

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. The BLM was provided with the necessary documentation to acquire a permit to operate the pilot project, but the project was postponed. In March 2002, *Mississippi Potash, Inc.* again 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 Environmental Impact Statement (EIS), which was approved by the BLM on March 19, 2012. Construction has been completed and production is expected to begin in late 2013. 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. On June 18, 2013, the NMOCD amended NMAC Title 19, Chapter 15, Part 17 (Pit Rule). This amendment makes compliance with the Pit Rule easier by allowing more flexibility in the registration and permitting process.

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 new 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. The DBDSP continues to identify and document alternative energy activities.

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 first survey of area operators was performed July 1999 and had been sent out each July until 2004. An annual survey was not performed in July 2004. The survey for 2004 was moved to January 2005 and is performed annually in January. With this change, results from the annual survey will be included in the annual report for that year as there will be nine months for surveys to be returned instead of two months. For the 2013 Annual Survey, 13 annual survey forms were sent to local area operators on February 13, 2013. As of this report, three annual survey forms have been received from local operators.

4.0 Summary - 2013 Delaware Basin Drilling Surveillance Program

- No new instances of air drilling.
- No Castile Brine encounters reported.
- The drilling rate has increased to 72.0 boreholes per square kilometer.
- Two new salt water disposal wells completed in the nine-township area.
- Fourteen wells spudded in the nine-township area.
- One hundred ninety-five wells spudded outside the nine-township area in New Mexico.
- Seven hundred thirty-four wells spudded in the Texas portion of the Delaware Basin.

5.0 References

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

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

New Mexico Institute of Mining and Technology (NMIMT). 2012. *A Report on the Seismicity of the WIPP Site for the Period July 1, 2012 through September 30, 2012*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2013a. *A Report on the Seismicity of the WIPP Site for the Period October 1, 2012 through December 31, 2012*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2013b. *A Report on the Seismicity of the WIPP Site for the Period January 1, 2013 through March 31, 2013*. Socorro, New Mexico.

New Mexico Institute of Mining and Technology (NMIMT). 2013c. *A Report on the Seismicity of the WIPP Site for the Period April 1, 2013 through June 30, 2013*. Socorro, New Mexico.

Nuclear Waste Partnership LLC. 2012. *Delaware Basin Drilling Surveillance Plan, Rev. 5.* November 2012. WP 02-PC.02. Carlsbad, NM: Carlsbad Field Office.

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

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

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

U.S. Department of Energy (DOE). 2012. *Delaware Basin Monitoring Annual Report*. September 2012. DOE/WIPP-12-2308. Carlsbad, NM: Carlsbad Field Office.

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

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

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

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

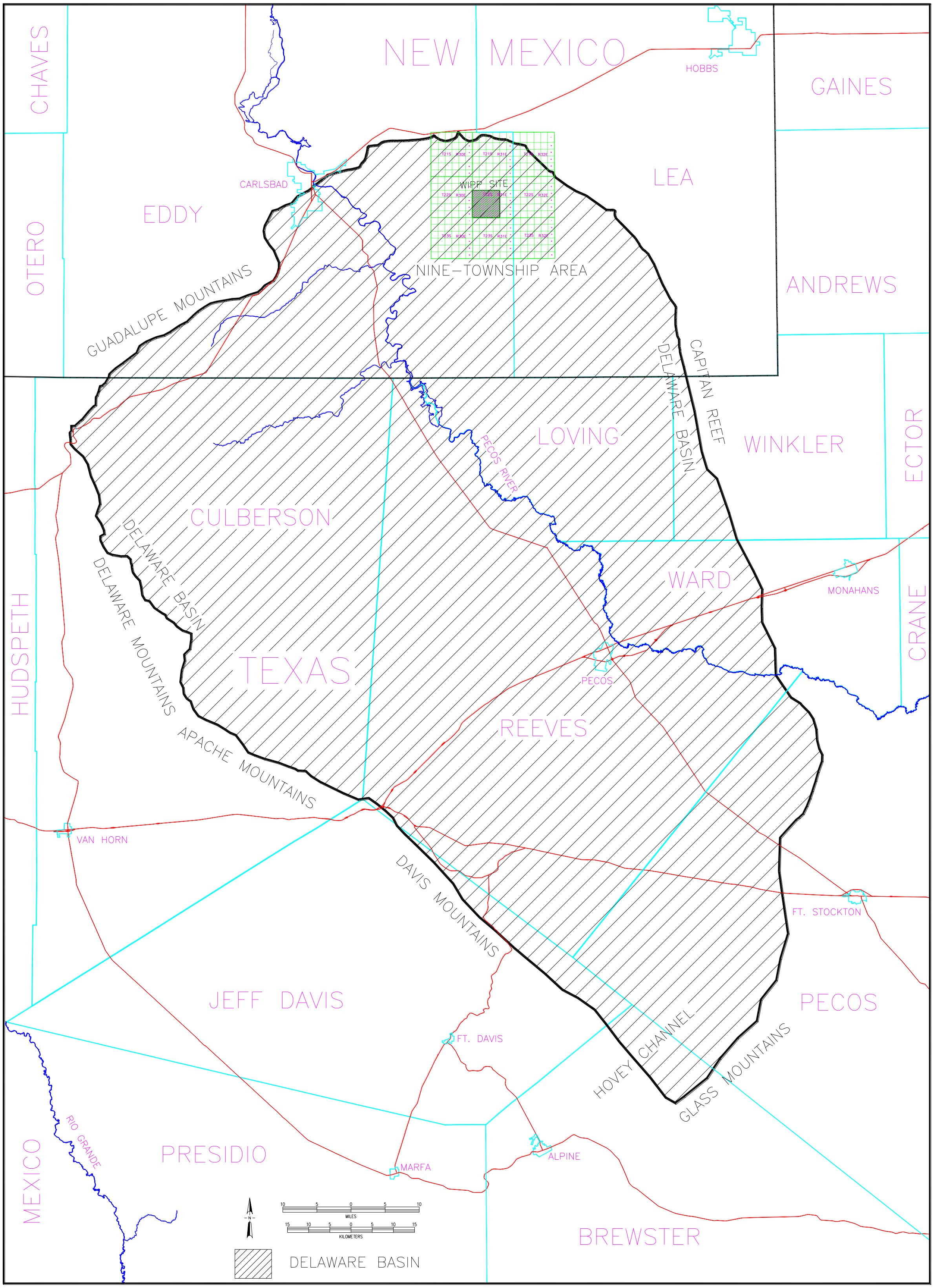

Figure 1: WIPP Site, Delaware Basin, and Surrounding Area

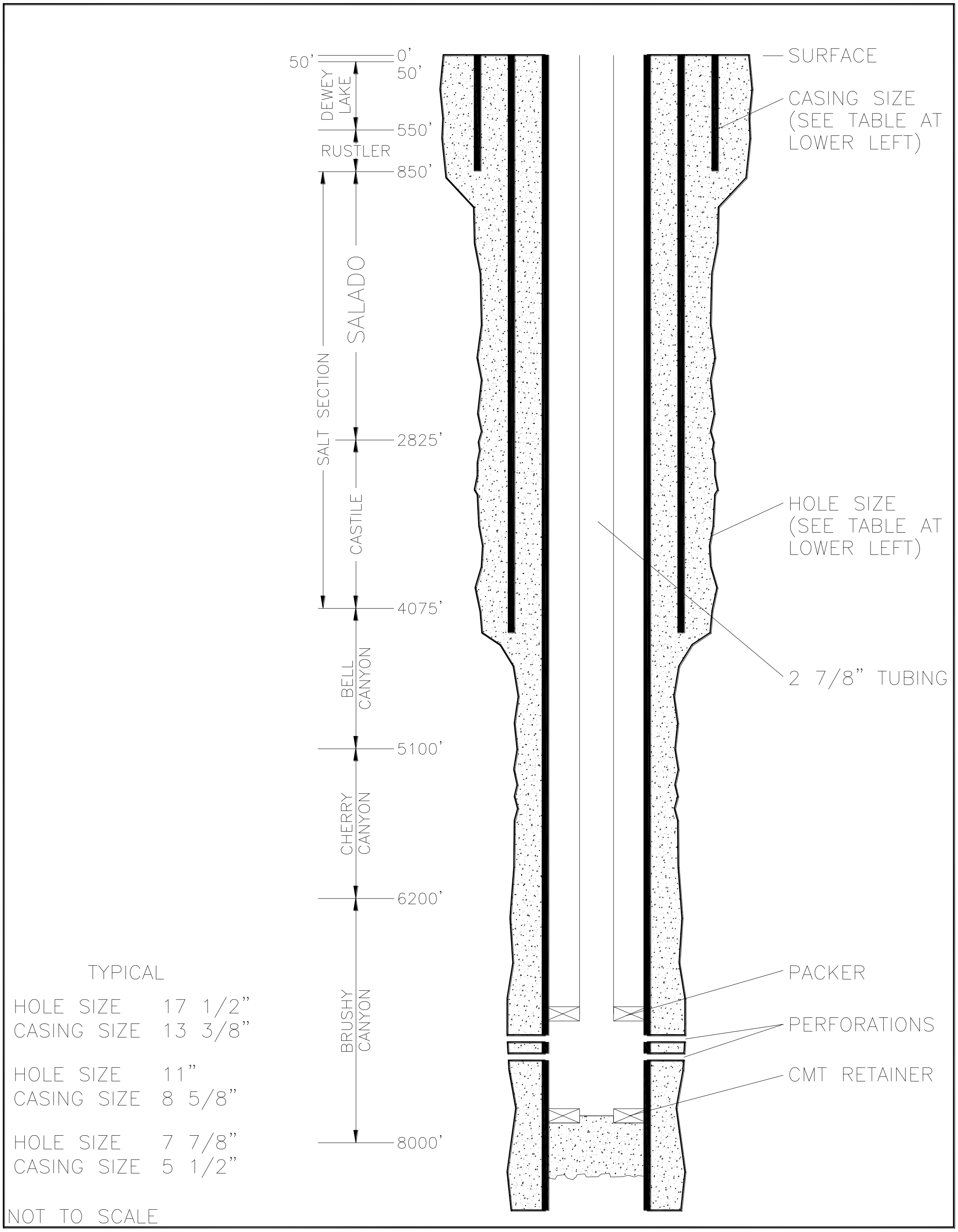

Figure 2: Typical Well Structure and General Stratigraphy Near the WIPP Site

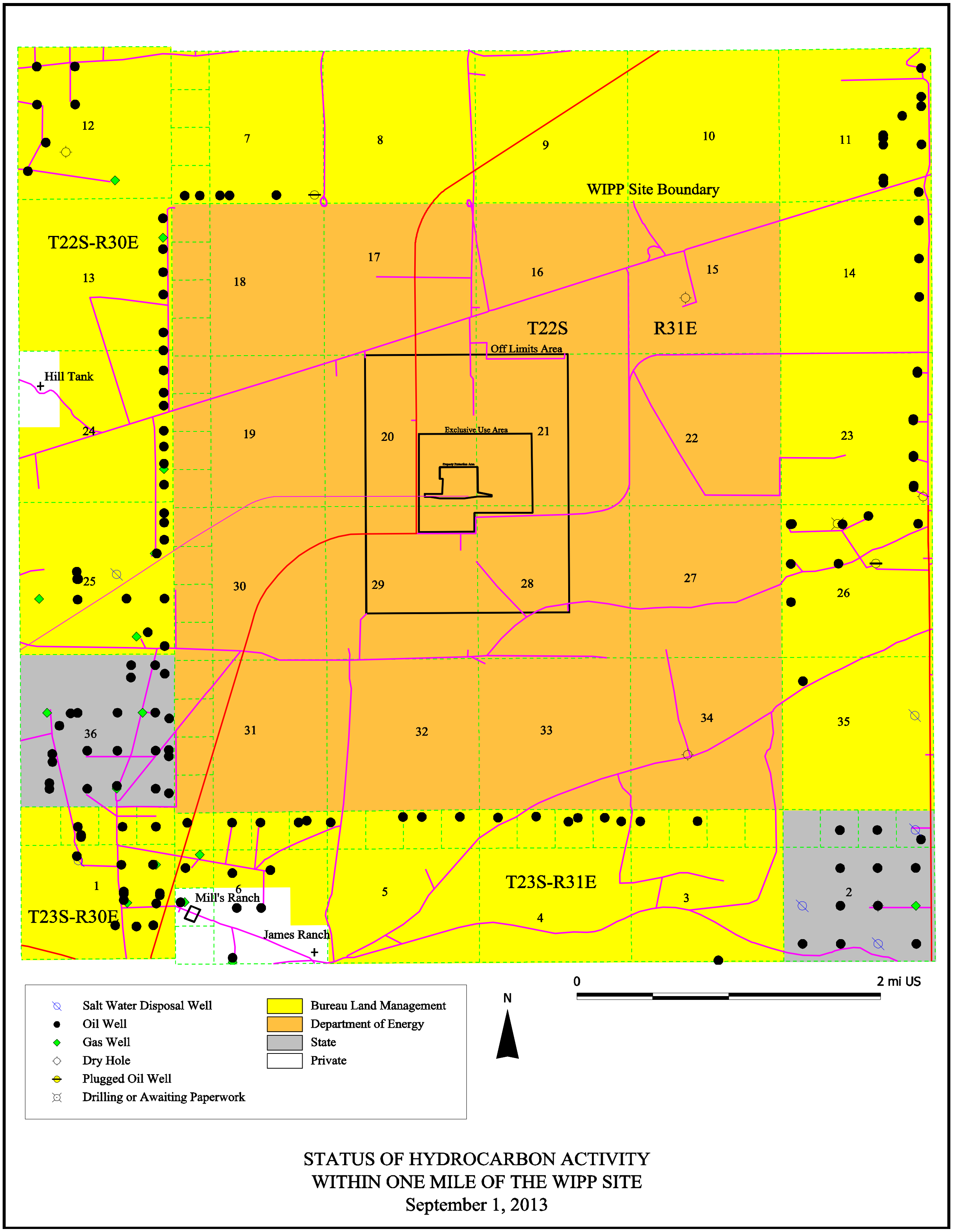

Figure 3: Oil and Gas Wells within One Mile of the WIPP Site

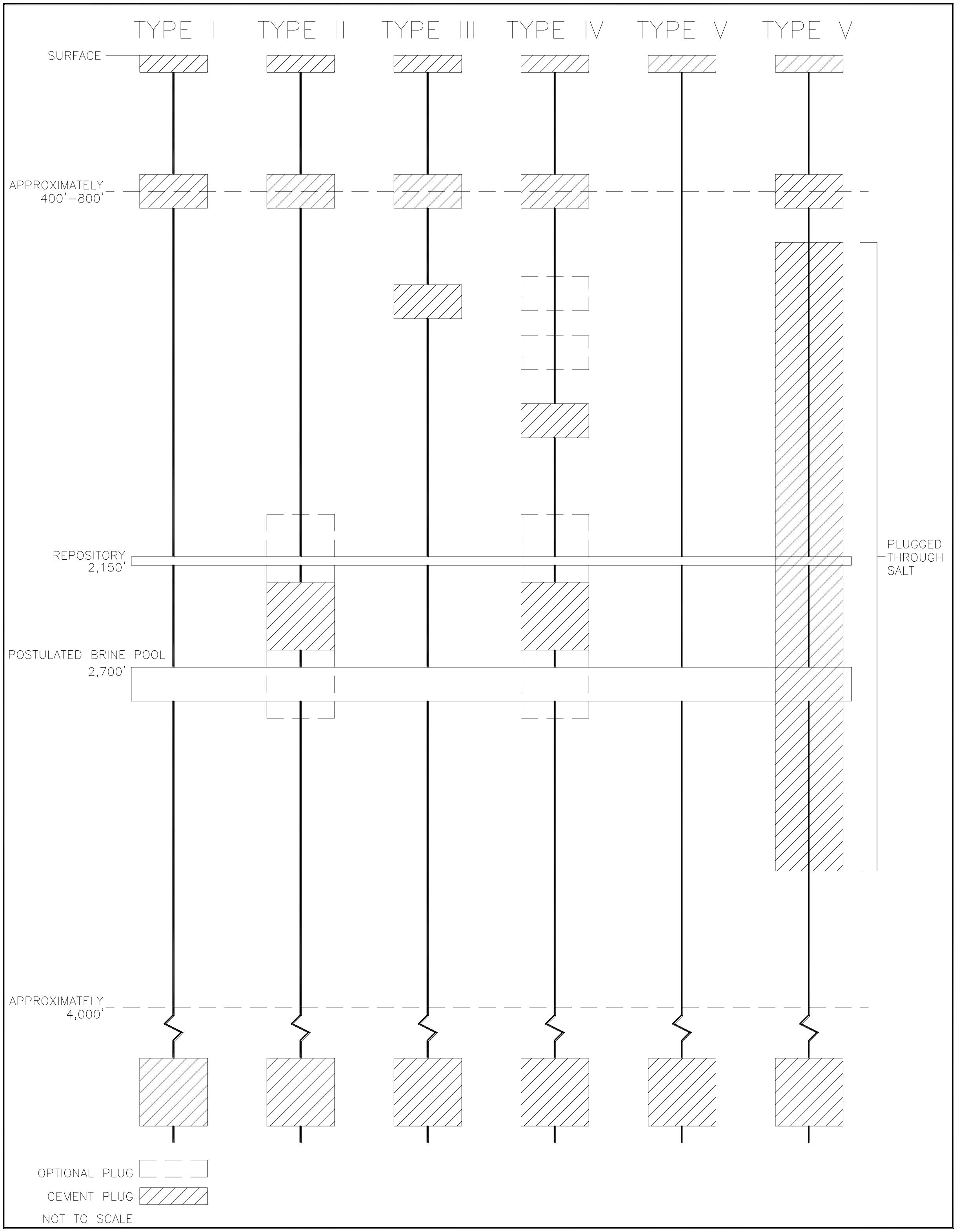

Figure 4: Typical Borehole Plug Configurations in the Delaware Basin

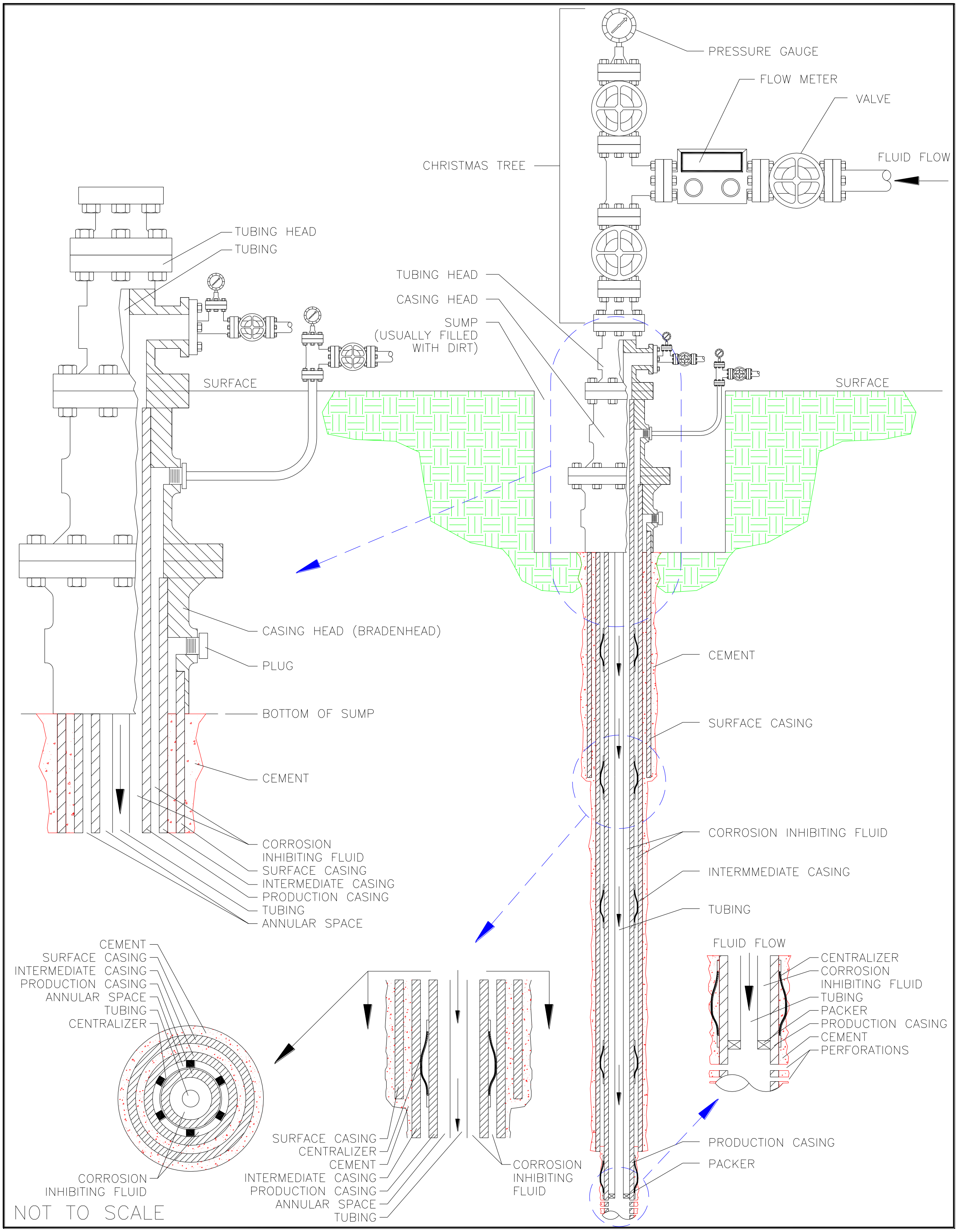

Figure 5: Typical Injection or Salt Water Disposal Well (SWD)

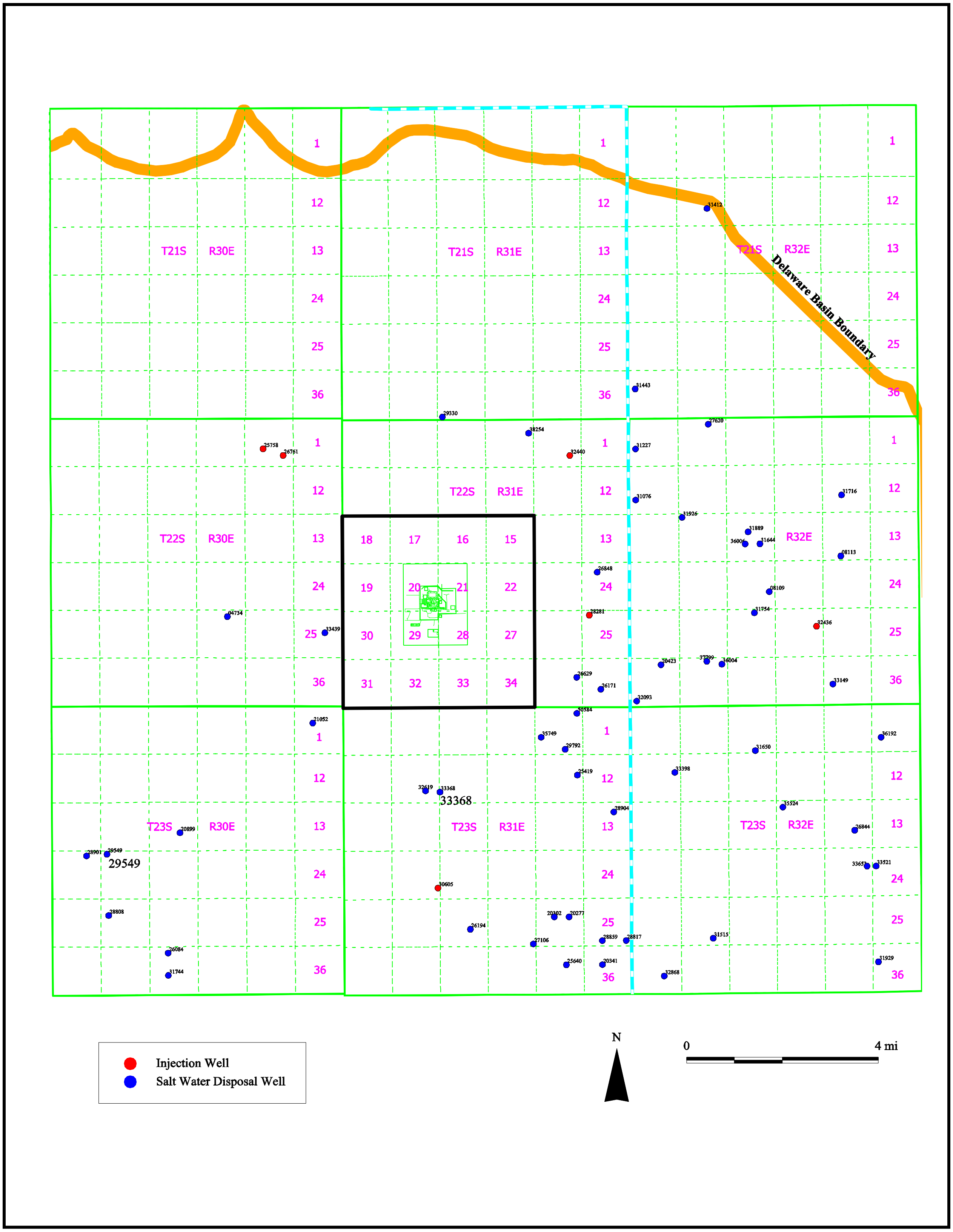

Figure 6: Active Injection and SWD Wells in the Nine-Township Area

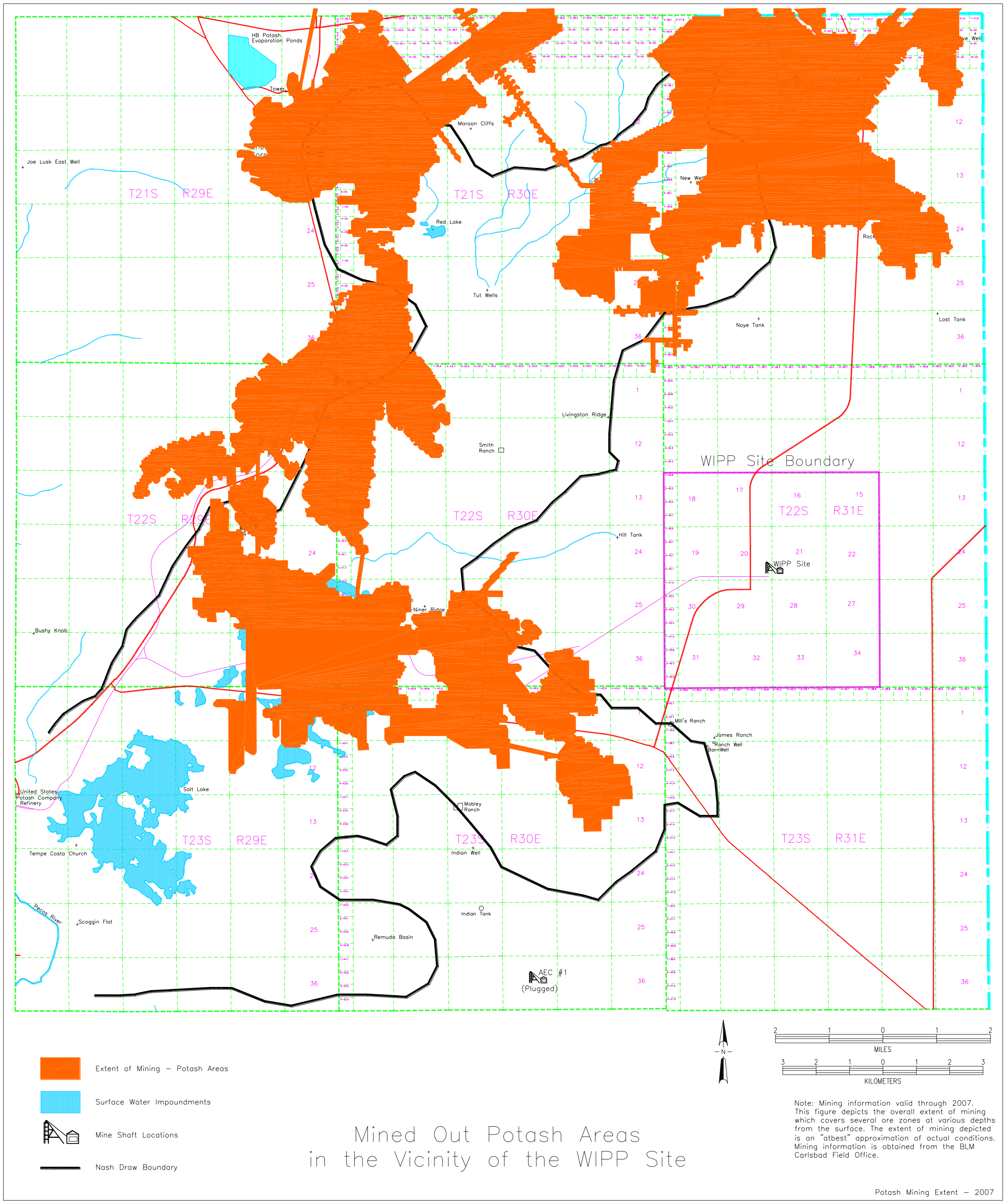

Figure 7: Potash Mining in the Vicinity of the WIPP Site

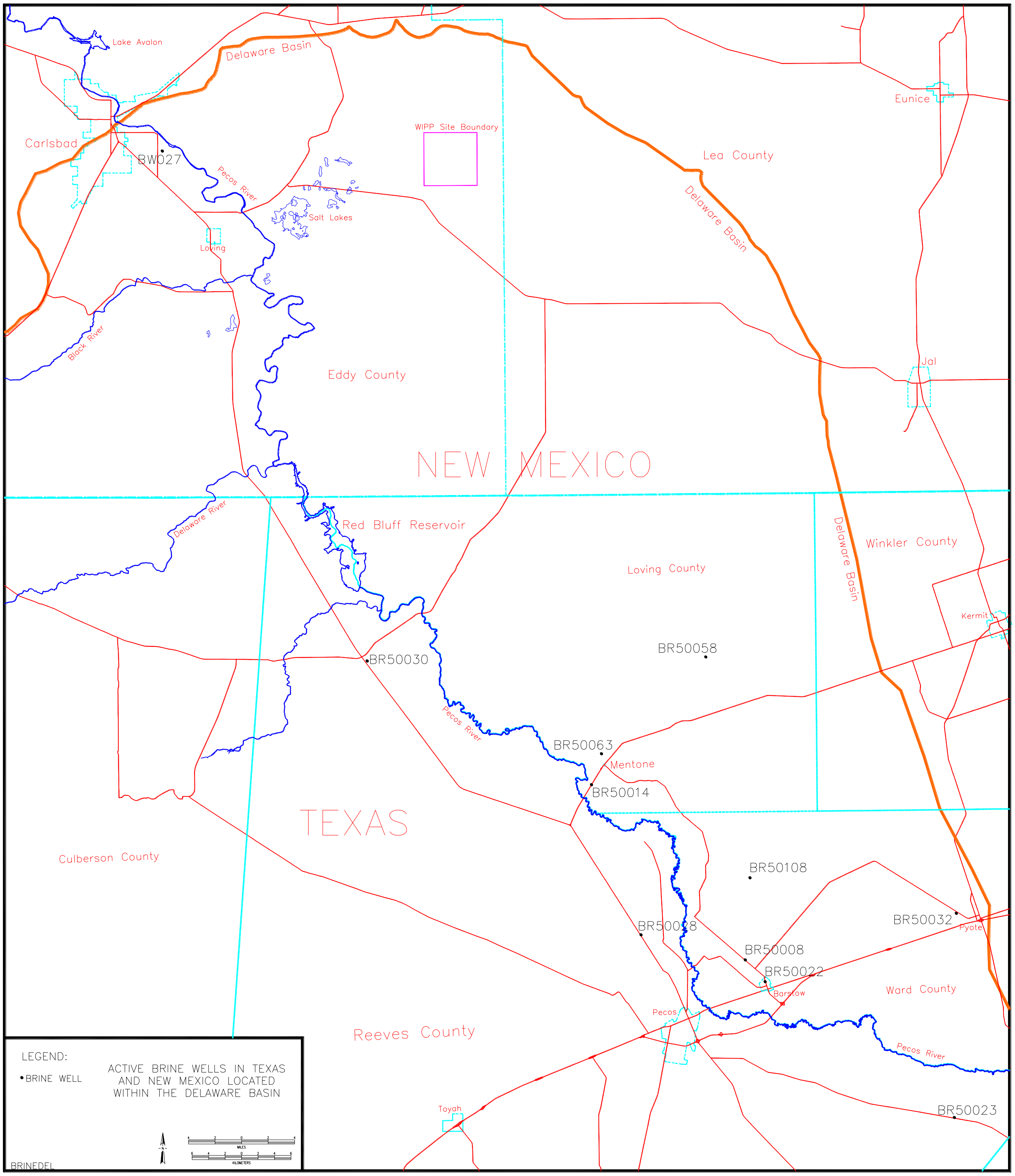

Figure 8: Active Brine Well Locations in the Delaware Basin

Table 1: Nine-Township Area Casing Sizes

Casing Size	Surface Casing	Intermediate Casing	Production Casing
16"	0	0	0
13 3/8"	9	0	0
11 3/4"	1	0	0
10 3/4"	0	0	0
9 5/8"	0	0	0
8 5/8"	0	8	0
7 5/8"	0	2	0
7"	0	0	3
5 1/2"	0	0	7

NOTE: There were fourteen wells drilled in the nine-township area between September 1, 2012 and August 31, 2013. Ten of the wells had complete records available on casing sizes. The other wells had partial records available or had just recently been spudded.

Table 2: Nine-Township Area Bit Sizes

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

NOTE: Of the fourteen wells drilled in the nine-township area, complete records were available on ten wells.

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' and 2,685' 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'. Hole was dry drilled to 1,792'. Supposedly, air drilled from 2,984' to 4,725'
3	23S-26E-17	Exxon "17" Federal #1	8/1/1989	Gas Well	Air drilled through the salt from 575' to 2,707'.
4	23S-28E-11	CP Pardue #1	10/28/1958	P&A	Air drilled through the salt from 390' to 2,620'
5	23S-28E-11	Amoco Federal #1	8/4/1979	Oil Well	Air drilled from 475' to 9,700'.
6	23S-28E-11	Amoco Federal #3	2/28/1980	Oil Well	Air drilled from 6,271' to 9,692'.
7	23S-28E-23	South Culebra Bluff Unit #3	1/21/1979	Oil Well	Air drilled from 6,345' to 8,000'.
8	23S-28E-23	South Culebra Bluff Unit #4	8/9/1979	Oil Well	Air drilled from 450' to 9,802'.
9	24S-31E-03	Lilly "ALY" Federal #2	5/1/1994	Oil Well	Air drilled conductor hole to 40'.
10	24S-31E-03	Lilly "ALY" Federal #4	5/16/1994	Oil Well	Air drilled conductor hole to 40'.
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'. 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'.
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'.
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'.

Table 4: Shallow Well Status in the Delaware Basin

Well Type	Texas	New Mexico	Totals
Core Hole	31	2	33
Dry Hole	348	159	507
Gas Well	8	9	17
Injection Well	5	1	6
Junked and Abandoned Well	64	32	96
Oil Well	104	41	145
Oil and Gas Well	2	0	2
Plugged Gas Well	1	4	5
Plugged Oil Well	18	21	39
Plugged Brine Well	2	3	5
Plugged Salt Water Disposal Well	0	5	5
Drilling or Waiting on Paperwork	509	88	597
Brine Well	1	2	3
Salt Water Disposal Well	0	2	2
Service Well	12	0	12
Stratigraphic Test Hole	1,170	0	1,170
Sulfur Core Hole	502	0	502
Potash Core Hole	0	1,117	1,117
Water Well	1,706	590	2,296
WIPP Well	0	210	210
Other (Mine Shafts, Gnome Project Wells)	0	44	44
TOTALS	4,483	2,330	6,813

NOTE: Only the known holes that occur in the Delaware Basin are listed in the above table. The 597 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
Core Hole	5	0	5
Dry Hole	2,187	812	2,999
Gas Well	1,219	922	2,141
Injection Well	310	54	364
Junked and Abandoned Well	55	19	74
Oil Well	5,393	3,001	8,394
Oil and Gas Well	124	4	128
Plugged Gas Well	262	201	463
Plugged Injection Well	62	58	120
Plugged Oil Well	858	484	1,342
Plugged Oil and Gas Well	44	0	44
Plugged Brine Well	0	1	1
Plugged Salt Water Disposal Well	4	31	35
Plugged Service Well	6	1	7
Drilling or Waiting on Paperwork	22	5	27
Brine Well	9	0	9
Salt Water Disposal Well	64	188	252
Service Well	62	0	62
Stratigraphic Test Hole	44	2	46
Sulfur Core Hole	85	0	85
Potash Core Hole	0	19	19
WIPP Well	0	11	11
Other (Mine Shafts, Gnome Project Wells)	0	6	6
TOTALS	10,815	5,819	16,634

NOTE: The 27 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

Year	No. of Deep Holes	Drilling Rate
1996	10,804 Holes Deeper Than 2,150 ft.	46.8
1997	11,444 Holes Deeper Than 2,150 ft.	49.5
1998	11,616 Holes Deeper Than 2,150 ft.	50.3
1999	11,684 Holes Deeper Than 2,150 ft.	50.6
2000	11,828 Holes Deeper Than 2,150 ft.	51.2
2001	12,056 Holes Deeper Than 2,150 ft.	52.2
2002[1]	12,139 Holes Deeper Than 2,150 ft.	52.5
2003	12,316 Holes Deeper Than 2,150 ft.	53.3
2004	12,531 Holes Deeper Than 2,150 ft.	54.2
2005	12,819 Holes Deeper Than 2,150 ft.	55.5
2006	13,171 Holes Deeper Than 2,150 ft.	57.0
2007	13,520 Holes Deeper Than 2,150 ft.	58.5
2008	13,824 Holes Deeper Than 2,150 ft.	59.8
2009	14,173 Holes Deeper Than 2,150 ft.	61.3
2010	14,403 Holes Deeper Than 2,150 ft.	62.3
2011	14,816 Holes Deeper Than 2,150 ft.	64.1
2012	15,558 Holes Deeper Than 2,150 ft.	67.3
Current	16,633 Holes Deeper Than 2,150 ft.	72.0

NOTE: The notable 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. Since that time, the drilling rate has increased approximately the same each year.

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.
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	09/11/200	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

#	Location	API#	Plug Date	R-111-P Area	Well Depth	Plug Depth	Plug Length
1	21S-32E-28	30-025-30664	3/13/2013	Yes	14,800	4750-4513 4270-4192 2848-2688 1056-916 676-520 60-0	237 ft 78 ft 160 ft 140 ft 156 ft 60 ft
2	22S-28E-7	30-015-22101	3/28/2013	No	3,450	2915-2880 2490-2250 1606-1337 462-106 60-0	35 ft 240 ft 269 ft 356 ft 60 ft
3	22S-28E-18	30-015-21391	4/9/2013	No	3,401	CIBP 3159 2464-2250 1600-1480 411-60 60-0	35 ft 214 ft 120 ft 351 ft 60 ft
4	22S-28E-19	30-015-21844	4/4/2013	No	3,450	CIBP 3195 2482-2188 1650-1550 452-100 60-0	35 ft 294 ft 100 ft 352 ft 60 ft
5	22S-31E-3	30-015-40769	1/9/2013	Yes	707	707-0	707 ft
6	22S-32E-26	30-025-31853	10/26/2012	No	8,840	7541-7162 6361-5492 4902-4406 2784-2582 1114-678 350-0	379 ft 869 ft 496 ft 202 ft 436 ft 350 ft
7	22S-32E-31	30-025-36381	9/11/2012	No	8,792	6902-6861 6861-6123 4600-4146 4125-3932 1055-725 60-0	41 ft 738 ft 454 ft 193 ft 330 ft 60 ft
8	22S-33E-8	30-025-36318	10/8/2012	No	15,400	8676-8450 7095-6890 4835-4454 3426-3187 1700-1560 1155-911 60-0	226 ft 205 ft 381 ft 239 ft 140 ft 244 ft 60 ft
9	23S-34E-10	30-025-24993	11/29/2012	No	13,600	11660-11123 8542-8297 7078-6194 5256-4821 4045-3409 1169-945 705-595 60-0	537 ft 245 ft 884 ft 435 ft 636 ft 224 ft 110 ft 60 ft

10	24S-26E-9	30-015-29659	11/10/2012	No	5,400	CIBP 2618 2550-2350 1810-1610 1180-1070 623-423 63-3	35 ft 200 ft 200 ft 110 ft 200 ft 60 ft
11	24S-30E-34	30-015-40772	1/3/2013	No	116	116-0	116 ft
12	24S-30E-34	30-015-40927	1/3/2013	No	95	95-4	91 ft
13	24S-31E-12	30-015-37605	6/28/2013	No	9	9000-8520 8520-8288 6160-6000 4625-2442 2440-1792 1790-1216 1214-1014 1000-528 63-3	480 ft 232 ft 160 ft 2183 ft 648 ft 574 ft 200 ft 472 ft 60 ft
14	24S-32E-6	30-025-32505	3/4/2013	No	9,930	5950-5688 4600-4271 4271-4009 1278-1150 648-528 126-0	262 ft 329 ft 262 ft 128 ft 120 ft 126 ft
15	24S-32E-32	30-025-40453	7/12/2013	No	60	60-0	60 ft
16	24S-33E-5	30-025-40675	10/12/2012	No	15,178	5000-4750 4654-4185 1332-1098 400-0	250 ft 469 ft 234 ft 400 ft
17	24S-34E-5	30-025-39253	11/26/2012	No	13,810	8880-8654 7089-6703 5226-5024 3255-3120 1305-1081 525-0	226 ft 386 ft 202 ft 135 ft 224 ft 525 ft
18	26S-29E-8	30-015-37614	6/7/2013	No	11,645	6662-6445 4500-4360 2919-2595 560-240	217 ft 140 ft 324 ft 320 ft
19	26S-29E-27	30-015-25436	1/22/2013	No	5,400	3592-3537 3525-3470 2907-2697 614-244 60-0	55 ft 55 ft 210 ft 370 ft 60 ft
20	26S-30E-21	30-015-39940	5/24/2013	No	653	653-0	653 ft

Table 9: Past Plugging Summary by Well Type

Type	CCA Well Count	CCA Frequency	CRA-2004 Well Count	CRA-2004 Frequency	CRA-2009 Well Count	CRA-2009 Frequency
I	61	32.5%	116	34.1%	131	30.5%
II	37	20%	60	17.7%	84	19.5%
III	64	34%	111	32.6%	142	33%
IV	19	10%	38	11.2%	52	12.1%
V	3	1.5%	10	2.9%	13	3%
VI	4	2%	5	1.5%	8	1.9%
TOTALS	188	100.0%	340	100.0%	430	100.0%

Type	CRA-2014 Well Count	CRA-2014 Frequency
I	147	26.9%
II	110	20.1%
III	163	29.9%
IV	90	16.5%
V	14	2.6%
VI	22	4.0%
TOTALS	546	100.0%

Table 10: Current Plugging Summary by Well Type for the CRA-2019

Type	CRA-2014	CRA-2014 Frequency	2013	2014	2015	2016	2017	Total	Current Frequency	Change
I	147	26.9%	3					150	26.6%	-0.3%
II	110	20.1%	2					112	19.9%	-0.2%
III	163	29.9%	2					165	29.3%	-0.6%
IV	90	16.5%	10					100	17.8%	+1.3%
V	14	2.6%	0					14	2.5%	-0.1%
VI	22	4.0%	0					22	3.9%	-0.1%
TOTALS	546	100.0%	17					563	100.0%	

NOTE: The 1996 Compliance Certification Application (CCA) used the 188 wells categorized into the above classifications to arrive at the percentage or frequency of each plugging event. The 2004 Compliance Recertification Application (CRA-2004) followed up on that study and 152 wells were added to the original value to update the frequency. For the CRA-2009, 90 wells were added to the CRA-2004 value to update the frequency. For the CRA-2014, 116 wells were added to the CRA-2009 value to update the frequency.

Table 11: Seismic Activity in the Delaware Basin

County	No. of Events	Earliest Event	Latest Event	Smallest Magnitude	Largest Magnitude
Culberson	15	10/27/1992	6/28/2007	1.1	2.4
Eddy	19	11/28/1975	3/18/2012	-1.3	3.7
Lea	1	6/23/1993	6/23/1993	2.1	2.1
Loving	3	2/4/1976	4/28/1997	1.1	1.6
Pecos	20	1/30/1975	3/22/2013	1.0	2.6
Reeves	23	2/19/1976	2/25/2013	0.6	2.4
Ward	50	9/3/1976	7/1/2009	0.3	2.8
Winkler	9	9/24/1971	10/19/2007	0.0	3.0
TOTAL	140				

KEY:

<u>Magnitude</u>

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

NOTE: Four of the nineteen seismic events in Eddy County can be directly attributed to mining activities.

Table 12: 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	May 2013	6,813,420
2	21S-32E-08	30-025-31412	SWD	4,826-5,978	1991	June 2013	14,627,315
3	21S-32E-31	30-025-31443	SWD	4,618-6,012	1992	June 2013	1,670,867
4	22S-30E-02	30-015-25758	Injection	7,200-7,264	1993	June 2013	25,095,185
5	22S-30E-02	30-015-26761	Injection	5,600-7,400	1991	June 2013	23,783,436
6	22S-30E-25	30-015-33439	SWD	5,678-7,682	2010	May 2013	1,461,463
7	22S-30E-27	30-015-04734	SWD	3,820-3,915	1981	May 2013	5,782,833
8	22S-31E-02	30-015-32440	Injection	6,989-7,020	2003	May 2013	2,615,934
9	22S-31E-03	30-015-38254	SWD	5,355-6,137	2012	May 2013	826,560
10	22S-31E-24	30-015-26848	SWD	4,519-5,110	1991	May 2013	12,327,358
11	22S-31E-25	30-015-28281	Injection	7,050-7,068	1995	May 2013	11,927,780
12	22S-31E-35	30-015-26629	SWD	4,500-5,670	1991	June 2013	23,440,804
13	22S-31E-36	30-015-26171	SWD	4,500-5,700	1998	May 2013	8,887,520
14	22S-32E-05	30-025-27620	SWD	5,150-8,602	2004	June 2013	7,497,064
15	22S-32E-06	30-025-31227	SWD	4,626-5,730	2012	June 2013	1,825,227
16	22S-32E-07	30-025-31076	SWD	4,676-5,814	1991	June 2013	12,973,243
17	22S-32E-11	30-025-31716	SWD	5,200-8,706	1994	May 2013	2,958,008
18	22S-32E-14	30-025-08113	SWD	4,900-6,080	1994	May 2013	6,072,278
19	22S-32E-16	30-025-31644	SWD	5,582-6,380	2010	June 2013	805,105
20	22S-32E-16	30-025-31889	SWD	5,240-8,710	1995	June 2013	11,775,920
21	22S-32E-16	30-025-36006	SWD	5,858-6,450	2010	June 2013	1,580,244
22	22S-32E-17	30-025-31926	SWD	6,807-6,828	2007	June 2013	2,509,218
23	22S-32E-21	30-025-08109	SWD	4,755-5,110	1992	May 2013	3,865,611
24	22S-32E-27	30-025-32436	Injection	6,831-8,388	1998	May 2013	9,490,400
25	22S-32E-28	30-025-31754	SWD	4,690-5,800	1993	May 2013	5,408,187
26	22S-32E-31	30-025-20423	SWD	4,662-5,915	1993	May 2013	5,701,834
27	22S-32E-31	30-025-32093	SWD	4,590-5,626	2004	May 2013	877,119
28	22S-32E-32	30-025-36004	SWD	6,744-8,518	2010	June 2013	2,802,040
29	22S-32E-32	30-025-37799	SWD	5,754-6,500	2010	June 2013	2,193,530
30	22S-32E-35	30-025-33149	SWD	4,950-6,252	1995	May 2013	8,421,357
31	23S-30E-01	30-015-21052	SWD	4,040-4,825	2001	May 2013	3,714,020
32	23S-30E-16	30-015-20899	SWD	4,433-5,952	2003	May 2013	2,309,983
33	23S-30E-19	30-015-28901	SWD	3,402-4,609	1997	May 2013	3,526,813
34	23S-30E-20	30-015-29549	SWD	4,124-4,774	2006	May 2013	2,448,095

35	23S-30E-29	30-015-28808	SWD	5,479-7,220	1996	May 2013	4,798,188
36	23S-30E-33	30-015-26084	SWD	4,470-7,558	2005	May 2013	6,333,191
37	23S-30E-33	30-015-31744	SWD	4,546-6,760	2002	May 2013	6,009,709
38	23S-31E-02	30-015-05840	SWD	4,489-5,670	1997	May 2013	9,289,449
39	23S-31E-02	30-015-29792	SWD	4,500-5,850	1998	May 2013	9,709,992
40	23S-31E-02	30-015-35749	SWD	4,600-5,880	2010	June 2013	1,126,788
41	23S-31E-08	30-015-32619	SWD	7,256-7,530	2004	May 2013	2,648,616
42	23S-31E-09	30-015-33368	SWD	7,942-7,952	2005	May 2013	4,366,017
43	23S-31E-11	30-015-25419	SWD	5,210-5,800	2005	May 2013	1,128,168
44	23S-31E-13	30-015-28904	SWD	5,760-5,862	2005	May 2013	935,273
45	23S-31E-20	30-015-30605	Injection	7,740-7,774	2001	May 2013	7,742,710
46	23S-31E-25	30-015-28817	SWD	5,776-5,920	2008	May 2013	384,637
47	23S-31E-25	30-015-28859	SWD	5,236-5,498	2008	May 2013	884,949
48	23S-31E-26	30-015-20277	SWD	4,460-5,134	1992	May 2013	4,969,998
49	23S-31E-26	30-015-20302	SWD	4,390-6,048	1971	May 2013	7,114,712
50	23S-31E-27	30-015-27106	SWD	4,694-5,284	1998	Feb 2013	5,925,475
51	23S-31E-28	30-015-26194	SWD	4,295-5,570	1993	May 2013	6,855,466
52	23S-31E-35	30-015-25640	SWD	4,484-5,780	1993	May 2013	8,220,258
53	23S-31E-36	30-015-20341	SWD	5,980-6,560	1994	May 2013	27,267,989
54	23S-32E01	30-025-36192	SWD	5,468-6,092	2013	June 2013	268,281
55	23S-32E-04	30-025-31650	SWD	4,884-5,886	2003	May 2013	4,640,046
56	23S-32E-07	30-025-33398	SWD	4,660-6,270	2009	March 2013	1,159,834
57	23S-32E-14	30-025-26844	SWD	5,496-6,014	1991	May 2013	2,023,224
58	23S-32E-15	30-025-35524	SWD	5,786-5,942	2008	May 2013	299,330
59	23S-32E-23	30-025-33653	SWD	5,954-6,064	2000	May 2013	1,694,279
60	23S-32E-24	30-025-33521	SWD	5,925-6,042	2001	April 2013	1,843,590
61	23S-32E-29	30-025-31515	SWD	4,844-4,944	1992	May 2013	11,599,507
62	23S-32E-31	30-025-32868	SWD	5,150-5,700	1996	May 2013	3,662,099
63	23S-32E-36	30-025-31929	SWD	5,364-6,138	1995	May 2013	4,298,822

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 on behalf of the New Mexico OCD (NMIMT).

Table 13: 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.	Plugged 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.	Active Brine Well
Reeves	Blk 04-08	42-389-20100	North Pecos Brine Station #WD-1	Chance Properties Company	Active 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