Pryor CHEMICAL CO.

CONVENIENCE COPY

November 9, 2018

Via Email & USPS

Ms. Hillary Young, P.E.
Chief Engineer
Land Protection Division
Oklahoma Department of Environmental Quality
Post Office Box 1677
Oklahoma City, Oklahoma 73101-1677

RE: Permit Renewal Application for Class I Non-Hazardous UIC Well
UIC Permit No. IW-NH-49022-R1
Response to ODEQ Notice of Deficiency

Dear Ms. Young:

Please find enclosed Pryor Chemical Company's (PCC) partial responses to the ODEQ's Notice of Deficiency dated September 25, 2018. Each response is listed numerically as in ODEQ's letter.

PCC will provide ODEQ with responses to the remaining NOD's following our meeting with you scheduled for November 15, 2018. If you have any questions or would like any additional information, please do not hesitate to contact me.

Sincerely,

John M. Carver
Vice President, Safety and
Environmental Compliance

cc: Saba Tahmassebi

3503 NW 63rd Street, Suite 500 · Oklahoma City, OK 73116 · (405) 235-4546

RESPONSE TO NOTICE OF DEFICIENCY

PRYOR CHEMICAL COMPANY

PERMIT NO. IW-NH-49022-R1

Item 2: *In Attachment C, it is stated that there are four (4) injection-related wells located within the 2.0 mile Area of Review. Three (3) of the wells are discussed including Kaiser Injection Well No.1, Kaiser Injection Well No. 2 and Oklahoma Ordnance Work Authority #2. PCC states that the fourth well is discussed in Attachment A; however, Attachment A provides no discussion of the fourth injection-related well. Please provide discussion and information on this well and all artificial penetrations of the upper confining layer. Pursuant to item 1 above, if the Area of Review is expanded, PCC must provide information on all artificial penetrations and wells within the expanded Area of Review.*

Response: PCC has corrected this reference to "..there are three injection related wells..". Information for each of these wells is presented in Table A-1 and records information is included in Attachment C. A revised Attachment C is included with these responses for replacement into the permit application document.

Item 3: *In Attachment D, no maps and cross-sections of USDWs are provided. The Application states that there are no aquifers above the confining zone and within the PCC injection well 2.0 mile radius Area of Review because none of the freshwater bearing formations have a sufficient yield (50 gallons per minute) to meet the definition of an aquifer. In accordance with 40 CFR 144.3, the definition of an aquifer is a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs. Please revise Attachment D with the correct definition of an aquifer and with maps and cross-sections of the aquifers within the 2.0 mile radius Area of Review in accordance with 40 CFR 146. 14(a)(4). Pursuant to item 1, if the Area of Review is expanded, please provide the required information on all aquifers within the expanded Area of Review*

Response: To clarify, the above provides the definition for "aquifer" under the applicable UIC rules. 40 CFR 144.3. Using that definition, ODEQ asks PCC to (1) revise Attachment D to show aquifers within the AOR, and (2) if the AOR is expanded, provide information on those aquifers within the expanded AOR.

We agree that the definition of an aquifer, given above in ODEQ's comments, is taken directly from 40 CFR 144.3. However, the UIC program ***is designed to protect underground sources of drinking water (USDW).*** Further, we note that the application information requirements of 40 CFR 146.14(d)(4) require maps and cross sections of USDWs, not aquifers. ODEQ's UIC rules adopt and incorporate this rule and do not contain a requirement for aquifer maps.

PCC's application addressed whether a USDW was present in the AOR, and no map was provided because no USDWs are present. Thus, Attachment D satisfies the requirements of 40 CFR 146.14(d)(4) and ODEQ UIC regulations. Since the AOR has not been expanded, nor is expansion warranted, no amended map showing USDWs within an expanded AOR is required.

Item 4: *In TABLE A-I, Kaiser Injection Well (John Deere) #1 shows a status of Plugged and Abandoned (P&A), but Figure B-2 shows Deere #1 with Unknown Status. Please revise Figure B-2 to correctly identify the status of Deere #1.*

Response: PCC has corrected Figure B-2 to show that the Deere #1 (Kaiser Injection Well #1) is plugged and abandoned. Additionally, PCC has corrected the well symbols for the Midwest #1 and Midwest #2 wells to show that they were drilled as "Test Well" per the Oklahoma Water Resources Board forms. An updated Figure B-2 is included with these responses for replacement into the permit application document.

Item 5: *In TABLE B-1, there is no information listed for adjacent landowner 15; however, landowner 15 is listed on Figure B-3. Please include the information for landowner 15 in TABLE B-1.*

Response: LSB/PCC is the owner for Tract 15 (same as tracts 9 and 10). Table B-1 has been updated to include Tract 15 and contains the LSB/PCC address. A revised Attachment B is included with these responses for replacement into the permit application document.

Item 6: *On Figure F-1, Midwest #1 is listed as a monitoring well, but it is listed as an injection well on Figures B-2 and F-2 through F-7. Midwest #1 is located within the 2.0 mile Area of Review. Please ensure this well is discussed and identified correctly in the Application, and please provide information related to its completion and plugging. Pursuant to item 1, if the Area of Review is expanded, please provide the information on all wells within the expanded Area of Review.*

Response: PCC has corrected the well symbols for the Midwest #1 and Midwest #2 wells to show that they were drilled as "Test Well" per the Oklahoma Water Resources Board forms. An updated Figure B-2 and Figures F-2 through F-7 are included with these responses for replacement into the permit application document.

Item 7: *In Section I.A.2.2 of the Application, the annual formation pressure tests from 2001 to 2016 were reanalyzed using an effective injection reservoir thickness of 30 feet which resulted in an effective permeability of 3,150 md assigned to the Arbuckle Dolomite injection interval. Considering that the Arbuckle formation is heterogeneous and the 30 foot effective reservoir thickness may not be consistent throughout the injection zone, please discuss how this use of effective thickness and permeability is appropriately conservative. Please also discuss the sensitivity of the plume migration modeling to the thickness and permeability values.*

Response: The 30-foot effective reservoir thickness for the Arbuckle is based on in-situ flow characteristics determined in the open hole of the injection well. These data include five-year annual mechanical integrity differential temperature log surveys and open hole flow meter results, including the most recent testing performed in 2015. The injection induced temperature anomaly adjacent to the well is on the order of 30 feet.

The effective receiving interval thickness is likely a direct consequence of two well stimulations performed on the well. The two acid fracture procedures were performed on the well on May 12, 1976 and July 10, 1980. Each fracturing treatment was performed using 28 percent hydrochloric acid, with a specific gravity of 1.14. Recent evaluations of both the May 12, 1976, and the July 10, 1980, fracturing treatment stimulations concluded that breakdown of the Arbuckle occurred at high pressures on the wellhead (ALL Consulting (2011)). During the July 10, 1980 stimulation, injection of 10/20 sand during three injection stages occurred with rates at 20 to 25 barrels per minute. Both well stimulations show high fracture gradients approaching 2.66 psi/ft of depth within the Arbuckle Group. Further, these treatments appear to have created a preferred fluid injection pathway immediately beneath the casing shoe in the well.

The DuPont Basic Plume model is a volumetric model that predicts that the distance the injectate front advances laterally in a formation. The analytic solution to the case of a single well in a homogeneous isotropic injection stratum is given by the well-known equation:

$$r = \sqrt{\frac{V}{\pi \phi b}}$$

Where r is the radial distance from the well to the leading edge of the waste plume at any time, and V is the total volume of waste injected. The Basic Plume Model accurately duplicates this volumetric result to within 0.01 percent in all cases tested, irrespective of the injection rate history imposed. Note that model results are completely insensitive to permeability.

The radial distance from the well to the leading edge of the plume is inversely proportional to the square root of the effective injection stratum thickness for the case of an isolated well in a laterally unbounded isotropic medium. Additionally, the lateral advance of the injectate front predicted by the model is inversely proportional to the square root of the porosity for the case of an isolated well in an unbounded isotropic medium. This is identical to the variation noted above with respect to the injection stratum thickness. Therefore, minor variations in either thickness or porosity results in only small changes to the radial distance to the advancing plume front. These small changes are inherently considered in the Multiplying Factor concept employed for dispersion in the Basic Plume Model. The employed Multiplying Factor value of 2.0 effectively increases the predicted radial plume radius by a factor of 1.414 (i.e., double the modeled injection volume). The plume migration modeling uses a value of 30 feet for the effective thickness and 10 percent for the average effective porosity, or a porosity thickness of 3.0 pu-feet.

Item 9: *Oklahoma Geological Survey (OGS) Bulletin 77 identifies several faults located about one mile west of the injection well that are in optimal orientation for potential earthquake*

occurrences (N\35E to N150E) per Dr. Murray's letter in APPENDIX F-l. In this orientation, they are not self-sealing and would potentially represent earthquake locales or pathways for injectate migration out of the injection zone. The other nearby faults to the northwest are deemed self-sealing due to their orientation and may represent barriers or boundaries to injectate flow. PCC addressed this concern in the April 8, 2014 response to the Five Year Review with anecdotal data and volunteered to do additional review and demonstration. Please provide an analysis of what effects these faults would have on plume movement, since the model did not consider them as consequential assuming them to be minor surface faults.

Response: The Huffman (1958) Bulletin 77 has since been updated by The Darold and Holland (2015) and Marsh and Holland (2016) maps and GIS databases. These updated publications include most fault segments from the Huffman (1958) Bulletin 77. The faults presented in Dr. Murray's letter in APPENDIX F-1 were based on the more recent Darold and Holland (2015) maps and GIS database rather than the Huffman (1958) Bulletin 77, which is sixty years old. As shown on Figure 1, attached, the six fault segments within the AOR mapped by Darold and Holland (2015) are sub-optimal (N7E, N8E, N13E, and N15E, and N89E) or moderately optimal (N17E) in their orientation relative to the contemporary stress field (N85E). In other words, because the faults are not optimally oriented, they are not prone to slip because of minor perturbations in the stress field or subsurface pressures, and the faults generally "have a low likelihood to have an earthquake." (Darold and Holland, 2015). In addition, we note that that slip potential is based on orientation and seismic history. An examination of the seismic history of Mayes County confirms virtually no seismic activity. As a result, the orientation and seismic history demonstrates that there is almost no seismic hazard risk in the region near the well.

At the time that the Huffman (1958) Bulletin 77 was published, only faults that were mappable or seen at the surface could be interpreted, so the vertical extents of the faults are unknown (e.g., hydraulic connection of the Arbuckle to near surface rocks or aquifers is unknown). Five (N7E, N8E, N13E, N15E, and N17E) of the six fault segments in the AOR would be undergoing compressional stresses because they are nearly perpendicular (at 68–78 angles) to the N85E contemporary stress field. The remaining one fault (N89E) would be experiencing shear stresses from the nearly parallel N85E contemporary stress field. However, compressional or shear stresses from the contemporary N85E stress field are not the sole indicators of a "self-sealing" or "transmissive" faults/fractures. Geologic conditions and history such as deposition and overburden development, uplift, karstification, and re-mineralization must also be examined to define the hydraulic characteristics of a fault or fracture zone. However, because the Arbuckle SWD zone has artesian pressure in Mayes County, there is no apparent natural hydraulic connection between the Arbuckle and overlying sedimentary units. If there were a hydraulic connection between the Arbuckle and overlying sedimentary units, the artesian pressure would have equilibrated to hydrostatic pressure over geologic time. The current artesian condition of the Arbuckle is a good indicator that faults and fractures in the region are not pathways for vertical fluid migration, but rather are barriers to fluid flow.

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ATTACHMENT C

Corrective Action Plan and Well Data

Well Data

There are three injection-related wells, six domestic groundwater wells, and six monitoring wells located within the 2.0-mile Area of Review (AOR). The three injection-related wells are considered artificial penetrations, in that they penetrate the confining and/or injection zones. The three artificial penetrations were completed in the Arbuckle Group, and currently, they are all plugged and abandoned. Two of the wells were operated by Amerex Environmental Solutions (formerly Kaiser) to inject storm water runoff from their facility; these wells were plugged in 2008. The remaining well was drilled and operated by the Oklahoma Ordnance Works Authority (OOWA), and it was plugged in 1985. Each artificial penetration was evaluated to determine if its construction and/or plugging required corrective action to protect groundwater from the proposed injection activities.

Records for artificial penetrations were obtained from the Oklahoma Corporation Commission (OCC) office, Oklahoma Water Resources Board, Oklahoma Geological Society, and previously-filed reports. Appendix C-1 contains wellbore diagrams constructed from these records and wireline geophysical logs for each well.

Table C-1 lists the artificial penetrations (penetrating the confining and/or injection zone) within the 2.0-mile AOR. For a map of the 2.0-mile AOR wells, see Attachment B, Figure B-2.

TABLE C-1
Artificial Penetrations

Well Information
Kaiser (Deere & Co.) Injection Well No. 1 Status: Plugged (2008) Owner: Amerex Environmental Solutions Location: NW-NW-NE, Section 33-2IN-19E Completion Year: 1955 Completion: 8-5/8-inch longstring casing cemented from 358 feet to surface. Packer set at 333 feet. Cement plug from 0 – 820 feet.
Kaiser (NIPAK) Injection Well No. 2. Status: Plugged (2008) Owner: Amerex Environmental Solutions Location: NW-SE-NW, Section 33-2IN-19E Completion Year: 1956 Completion: 8-5/8-inch longstring casing cemented from 397 feet to surface. Packer set at 389 feet. Cement plug from 0 – 789 feet.
Oklahoma Ordnance Work Authority #2. Status: Plugged (1985) Owner: Oklahoma Ordnance Works Authority Location: NE-SW-SW, Section 3-20N-19E Completion Date: March 27, 1985 Completion: Bentonite super gel from 473' – 938' and cement from 0'-473'.

Corrective Action Plan

Based on review of the well records and construction of the wells, no corrective action is needed for the three artificial penetrations located within the 2.0-mile AOR.

Appendix C-1
Artificial Penetrations Documentation

Kaiser

Disposal Well No. 1

Kaiser

Disposal Well No. 2

Oklahoma Ordnance Works Authority

Injection Well No. 2

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Maps of Wells/Area and Area of Review

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ATTACHMENT B

Maps of Wells/Area and Area of Review

The PCC injection well site is located on the PCC Facility in Section 3, Township 20 North, Range 19 East of Indian Meridian in Mayes County, Oklahoma. The site is located within the Mid America Industrial Park. A copy of the deed for the property is included as Figure B-1. The well site is shown on the topographic map of the area (Figure B-2). The 2.0-mile radius Area of Review (AOR) contains three injection-related wells (all plugged), six domestic groundwater wells, and six monitor wells. The injection and monitoring wells are discussed in Attachment C, and the water wells are discussed in Attachment D.

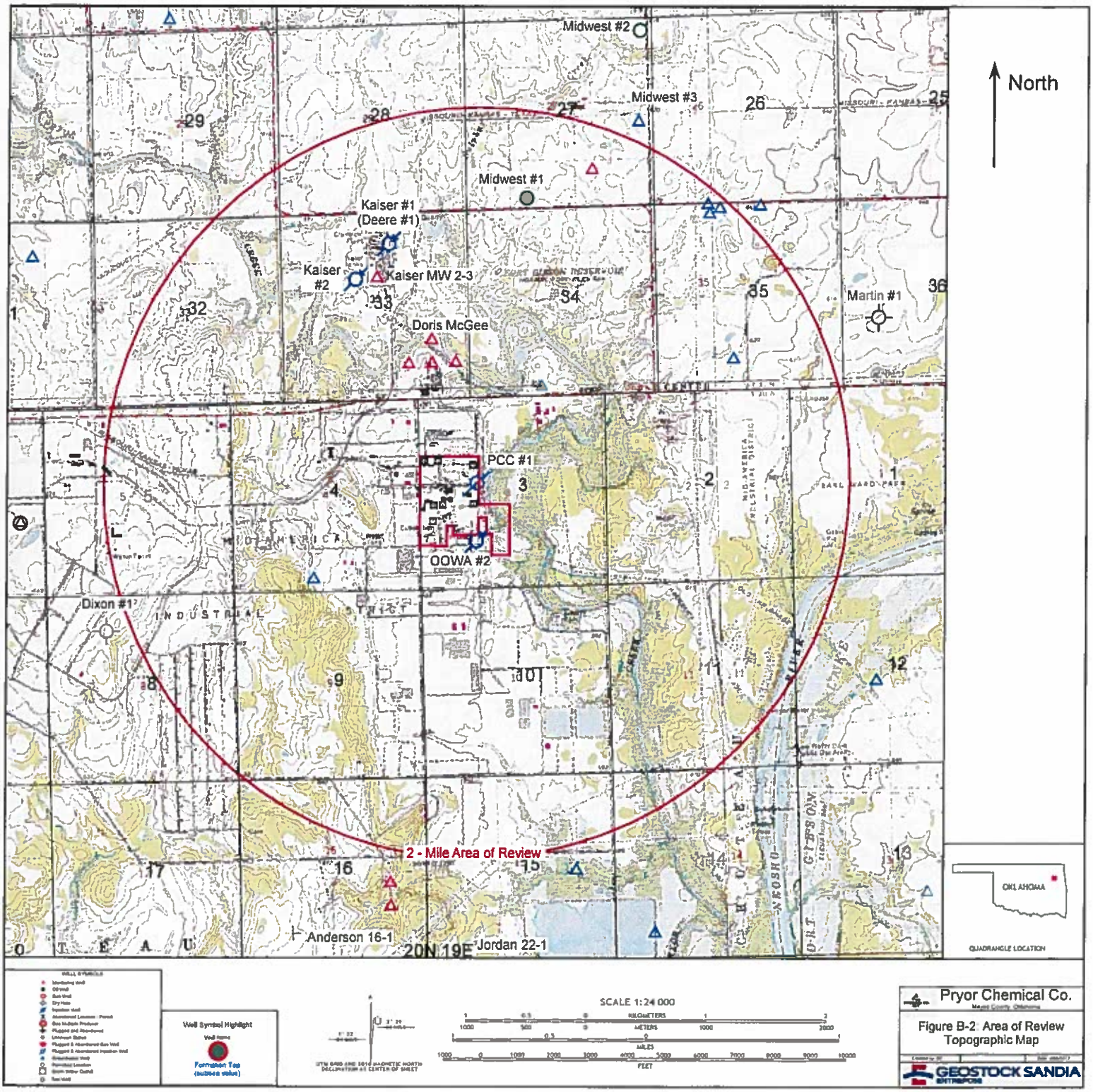
Table B-1 contains a list of the landowners for property adjacent to the PCC facility. Figure B-3 shows the location of these tracts.

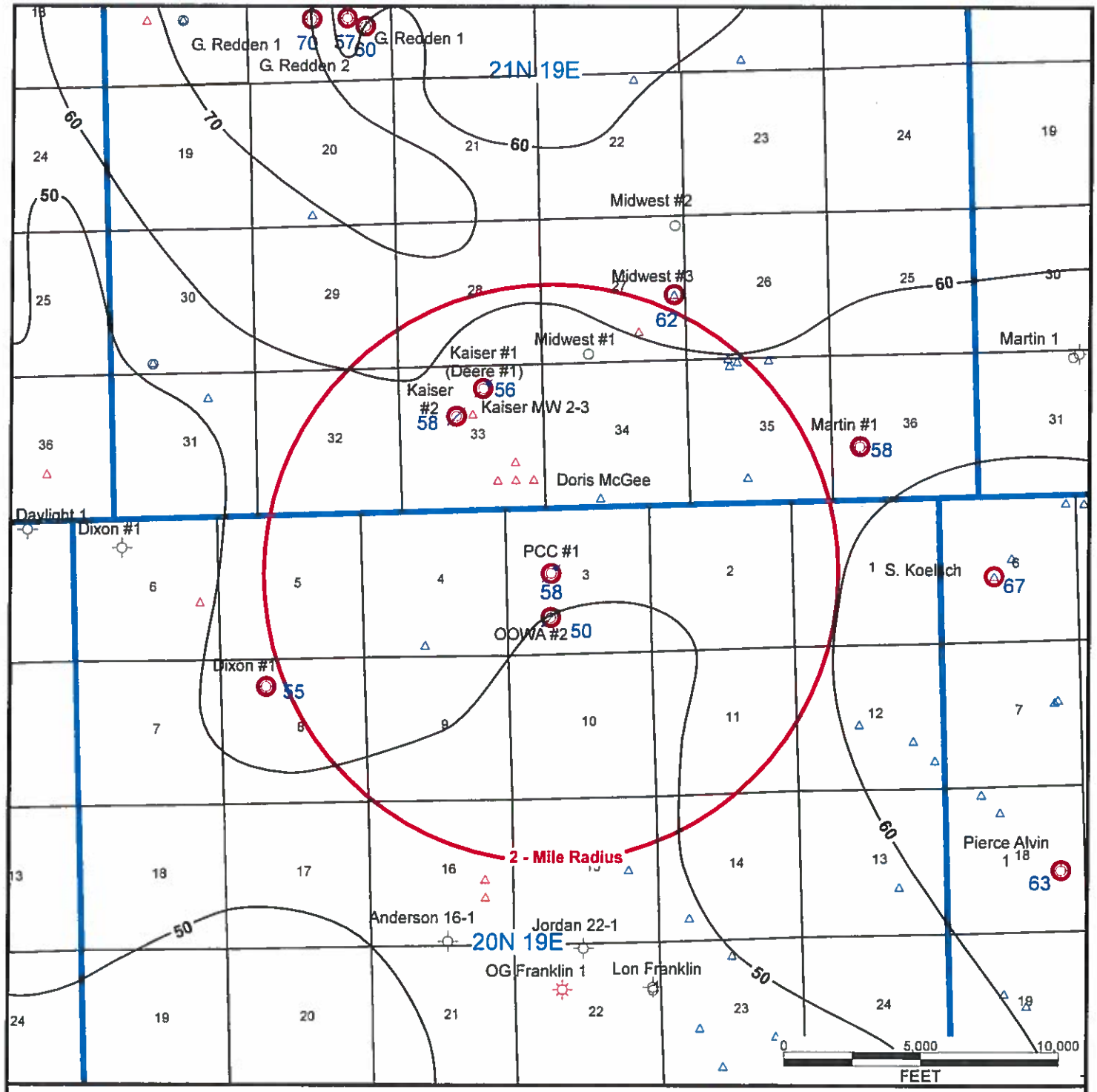
TABLE B-1
Adjacent Landowner Information

Map Key No. (Tax Property ID No.)	Landowner	Address
1 (0000-04-20N-19E-1-022-00)	GAP ROOFING	4444 HUNT STREET PRYOR OK 74361
2 (0000-04-20N-19E-1-001-00)	GAP ROOFING	4444 HUNT STREET PRYOR OK 74361
3 (0000-04-20N-19E-1-007-00)	GAP ROOFING	4444 HUNT STREET PRYOR OK 74361
4 (0000-04-20N-19E-1-018-00)	MAYFIELD, FREDERICK REVO TRUST	PO 1102 PRYOR OK 74362-0000
5 (0000-04-20N-19E-1-004-00)	RAE CORPORATION	C/O BOYDSTON CO 616 S MAIN ST SUITE 302 TULSA OK 74119-1261
6 (0000-04-20N-19E-4-001-00)	ORCHIDS PAPER PRODUCTS	4826 HUNT STREET PRYOR OK 74361
7 (0000-03-20N-19E-3-006-00)	ORCHIDS PAPER PRODUCTS	4826 HUNT STREET PRYOR OK 74361
8 (0000-03-20N-19E-2-005-00)	SALINA DRILLERS	PO BOX 255 SALINA OK 74365-0000
9 (0000-03-20N-19E-3-007-00)	LSB/PCC	PO BOX 754 OKLAHOMA CITY OK 73101-0000
10 (0000-03-20N-19E-3-004-00)	LSB/PCC	PO BOX 754 OKLAHOMA CITY OK 73101-0000

TABLE B-1
Adjacent Landowner Information

Map Key No. (Tax Property ID No.)	Landowner	Address
11 (0000-03-20N-19E-1-001-00)	OOWA	PO BOX 945 PRYOR OK 74361
12 (0000-03-20N-19E-2-001-00)	NGC INDUSTRIES INC (NAT'L GP)	2001 REXFORD RD CHARLOTTE NC 28211-0000
13 (0000-04-20N-19E-4-004-00)	EVANS ELECTRIC INC	PO BOX 1316 TULSA OK 74101-0000
14 (0000-04-20N-19E-1-005-00)	HARRIS HOLDING LLC	PO BOX 1148 PRYOR OK 74362-0000
15 (0000-03-20N-19E-3-007-00)	LSB/PCC	PO BOX 754 OKLAHOMA CITY OK 73101-0000


North
Midwest #2
Midwest #3
Midwest #1
Kaiser #1
(Deere #1)
Kaiser
#2
Kaiser MW 2-3
Doris McGee
Martin #1
PCC #1
OOWA #2
Dixon #1
2 - Mile Area of Review
Anderson 16-1
Jordan 22-1
20N 19E
OKLAHOMA
QUADRANGLE LOCATION
Well Symbol Highlight
Formation Top
SCALE 1:24 000
Pryor Chemical Co.
Figure B-2. Area of Review
Topographic Map
GEOSTOCK SANDIA



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

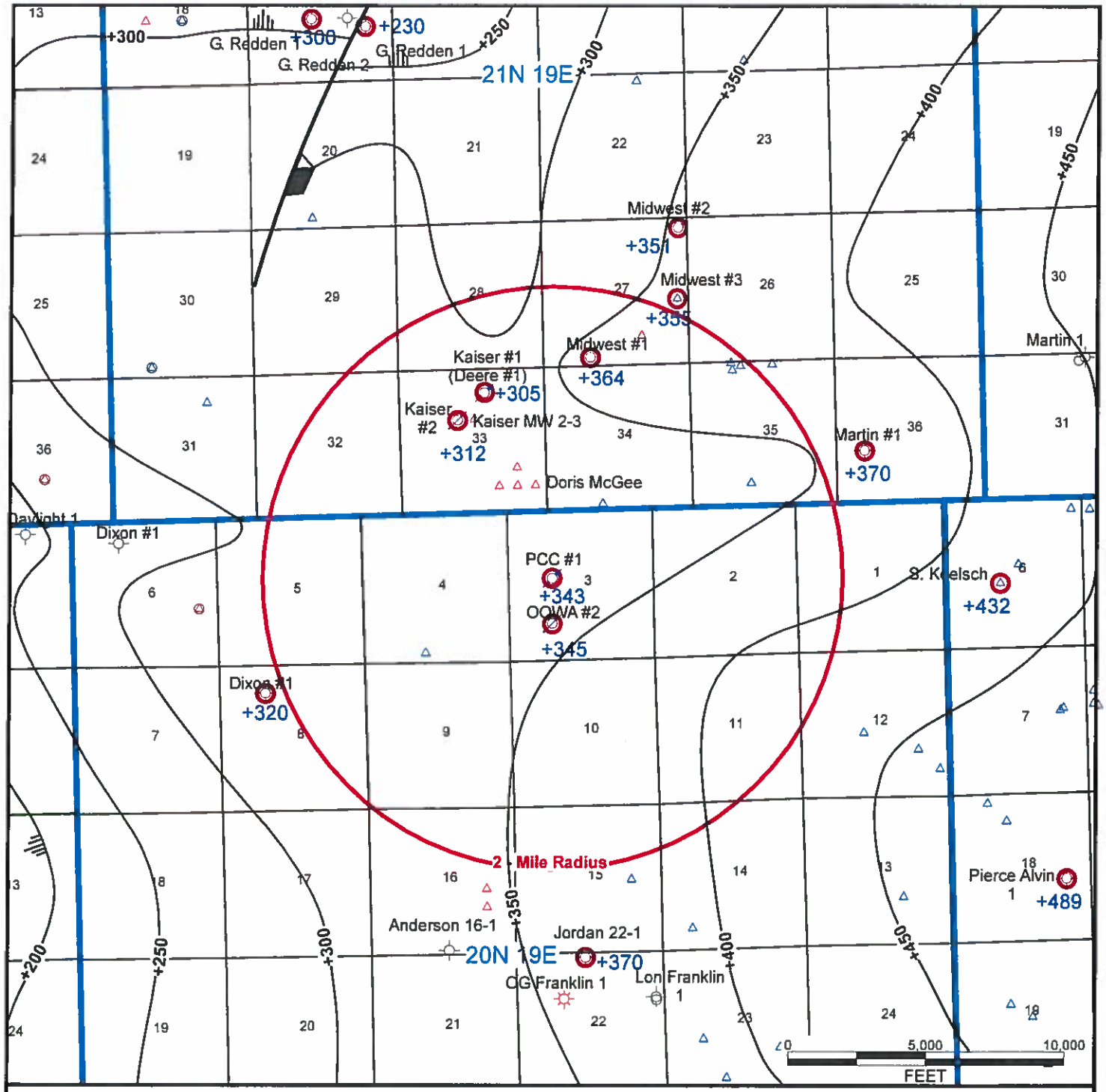
Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-2: Confining Zone (Woodford) Isopach Map

Created by: DC/EDG	C.I. 10 feet	Date: June 2017

GEOSTOCK SANDIA ENTREPOSE



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

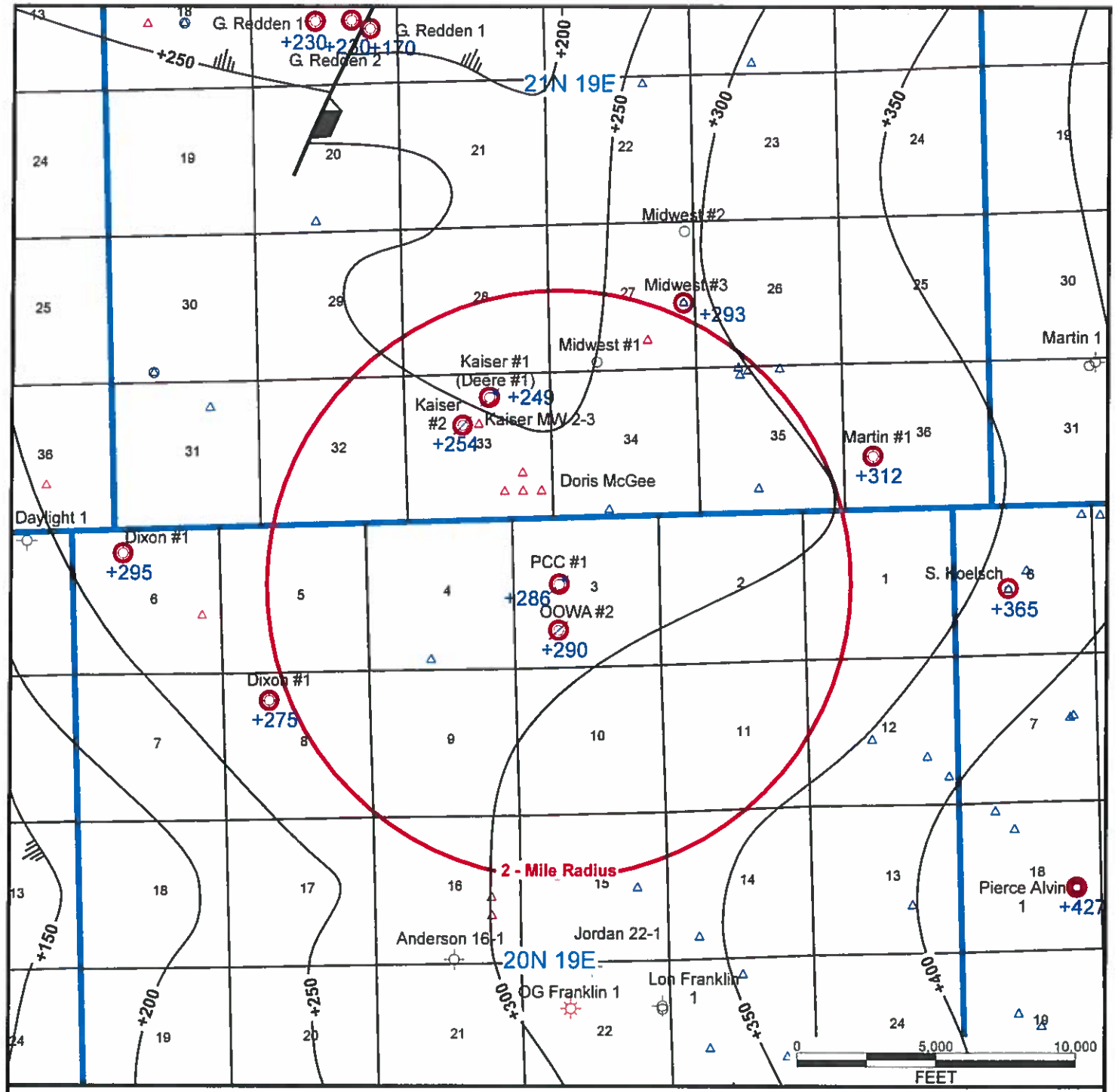
Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-3: Top of Confining Zone (Woodford) Structure Map

Created by: DC/EDG	C.I. 50 feet	Date: June 2017

GEOSTOCK SANDIA ENTREPOSE



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

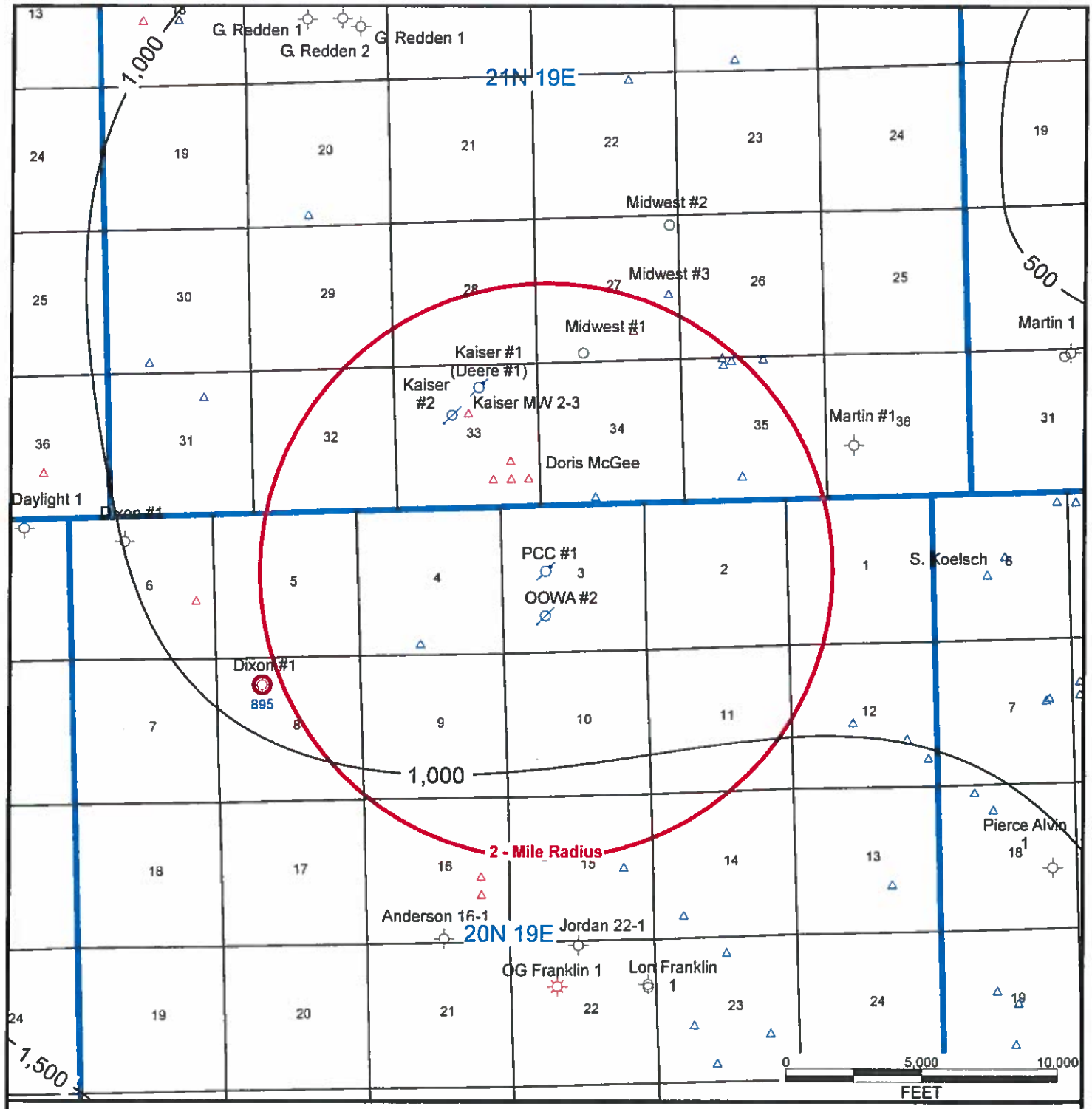
Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-4: Top of Injection Zone (Arbuckle) Structure Map

Created by: DC/EDG	C.I. 500 feet	Date: June 2017

GEOSTOCK SANDIA ENTREPOSE



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

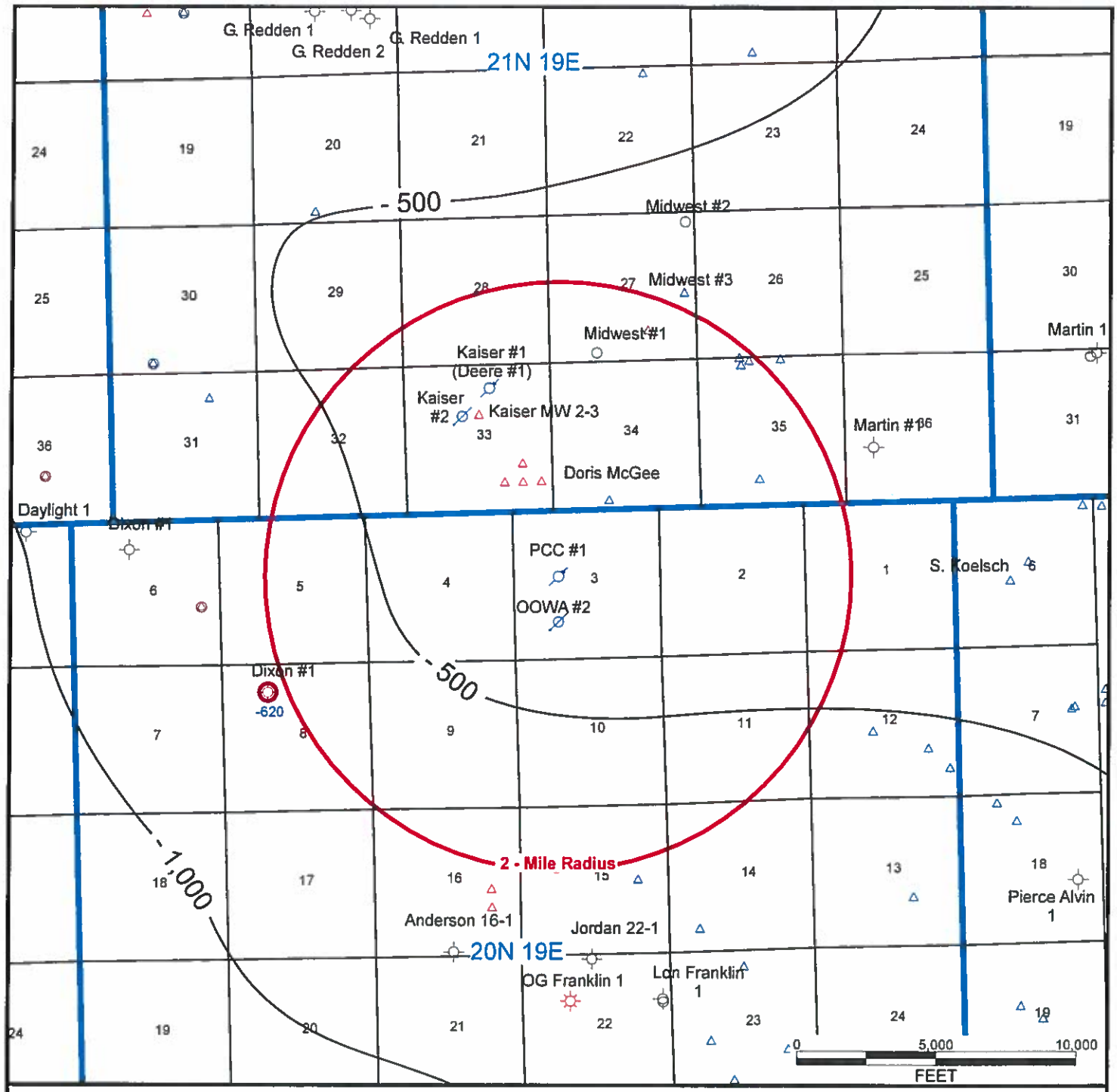
Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-5: Injection Zone (Arbuckle) Isopach Map

Created by: DE & EDG	C.I. 500 feet	Date: June 2017

GEOSTOCK SANDIA
ENTREPOSE



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

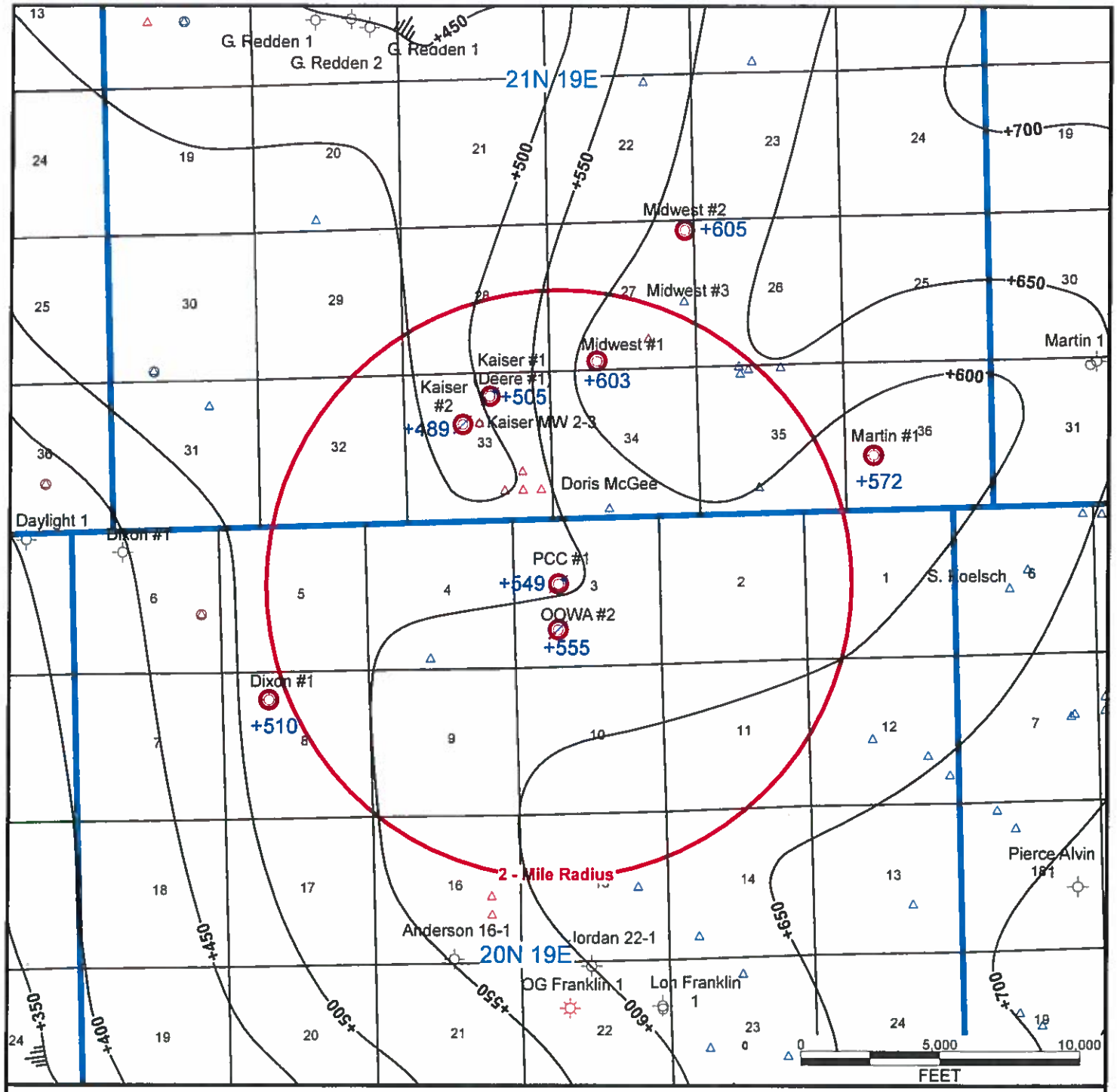
Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-6: Top of Lower Confining Zone Structure Map

Created by: DE & EDG	C.I. 500 feet	Date: June 2017

GEOSTOCK SANDIA
ENTREPOSE



WELL SYMBOLS

- Monitoring Well
- Oil Well
- Gas Well
- Dry Hole
- Injection Well
- Abandoned Location - Permit
- Gas Multiple Producer
- Plugged and Abandoned
- Unknown Status
- Plugged & Abandoned Gas Well
- Plugged & Abandoned Injection Well
- Groundwater Well
- Permitted Location
- Test Well

Well Symbol Highlight

Well Name

Formation Top
(subsea value)

Pryor Chemical Co.

Mayes County, Oklahoma

Figure F-7: Top of Boone (Mississippian) Structure Map

Created by: DC/EDG	C.I. 50 feet	Date: June 2017

GEOSTOCK SANDIA ENTREPOSE

PCC Response to Notice of Deficiency – Figure 1

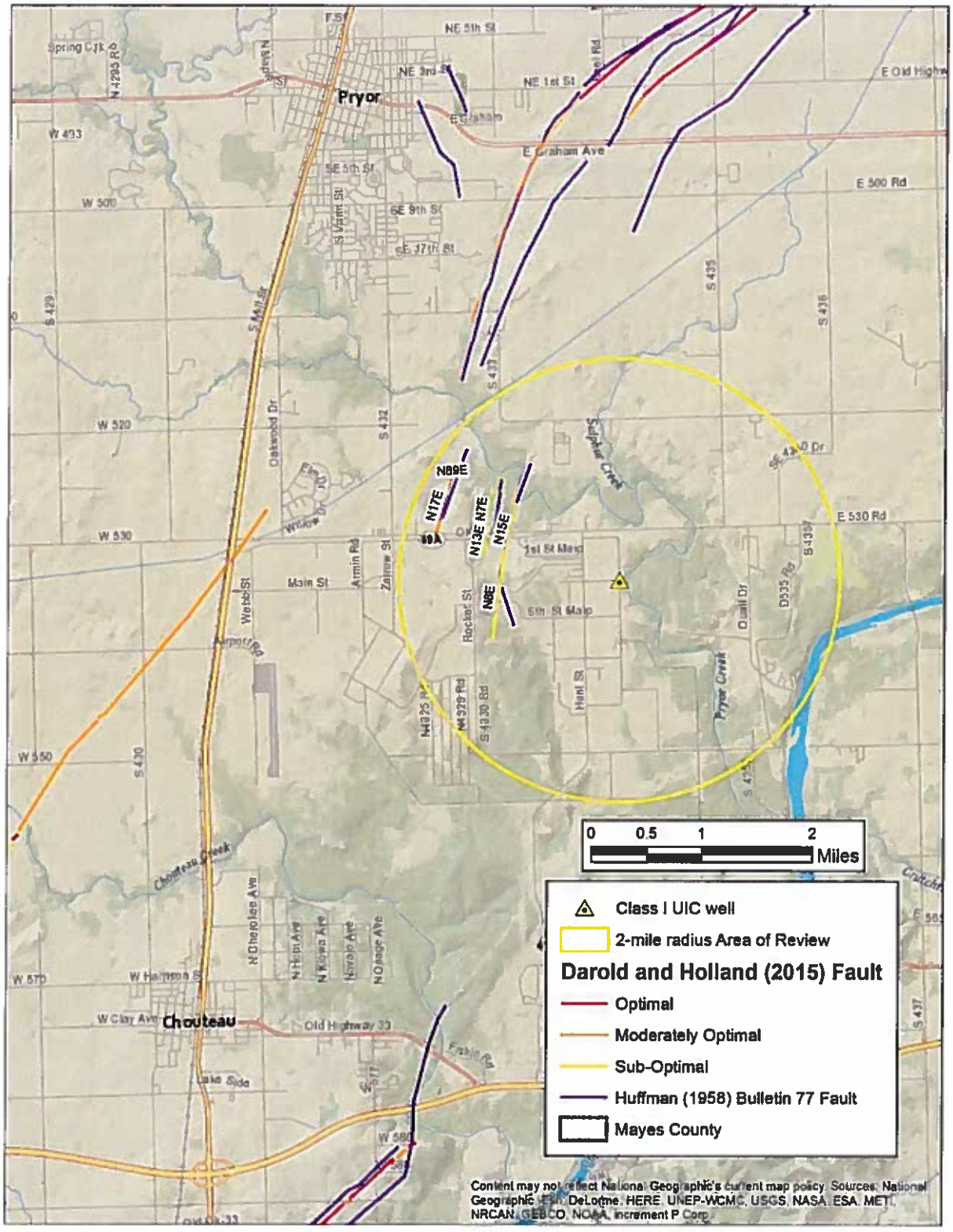


Figure 1 Area Of Review (AOR) and faults from Huffman (1958), Darold and Holland (2015)