Jillson Federal SWD Well No. 1
Unit F-Section 8, T24N, R03W, NMPM
Application of Meridian Oil Inc. for
Designation of a Portion of the Entrada
formation as an "Exempted Aquifer"
Rio Arriba County, New Mexico

1. The referenced aquifer is not now used as a drinking source and cannot in the future serve a a drinking source because:

   (1) It is situated at a **depth and location** which makes recovery of water for drinking water purposes **economically impractical**; and

   (2) The **total dissolved solids** (TDS) content of the ground water is **more than 3,000 and less than 10,000 mg/l** and it is **not reasonably expected to supply a public water system.**

2. Description of proposed aquifer exemption

   a. Name of formation: **Entrada**

   b. Subsurface depth interval of zone: **8404' - 8672'**

   c. Area of exemption: **Appendix A, Figure 1, (2. c.)** details estimated reservoir parameters associated with the Entrada formation at this location. A 1440 acre area of exemption is requested. Surface location associated with this area is:

   SW/4 SW/4 of Section 4, T24N, R03W
   SW/2 of Section 5, T24N, R03W
   SE/4 SE/4 of Section 6, T24N, R03W
   Section 7, T24N, R03W
   Section 8, T24N, R03W
   W/2 W/2 of Section 9, T24N, R03W
   N/2 N/2 of Section 17, T24N, R03W
   NE/4 NE/4 of Section 18, T24N, R03W NMPM

   See **Appendix A, Figure Two, (2. c.)** for map detailing area of interest.

   d. Vertical confinement from other underground sources of drinking water.
   See Appendix A, Figure Three, (2.d.)

   e. Thickness of proposed exempted zone: **268 ft.**

   f. Water analyses from the proposed exempted aquifer are attached under **Appendix B.**

pH	7.39
Specific Gravity @ 60°F	1.0086
Resistivity @ 75°F (Ω.m)	0.1481

   g. Direction and speed of regional and local ground water flow. **Appendix A, Figure Four, (2. g.)**

   h. There are no major regional water supplies in the area of interest of the proposed exempted aquifer. The community of Lindrith, NM takes water from 1100' in the San Jose Sandstone interval.

i. No hydrologic testing of the proposed exempted aquifer has been conducted.

j. Any monitoring schemes to assure that injected fluids do not migrate from exempted aquifer. **Appendix A, Figure Five, (2. j.)**

k. **Appendix A, Figures 6, (2. k.) - 10, (2. k.)** provide a summary of public notification of the proposed exemption. All surface owners and offset operators within a two mile radius were sent notification of the proposed aquifer exemption. In addition, general public notification was given through advertisement in a local newspaper.

3. The following maps are attached in **Appendix C.**

a. A USGS topographic map showing lateral limits of the proposed exemption. **See Appendix C, Figure 1, (3. a.)**

b. A map showing water supply wells within the exempted area and less than one-quarter mile from the exempted area boundaries. **See Appendix C, Figure 2, (3. b.)**

c. There are no major regional supply wells located in the area of interest of the proposed exempted aquifer. Lindrith, NM water supply, 1100', San Jose Sandstone

d. A map showing other artificial penetrations of the exempted formation within one-quarter mile of the exempted aquifer boundaries. **See Appendix C, Figure Three, (3. d.)**

e. A map of regional ground water gradient. **(Not Available)**

4. The following tables are attached in **Appendix C.**

a. A list of water supply wells shown on the maps in "3.b" and "3.c" above. **See Appendix C, Table I, (4. a.)**

b. A list of artificial penetrations shown on the map "3.d" above. **See Appendix C, Table II, (4. b.)**

c. Results of chemical analyses of formation water and injected fluids. **See Appendix C, Tables III, (4. c.) and IV, (4. c.)**

5. Attached are two cross-sections **(See Figures 2 and 3, Appendix D.)** which shows the vertical limits of the proposed exemption, upper and lower confining layers, potential drinking water sources overlying and underlying the exempted aquifers, and names of geologic formations shown.
Also attached is a cross-section trace on a area reference map. **(See Figure 1, Appendix D.)**

6. Attached is a cost analysis detailing that recovery of water for drinking purposes from the Entrada aquifer at this location and depth is economically infeasible. **(See Tables I-II and Figures 1 - 2, Appendix E.)** The Entrada aquifer is economically infeasible at this location and depth for the following reasons:

a.) Drilling and completion costs of a water supply well to this depth at this location are $739,332. Included in these costs are 1.) the setting of 7" casing to a depth of 8,800', 2.) zonal isolation of uphole hydrocarbon reservoirs, 3.) perforation and breakdown of 250 ft. of Entrada reservoir, 4.) the setting of 3 1/2" plastic coated tubing to a depth of 8400', 5.) Installation of artificial lift pumping unit and rods.

The tubular configuration of this wellbore is required to mechanically lift fifty barrels of water per hour. The Entrada zone tested at fifty barrels per hour during completion operations.

b.) Surface facility costs to treat produced water from the Entrada at this depth to meet UICP domestic water supply qualifications are $ 3,500,000. Included in these costs are: 1.) Capital costs for the facility (Reverse Osmosis, Filtering, Chemical Feed, Solids processing, and Iron removal), 2.) Power Requirements, 3.) Chemical Requirements, and 4.) Disposal Costs.

c.) Annual operational costs for a water source well and facility at this location and depth will be $ 295,000. $250,000 for the treatment facility including Power, Chemicals, Solids Disposal, Supervision, and Maintenance. $ 45,000 for lifting costs including pumping unit maintenance, rod wear, pump failure and environmental compliance

Based upon cost estimate data given in Tables I - II and Figures 1 - 2, Appendix E, a capital investment of $4,239,332 is required to drill, complete, and facilitate a water source well to the Entrada aquifer at this location. In addition, annual operating expenses of $295,000 are estimated to produce 1,200 barrels per day. Because of the substantial capital investment and annul operational costs associated with a water well and treatment facility, the use of the Entrada as a water supply aquifer at this location is deemed economically infeasible now and in the future.

7. Future usage assessment. Water recovered from the Entrada interval tested at a Total Dissolved Solids content of 6,900 mg/l. Based on the above mentioned data, including Drilling, Completion, Pumping, and Treatment (Iron, Metals, Hydrocarbon, and TDS), as well as issues such as Storage, and Transportation the Entrada interval at this depth and location is not reasonably expected to supply a public water system. The more shallow options that exist and are currently in limited use at depths of 2,500' or less will most certainly be expected to suffice as a public water supply at this location.

APPENDIX A

Figures 1 - 10

Appendix A

Figures 1-10

1. Figure One (2. c.) - Area of exemption calculations; included are reservoir parameters and injection volume estimations.

2. Figure Two (2. c.) - Area interest map which diagrams areal extent of proposed aquifer exemption.

3. Figure Three (2. d.) -
   - Description of vertical confinement (Seals)
   - Jillson Federal SWD #1 Geologic Summary
   - Array Induction w/Gamma Ray type log for Entrada interval of Jillson Federal SWD #1.
   - Litho Density w/Gamma Ray type log for Entrada interval of Jillson Federal SWD #1.
4. Figure Four (2. g.) - Estimated Direction and Velocity of Regional and Local Ground water Flow within the Entrada Sandstone.

5. Figure Five (2. j.) - Wellbore schematic describing the continuous annular pressure monitoring (with automatic shut-off) and the required Mechanical Integrity Testing.

6. Figure Six (2. k.) - Area of interests map detailing all offset operators within a two mile radius around the Jillson Federal SWD #1. Mailing list of all offset operators within a two mile radius of the Jillson Federal SWD #1. All operators on this list received notification of the proposed exemption.

7. Figure Seven (2. k.) - Area of interest map detailing all surface ownership within a two mile radius of the Jillson Federal SWD #1. All surface owners within this area of interest received notification of the proposed exemption.

8. Figure Eight (2. k.) - Sample of notification sent to all offset operators and surface owners within the area of interest.

9. Figure Nine (2. k.) - Newspaper advertisement of public notification of the proposed exemption. *To be supplied.*

10. Figure Ten - Copy of the original Order authorizing the drilling of the Jillson Federal SWD #1 and the disposal of produced salt water into the Entrada formation.

Meridian Oil Inc

Well: Jillson Federal SWD #1
Location: SE/4 NW/4 Section 8, T-24-N, R-03-W
Injection Zone: Entrada
Injection Depths: 8404' - 8659'

Estimated Area of Influence:

The estimated area of influence is calculated by deriving the material balance equation for ultimate storage capacity then solving for area (A).

$$V_{ult} = 7758\ A\ h\ \phi\ C_t\ \Delta P$$

where:

V_{ult} = ultimate storage capacity, bbl
7758 = unit conversion constant, bbl/acre-foot
A = area of influence, acres
h = net thickness of injection zone, feet
ϕ = average porosity, fraction
C_t = total compressibility, psi^{-1}
ΔP = final average pressure minus initial pressure, psi

utilizing:

V_{ult} = 6,000 Mbbls
h = 253 ft
ϕ = 0.148
C_t = 10e-6 psi^{-1}
ΔP = 1453 psi

solving for A: A = **1422 acres**

converting to a radius of **4440 feet**

Assumptions:

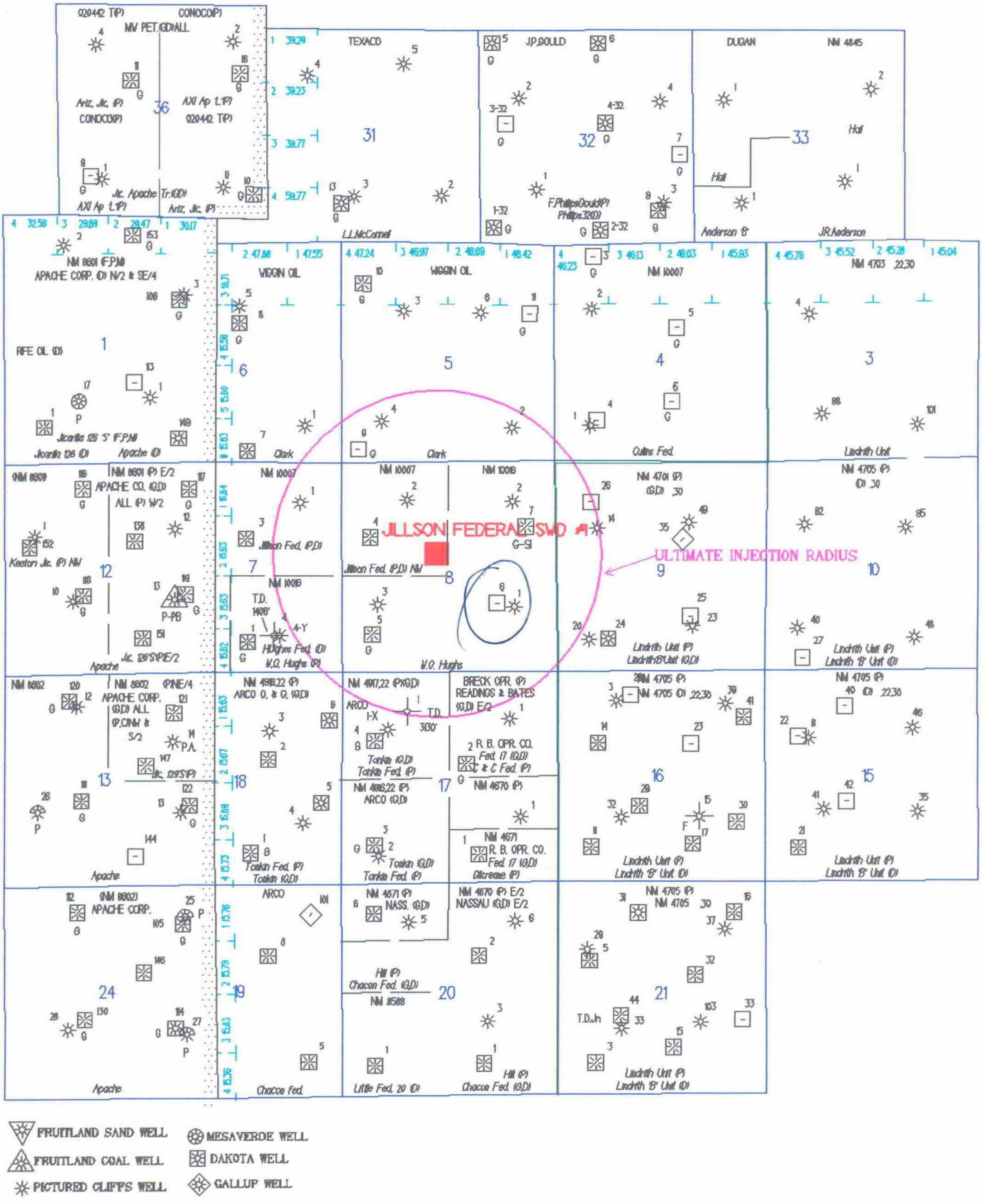
1. Figures 3 and 4 of Appendix A are type logs for the Jillson Federal SWD #1 illustrating reservoir characteristics of the Entrada interval (h & ϕ). Effective pay based upon 7% porosity cutoff.

2. Total Compressibility is assumed to be 10e-6 psi^{-1} (log and flow test data verify reservoir is 100% water saturated).

4. Initial and final pressure reflect gradients of 0.43 psi/ft and 0.60 psi/ft respectively at an average depth of 8532 feet.

5. V_{ult} of 6,000 Mbbls reflects estimated water production from MOI wells that will be serviced by the Jillson Federal SWD #1.

JILLSON FEDERAL SWD #1
Section 8, T24N, R3W
Rio Arriba County, New Mexico



Seals

The proposed exempted aquifer, the Middle Jurassic Entrada formation, is stratigraphically located 5,612 feet below the Tertiary Ojo Alamo, Nacimiento and San Jose fresh water aquifers. The accompanying Table summarizes the stratigraphic relationships, thicknesses and sealing versus non-sealing and/or hydrocarbon-bearing nature of the entire stratigraphic column from grass roots to the Chinle formation, which underlies the Entrada formation.

The Upper Triassic Chinle formation unconformably underlies the Entrada formation throughout the San Juan Basin. The formation is approximately 768 feet thick in this part of the basin and consists of primarily shales with minor interbeds of sandstone and siltstone. The Chinle is basically impervious to fluids. The Middle Jurassic Entrada consists of 268 feet of primarily eolian dune sandstones. In the surrounding area, the Entrada sandstones vary in thickness from 200' to 270'. The Entrada is most often water-bearing but does produce stratigraphically-trapped oil updip in the following nearby fields (townships): Media (T.19N., R.3W.), Eagle Mesa (T.19N., R.4W.), Papers Wash (T.19N., R.5W.), Ojo Encino (T.20N., R.5W.), and Snake Eyes (T.21N., R.8W.). All of these fields produce a lot of water, with salinities ranging from 2,500 ppm(Media field) to 11,114 ppm (Snake Eyes field).Dead oil stains were noted by mudloggers in the uppermost feet of Entrada sandstone in the Jillson SWD #1. Six (6) barrels of oil and 62 barrels of water were swabbed from the upper Entrada in the Magnolia Ingwerson Federal #1 in Section 20, T.24N., R.2W.

The Entrada formation is overlain by fourteen feet of Todilto sealing limestone, anhydrite and shale. Above the Todilto is thirteen feet of Summerville shale. Both the Summerville and Todilto thin (13' & 14') on top of Entrada dune build-ups and thicken (50+' & 50+') in areas where the Entrada dunes thin. Both the Jillson SWD #1 and the W.O. Hughes #6 wells penetrated thick Entrada dune build-ups and consequently, thinner Summerville and Todilto formations. The 59 foot thick Bluff formation is not well developed in this location, so it is a better seal due to the lack of a well-developed sandstone. For the most part, the 618 feet of Morrison formation is a seal. The thin, interbedded sandstones are tight and yield very little, if any, water or hydrocarbons. The non-marine, waxy shales are vari-colored and bentonitic. The Lower Cretaceous Burro Canyon formation consists of primarily clayey sandstones, which are mostly water-bearing in the immediate area. The 176 foot thick Upper Cretaceous Dakota formation and 138 foot thick Graneros formation are comprised of interbedded sandstones and shales with minor coals. The Dakota and Graneros are continuous and hydrocarbon-productive in most of this and the surrounding townships. Lack of production is usually due to lack of porosity and permeability, not due to water occurrences. Above the Graneros is the 58 foot thick Greenhorn Limestone, which consists of thinly interbedded organic shales and shaley limestone. The regionally occurring Greenhorn is more a hydrocarbon source rock and seal than it is a viable reservoir. The overlying 305 feet of Lower Mancos Shale is a definite seal rock.

The Juana Lopez is a regional stratigraphic marker like the Greenhorn. It is a twelve feet thick sequence of slightly sandy, shaley and calcareous siltstone that yields mudlog shows but is not a commercial reservoir. The Gallup formation is a 531 foot thick sequence of very thinly interbedded organic shales, sandy shales and shaley sandstones. When the Tocito sandstone, which has matrix porosity, is absent as it is in the area around the well in question, the Gallup is only hydrocarbon-productive when fractured. The fractures die out upward near the top of the Gallup into the overlying Upper Mancos Shale. The 644 feet of Upper Mancos Shale is a definite seal rock because it rarely yields hydrocarbon shows and is non-productive. The Mesaverde formation is 982 feet thick in this and is either tight or yields salt water and minor gas. To the northwest, the Mesaverde formation is one of the major hydrocarbon producing zones in the San Juan Basin. Above the Mesaverde is the Chacra member of the Lewis shale. The Chacra is 774 feet of predominantly shale with only tens of feet of interbedded tight sandstone and is definitely a seal in this part of the basin. The main Lewis Shale, being 749 feet thick, overlies the Chacra and is a possible hydrocarbon source rock and a seal. Above the Lewis Sale is the 144 feet thick Pictured Cliffs formation. The Pictured Cliffs is usually gas-productive or tight and is rarely water-bearing. In this southeast portion of the San Juan Basin, the Fruitland formation is 149 feet thick, consisting of interbedded coals, shales and minor sandstones. The Fruitland produces neither gas nor water in the area, so is in effect a good seal. The 128 feet of non-marine Kirtland Shales has minor interbeds of fluvial sandstones that are basically tight and sealing. The Tertiary Ojo Alamo and Nacimiento formations are mostly freshwater-bearing but do produce some gas at Schmitz Anticline in T. 24N., R.1W. The Nacimiento and San Jose formations are comprised of interbedded lenticular sandstones and non-marine shales. The sandstones are variable in thickness and lateral extent, which makes them very difficult to correlate in wells on 160 acre spacing. (see cross section B-B').

The effectiveness of the main sealing formations highlighted on the accompanying Table is evidenced by the occurrence of discreet, stratigraphically isolated hydrocarbon producing and water-free formations throughout the Upper Cretaceous geologic section. No faults have been detected in the Jillson or other nearby wellbores, so there is no feasible way for Entrada water to reach the much shallower Tertiary formations. If such an avenue already exists, the Tertiary water sources would be naturally contaminated from the underlying 2,366 feet of hydrocarbon-bearing formations.

JILLSON FEDERAL SWD #1 GEOLOGIC SUMMARY					
SE/4 NW/4 Section 8, T. 24N., R. 3W. Rio Arriba Co., NM				Total Depth: 8,800 feet	
GEOLOGICAL AGE	FORMATION	THICKNESS(FT.)	LITHOLOGY	PRODUCTION	REMARKS
RECENT	Alluvium	10	Unconsolidated sand & shale	None	
TERTIARY	**San Jose	1200	Sand & shale	**Fresh water	Source for most wells
TERTIARY	**Nacimiento	1400	Sand, shale & conglomerate	**Fresh water	also Seals
TERTIARY	**Ojo Alamo	182	Conglomerate, sand & shale	**Water (fresh to brackish)	also Seals
U. CRETACEOUS	Kirtland	128	Shale w/ some sandstone	None	Seals
U. CRETACEOUS	Fruitland	149	Coal, shale & sandstone	minor Gas	also Seals
U. CRETACEOUS	Pictured Cliffs	144	Sandstone & shale	Gas & minor oil	also Seals
U. CRETACEOUS	Lewis Shale	749	Shale & siltstone	minor Gas	Seals
U. CRETACEOUS	Chacra	774	Sandstone & shale	None	Seals
U. CRETACEOUS	Mesaverde	982	Sandstone, shale & minor coal	Salt water, gas & condensate	also Seals
U. CRETACEOUS	Upper Mancos Sh.	644	Shale & siltstone	None	Seals
U. CRETACEOUS	Gallup	531	Sandy shale; minor sandstone	Oil & gas	also Seals
U. CRETACEOUS	Juana Lopez	12	Sandy shale	minor gas	also Seals
U. CRETACEOUS	Sanastee/Semilla	(Absent)	Shaley sandstone	minor gas & oil	(Absent)
U. CRETACEOUS	Lower Mancos sh.	305	Silty shale	None	Seals
U. CRETACEOUS	Greenhorn Ls.	58	Shaley limestone	minor gas & oil	also Seals
U. CRETACEOUS	Graneros	138	Shale & sandstone	Gas & oil	also Seals
U. CRETACEOUS	Dakota	176	Sandstone, shale & minor coal	Gas & oil	also Seals
L. CRETACEOUS	Burro Canyon	118	Sandstone & shale	Salt water, minor gas	also Seals
U. JURASSIC	Morrison	618	Shale & sandstone	Minor salt water; minor gas	Seals
U. JURASSIC	Bluff	59	Sandstone & shale	None	also Seals
U. JURASSIC	Summerville	13	Shale	None	Seals
U. JURASSIC	Todilto	14	Limestone, anhydrite & shale	None	Seals
M. JURASSIC	Entrada	268	Sandstone	Oil, water & minor gas	Dead oil stain @ top
U. TRIASSIC	Chinle	768 (regional)	Shale & minor sandstone	None	Seals

The Entrada formation is stratigraphically located 5,612 feet below fresh water zones of the Ojo Alamo, Nacimiento and San Jose formations.
The 5,611 feet include 3,245 ft. of SEAL rock and 2,366 ft. of hydrocarbon/salt water zones.
The Entrada formation is underlain by approximately 768+ feet of sealing shales.
Potential drinking water.

Appendix A,
Figure Three (2. d.)

COMPANY: Meridian Oil Company, Inc.

WELL: Jillson Federal SWD

FIELD: Salt Water Disposal

COUNTY: Rio Arriba STATE: New Mexico

Schlumberger

Array Induction Log
W / Gamma Ray

2305' FNL & 2415' FWL (SE NW)

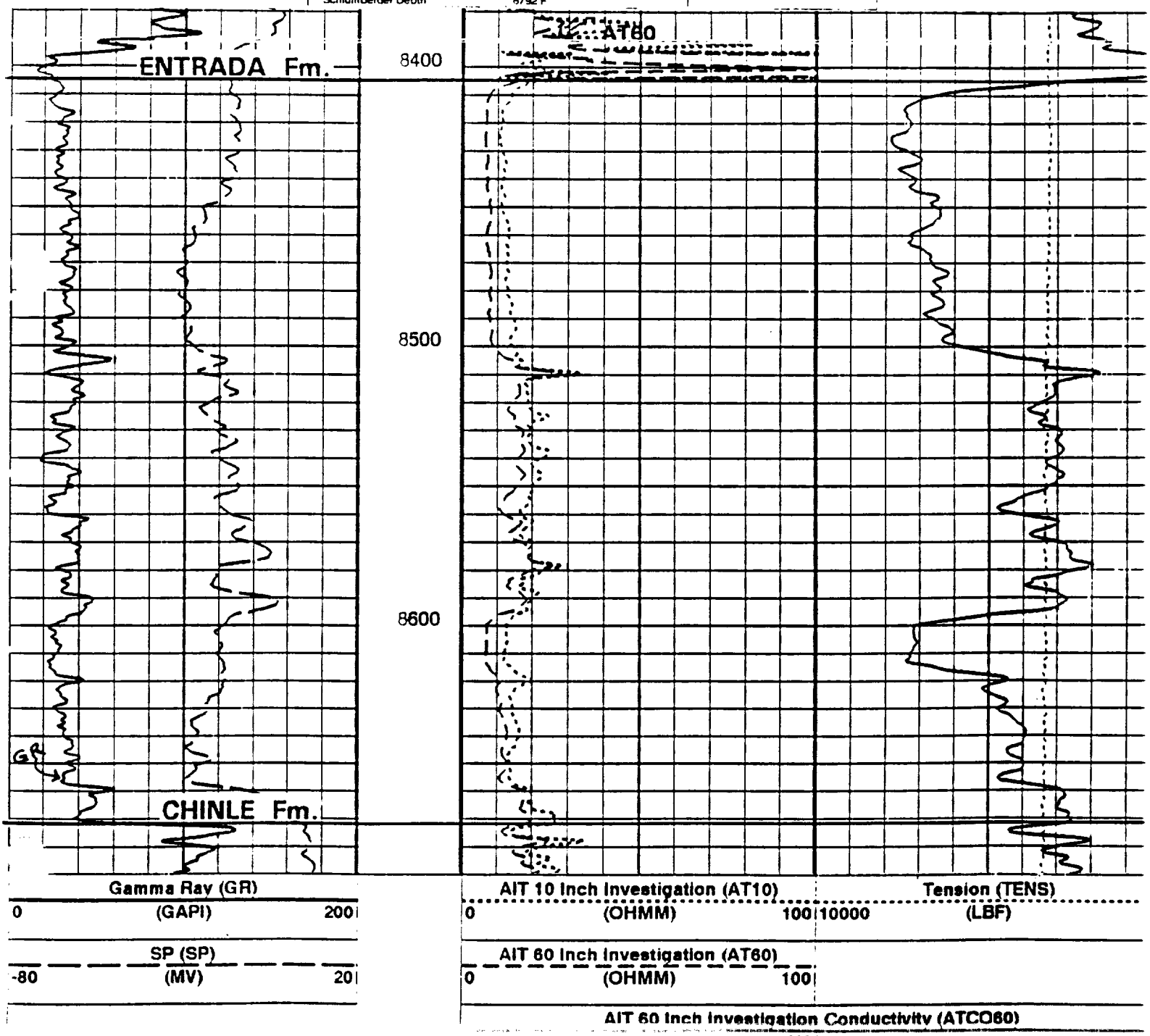
Elev.: K.B. 6918 F
G.L. 6908 F
D.F. 6917 F

Permanent Datum: Ground Level Elev.: 6906 F
Log Measured From: Kelly Bushing 12.0 F above Perm. Datum
Drilling Measured From: Kelly Bushing

API Serial No	SECTION	TOWNSHIP	RANGE
	8	24N	3W

Logging Date	26-OCT-1994
Run Number	One
Depth Driller	8800 F
Schlumberger Depth	8792 F

COUNTY Rio Arriba
Field Salt Water Disposal
Location 2305' FNL & 2415' FWL (SE NW)
Well Jillson Federal SWD
Company Meridian Oil Company, Inc.
LOCATION



COMPANY: Meridian Oil Company, Inc.

WELL: Jillson Federal SWD

FIELD: Salt Water Disposal

COUNTY: Rio Arriba STATE: New Mexico

COUNTY Rio Arriba
Field: Salt Water Disposal
Location 2305' FNL & 2415' FWL (SE NW)
Well Jillson Federal SWD
Company Meridian Oil Company, Inc.

Schlumberger

Litho-Density Log
W / Gamma Ray

LOCATION 2305' FNL & 2415' FWL (SE NW)

Elev.: K.B. 6918 F
G.L. 6906 F
D.F. 6917 F

Permanent Datum: Ground Level Elev.: 6906 F
Log Measured From: Kelly Bushing 12.0 F above Perm. Datum
Drilling Measured From: Kelly Bushing

API Serial No	SECTION	TOWNSHIP	RANGE
	8	24N	3W

Logging Date	26-OCT-1994
Run Number	One
Depth Driller	8800 F
Schlumberger Depth	8792 F

ENTRADA Fm.

8400

8500

8600

CHINLE Fm.

TENS

DPHI

Caliper (CALI)
6 (IN) 16

Gamma Ray (GR)
0 (GAPI) 200

Density Porosity (DPHI)
0.3 (V/V) -0.
30% 20% 10% 0% -10

Tension (TENS)
10000 (LBF)

Estimated Direction and Velocity of Regional and Local Groundwater Flow within the Entrada Sandstone

Regional Flow

The San Juan Basin is an asymmetric northwest-trending structural depression located on the eastern edge of the Colorado Plateau in northern New Mexico (Thorn and others, 1990). The San Juan Basin contains a thick sequence of sedimentary rocks ranging in age from Cambrian through Tertiary. The Entrada Sandstone is a Late Jurassic formation that can be found in the San Juan Basin. The Meridian Jillson well is located in the east-central portion of the basin and intercepts the Entrada Formation approximately 8,400 feet beneath ground surface.

Limited data are available on the regional hydrology of the Entrada Formation. Figure 82 of Stone and others (1983) shows a total of 11 wells completed in the Entrada for which specific conductivity data are available within the entire 30,000 square mile basin. None of these wells are located within 10 miles of the Jillson well. Stone and others (1983) state that the hydrologic properties, regional flow patterns, and water quality do not vary significantly from unit to unit within the San Juan Basin. They also reference regional flow within the basin as occurring from elevated recharge areas on the basin margin toward discharge areas along the San Juan River in the northwest and along the Rio Puerco in the southeast. They also state that vertical flow occurs across unit boundaries and along geologic structures within the basin. No regional groundwater gradient maps have been found for the Entrada.

Local Flow

The hydrology of the Entrada at the Jillson location can only be surmised from the known physical characteristics of the formation and generalizations about them. If one were to assume that the local flow follows the structural contours of the top of the Entrada, ignoring vertical flow between units and along geologic structures, then according to Figure 78 of Stone and others (1983) the direction of the flow at the Jillson well would be to the north at a gradient of approximately 0.012. Using the average of the range in hydraulic conductivity for the Entrada reported by Stone and others (1983) of 2.75 feet per day and an average of the range in porosity for sandstone from Freeze and Cherry (1979) of 0.175, the average linear velocity of the groundwater in the Entrada would be 0.189 feet per day.

References

Freeze, R.A., and Cherry, J.A., 1979, Groundwater, Prentice Hall, Inc., Englewood Cliffs, N.J. 604 pp.

Stone, W.J., Lyford, F.P., Frenzel, P.F., Mizell, N.H., and Padgett, E.T., 1983, Hydrogeology and water resources of San Juan Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Hydrologic Report 6, 70 pp.

Thorn, C.R., Levings, G.W., Craigg, S.D., Dam, W.L., and Kernodle, J.M., 1990, Hydrogeology of the Cliff House Sandstone in the San Juan structural basin, New Mexico, Colorado, Arizona, and Utah: U.S. Geological Survey Hydrologic Investigations Atlas 720-E, 2 sheets.

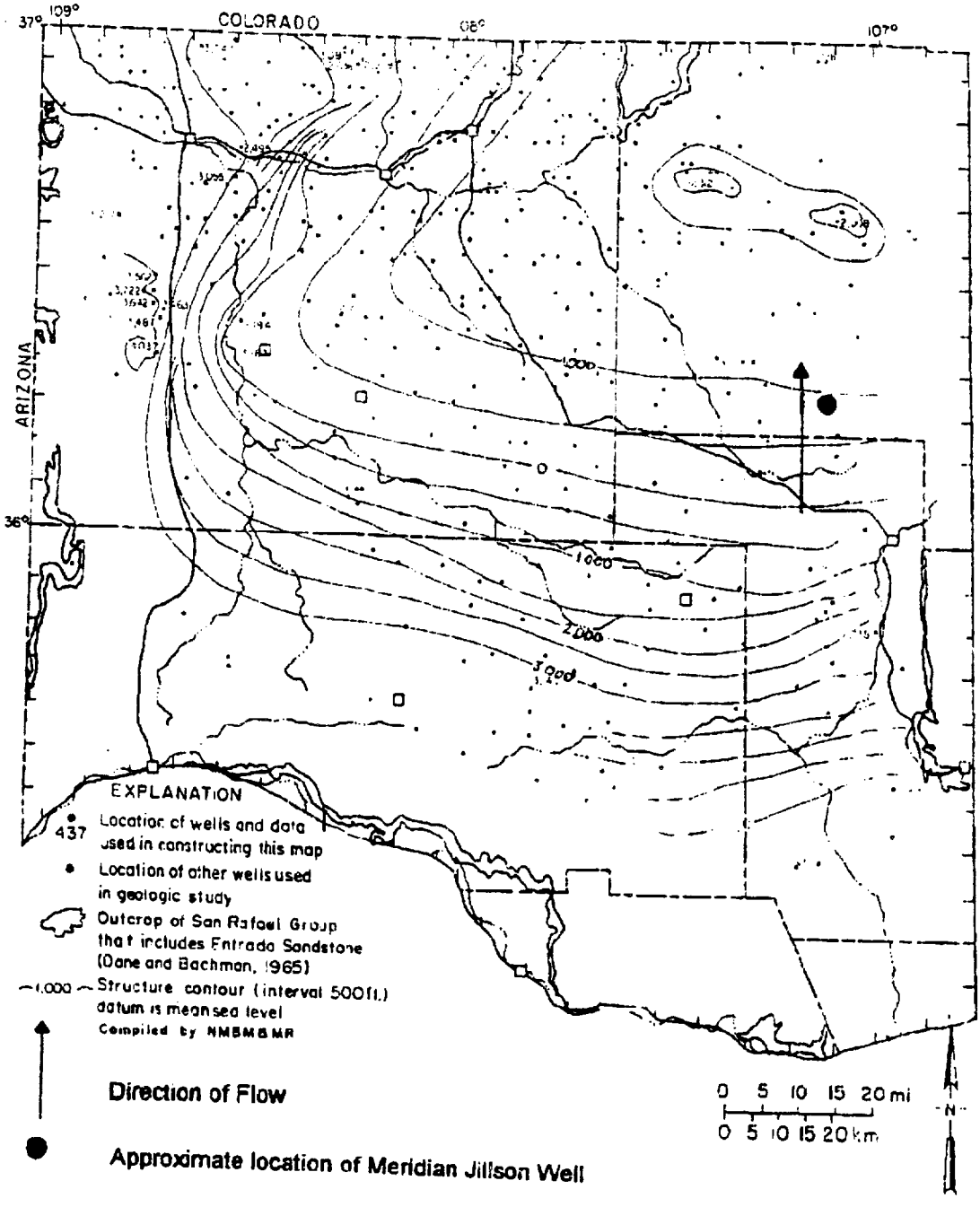


Figure 78—Elevation of top (structure) of Entrada Sandstone.

Modified from Stone and Others, 1983

JILLISON FEDERAL SWD #1

Proposed Entrada Disposal Well

Unit F, Sec 08, T24N - R03W
Rio Arriba County, New Mexico