

**IN THE MATTER OF THE APPLICATION FOR AUTHORIZATION TO  
INJECT, C-108, FOR THE EXXON STATE NO. 8 WELL OPERATED BY  
MESQUITE SWD, INC.**

***EXPERT REPORT REGARDING***

**ASSESSMENT OF THE GEOLOGICAL STRUCTURE AND  
STRATIGRAPHY AND HYDROGEOLOGICAL SETTING OF  
THE MESQUITE EXXON STATE NO. 8 SALTWATER  
DISPOSAL WELL AND OTHER WELLS  
in and around Section 15, Township 21 South, Range 27 East  
Eddy County, New Mexico**

June 19, 2008

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**ASSESSMENT OF THE GEOLOGICAL STRUCTURE AND  
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Eddy County, New Mexico**

**I. EXECUTIVE SUMMARY**

**A. Purpose and Scope**

The study is to determine the structure, stratigraphy, and hydrogeology relative to water injection in the subject well and area. It was initiated to evaluate and address questions raised as to the geological formation of injection in the Exxon State #8 water disposal well. The study also provides additional data applicable to C-108 Application.

**B. Discussion of Geology and Wells Drilled**

Remapping of the Magruder (Yates) field and extension of correlation by e-log and sample data from the Exxon State #8 to wells outside the Area of Review permitted a sound basis for structural mapping and stratigraphic correlation. The high degree of correlativity across the Magruder (Yates) field, illustrated in cross-section, and into adjoining areas yields a basis for the understanding the stratigraphy and structure of the Yates Formation in the study area.

Conclusions p. 23. Discussion p. 1.

**C. Determination of Injection Formation Mesquite #8 Exxon State**

Careful subsurface e-log and sample log correlations, enhanced with surface outcrop thickness of the Yates Formation less than 13 miles from the Exxon State #8, provide a reliable estimate of Yates Formation thickness for the Exxon State #8 of least 405 feet. That projection was supported by other outcrop information suggesting the base of the Yates Formation at the subject well is at about 900 feet. The e-log correlations used in the area allow a projection of the base of the Yates Formation in the Exxon State #8 to be at least 50 feet - probably more - below

the 694 foot TD of the well. The conclusion is that the Exxon State #8 was more than reasonably within the Yates Formation at its total depth.

Conclusions p. 23. Discussion p.14.

#### **D. Other Wells Penetrating Injection Zone within Area of Review**

In the Area of Review there are 20 wells deep enough to have possibly penetrated into the disposal zone of the Exxon State #8. Thirteen of the wells have been plugged. Two are temporarily abandoned (Operator: Mesquite). Of the remaining 5 wells the Yates Formation in 3 of them behind casing. The two remaining unplugged wells are listed as possibly penetrating the injection horizon; but well data is insufficient to definitely establish they drilled below the top of the Magruder (Yate) pay. Two additional wells unlisted by OCD penetrated to Magruder (Yates) sand and one penetrated Capitan reef.

Conclusions p. 24 Discussion p. 18.

#### **E. Groundwater in the Study Area**

Within the two-mile radius area from the Exxon State #8 there are no known water wells, and the hydrogeology indicates no potable aquifers are present in or under the Area of Review. Control exists to demonstrate that the Exxon State #8 is more than two-miles north of the high transmissivity area of the Capitan reef. Numerous cable tool drilled wells in and around the Area of Review clearly reflect no water was encountered above the Magruder (Yates) sand.

Conclusions p. 24. Discussion p. 19.

#### **F. Faults and Hydrologic Connections to Potable Underground Water**

GeoScience Technologies on behalf of Mesquite SWD, Inc., affirms that thorough examination of available geologic, hydrogeologic, and engineering data found no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water

Conclusions p. 24. Discussion p. 20.

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## **II. Purpose and Scope**

Mr. Clay Wilson, on behalf of Mesquite SWD, Inc.(Mesquite), received and complied with both the Oil Conservation Division (OCD) telephone communication and following written Order dated May 9, 2008 requiring immediate shutting-in of the Mesquite Exxon State #8 salt water disposal well (30-015-22055) located 1268' FSL and 2032' FEL of Section 15, T21S-R27E, Eddy County, New Mexico. Mr. Wilson has filed a C-108 Application to modify permit SWD #180. The well has been in almost continuous use without substantive changes since completion in 1977. The OCD questioned details of the application filed by A. H. Rains on or about 2/8/1977, and initiated Mesquite running a fluid tracer survey that indicates fluid injection from 587 feet to TD 694 feet. The Order stated: "The fluids are being injected near or into the top of the Capitan Reef, which is an extremely porous aquifer."

This study will address the geological structure, stratigraphy, and the hydrogeology of the greater field area for qualification to dispose produced water via C-108 Application.

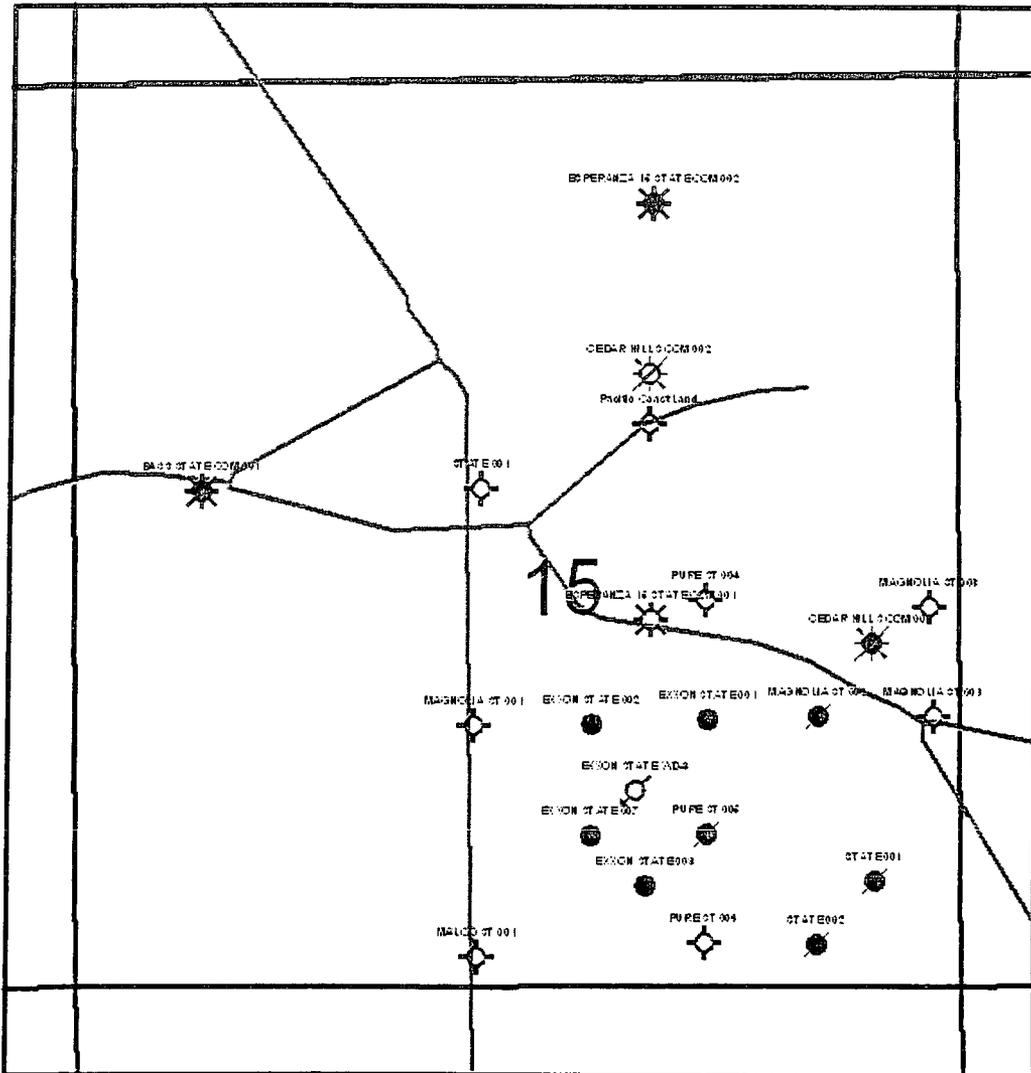
## **III. Discussion of Geology and Wells Drilled**

Mr. Wilson contacted GeoScience Technologies (GeoScience) and relayed the OCD's concerns that the Exxon State #8 may be injecting water into underlying non-Yates Formation and possibly the Capitan reef. He requested GeoScience evaluate the well and its disposal horizon, and address other geological and hydrological requirements for the C-108 Application.

### **A. Examination of Magruder (Yates) Field**

The discovery well, R.S. Magruder #1 State, located 660' FSL and 660' FEL of Sec. 15, T21S-R27E, was completed January 20, 1953 at a depth of 562 ft. Magruder reported the well was in limestone and sand at total depth (TD). All known wells drilled in Section 15, T21S-R27E are shown in Figure 1, page 2. All of Section 15 is State leased acreage.

**Mesquite SWD, Inc.**  
**Section 15, T21S-R27E, Eddy County, NM**  
**Well Identification and Type**



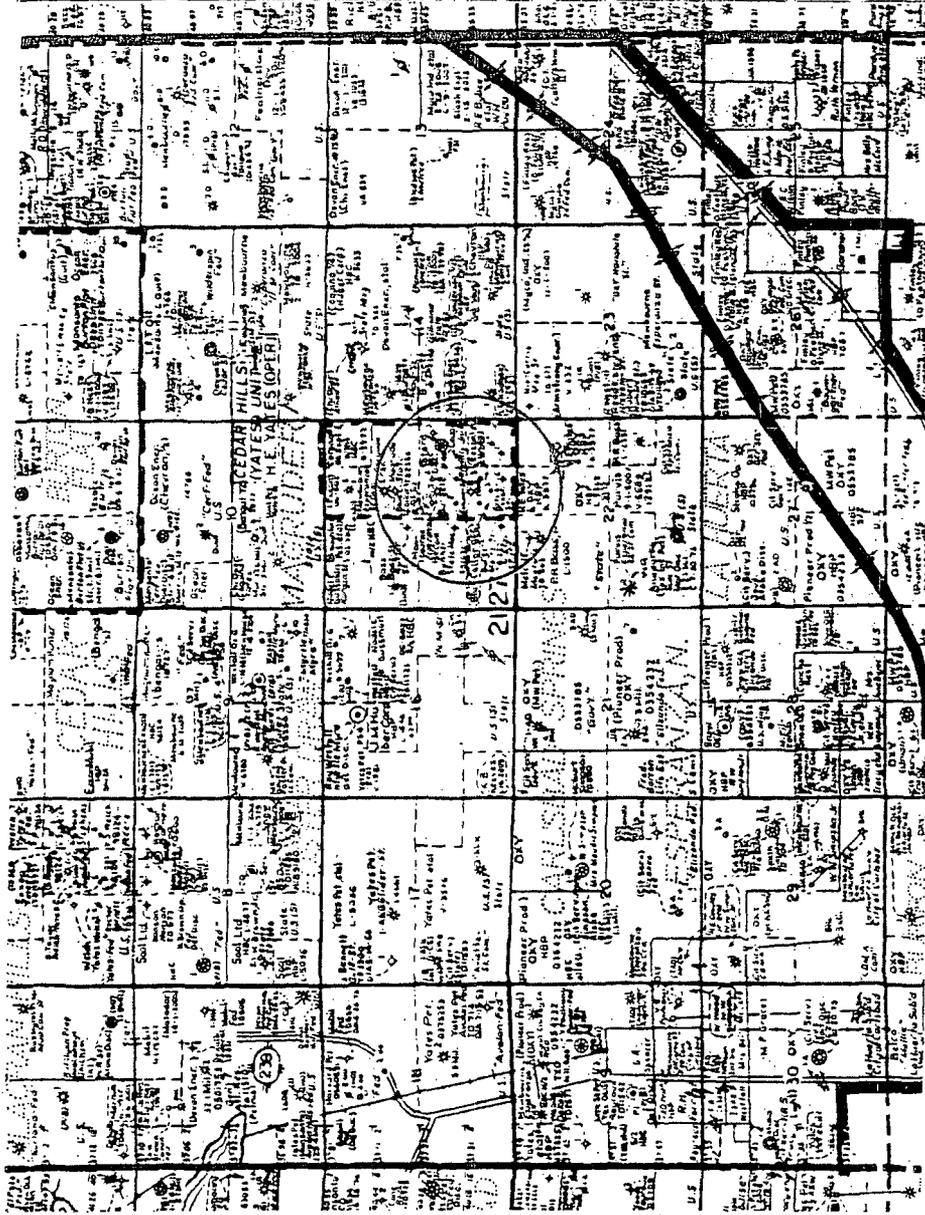
- ~ Lease access road
- ◊ Water Disposal well
- Oil well
- ✱ Gas well
- ✱ Gas - Oil well
- Abandoned Gas well
- ✱ Abandoned Gas well
- ✱ Abandoned Oil/Gas well
- ◇ Dry hole

Map source: USGS topo NAD27 base  
 DeLorme XMap 4.0

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**Roswell, New Mexico**  
**June 1, 2008**

**Fig. 1** Well names and locations Magruder (Yates) Field.

**Mesquite SWD, Inc.**  
**Area of Review Map T21S-R27E, Eddy County, NM**



Map from Midland Map Company  
 Midland, Texas

0 1  
 Mile

GeoScience Technologies  
 Kay Havenor, Ph.D., RPG  
 Roswell, New Mexico  
 June 13, 2008

**Fig. 1a** Area of Review for C-108 Application

The Magruder discovery well was drilled with cable tools, as was the subject Mesquite #8 Exxon State well completed September 20, 1977, and a majority of the other wells drilled within the field. Geophysical logs were not run on a majority of the older wells. The detail provided by cable tool drillers varies from their reporting only major lithological changes and oil/gas shows to very detailed changes. All of these ranges exist in logs filed from wells in the Magruder Field. Fortunately, the log filed by A.H. Rains on the Exxon State #8 is one of the better logs.

### **B. Structure of Magruder (Yates) Field**

Goodger (1956) presented a brief symposium report on the structure and pay zone lithology of the Magruder (Yates) field. His structure map was on the top of the Magruder pay zone, which was reported by R.S. Magruder in 1953 as the top of the Yates sand instead of the Magruder (Yates) sand. Goodger's structure map is shown in Figure 2, page 5. This map uses a 20 ft contour interval and conveys the configuration as a small structural closure.

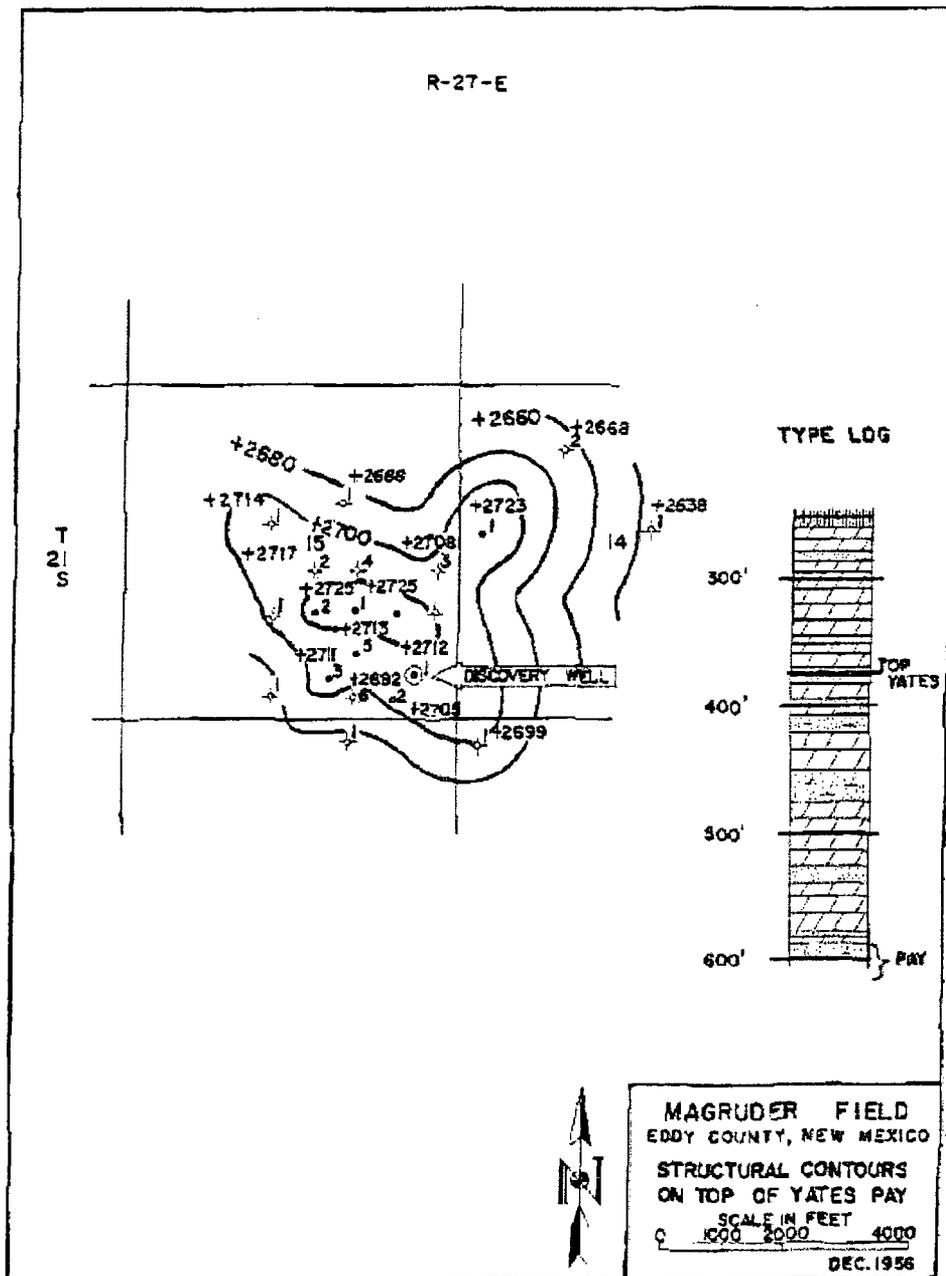
Following Gooder's mapping horizon, the top of the Magruder (Yates) horizon, GeoScience presents the Section 15 structure map that includes all the currently available structural data in Figure 3, page 6. Figure 3 is also mapped on 20 ft contour interval, but with more control. It illustrates a bench-like configuration, common in near-shore shallow marine waters such as the back-reef facies of the Permian Delaware sea.

### **C. Lithology of the Magruder (Yates) area**

As stated above, the most detailed sample description of cuttings in the Section 15 area have been provided from the well that is the subject of this action, the Exxon State #8. Figure 4, page 7, is a copy of the original driller's log. The OCD scanned records do not include the bottom full line of sample descriptions.

The described lithologies in the driller's log are characteristic of the subsurface Yates Formation throughout most of middle Eddy and Lea Counties behind the Capitan reef. The general absence of recent generation geophysical logs, especially in the shallower depths, makes

# Magruder (Yates) Field Roswell Geological Society Oil & Gas Fields Symposium 1956

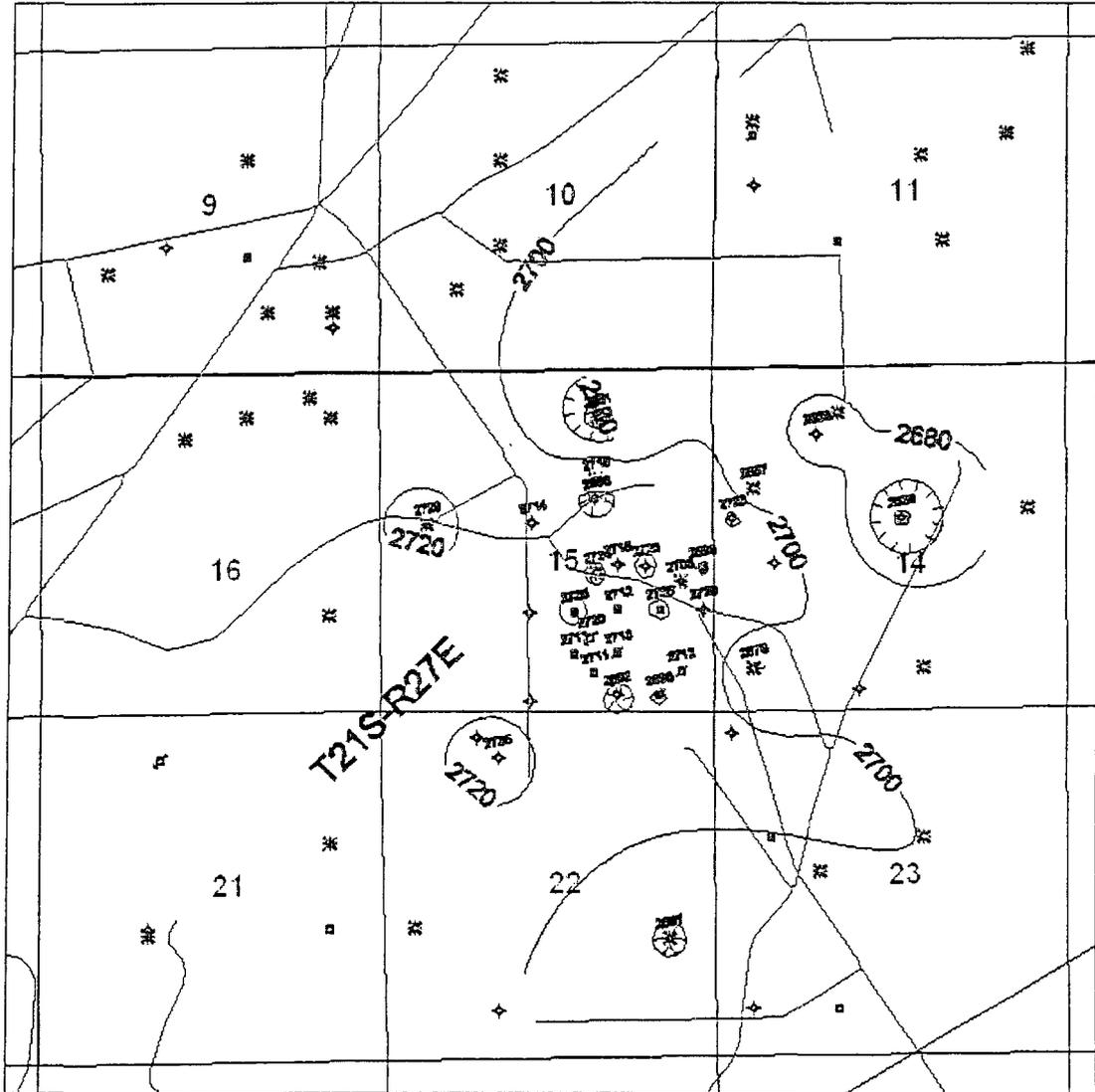


Map prepared by:  
J. M. Goodger  
The Pure Oil Company  
11-13-56, p. 262

**GeoScience Technologies**  
**Kay Havenor, Ph.D., RPG**  
**Roswell, New Mexico**

**Fig. 2** Structure contour map 1956 Roswell Geological Society symposium

**Mesquite SWD, Inc.**  
**T21S-R27E, Eddy County, NM**  
**Structure on Magruder (Yates) Sand**



Contour Interval: 20 ft MSL datum

Map source: USGS topo NAD27 base  
 DeLorme XMap 4.0

- Lease access road
- ◻ Water Disposal well
- Oil well
- \* Gas well
- \* Gas - Oil well
- ◐ Abandoned Oil well
- \* Abandoned Gas well
- \* Abandoned Oil/Gas well
- ✦ Dry hole

Data Sources: Roswell Geological Society Symposium 1956.  
 OCD, Scout data, Sample logs, Geophysical logs

**GeoScience Technologies**  
**Kay Havenor, Ph.D., RPG**  
**Roswell, New Mexico**  
**June 12, 2003**

Fig. 3 Structure top of Magruder (Yates) horizon.

This form is to be filled with the name of the formation or zone and the thickness of each zone. It is after the completion of any newly drilled well or well which has been completed by the company of oil, natural gas, and geologically localities. It is self-explanatory and all special notes concerning the formation or zone. All formations reported shall be numbered depths, in the case of uncertainty, the vertical depth shall be reported in feet and the horizontal distance shall be reported for each zone. The formation to be filled in shall be listed in alphabetical order except on those cases where six zones are reported. See Rule 126.

INDICATE FORMATION TOPS IN CONFORMANCE WITH GEOGRAPHICAL SECTION OF STATE

Southeastern New Mexico			Northwestern New Mexico		
T. Anhy <u>70</u>	T. Canyon	T. Ojo Alamo	T. Penn. "B"		
T. Salt <u>No SALT</u>	T. Strawn	T. Kirtland-Fruitland	T. Penn. "C"		
T. Salt <u>No SALT</u>	T. Anoka	T. Pictured Cliffs	T. Penn. "D"		
T. Yates <u>694</u>	T. Miss	T. Cliff House	T. Leadville		
T. 7 Rivers <u>694</u>	T. Devonian	T. Menefee	T. Madison		
T. Queen	T. Silurian	T. Point Lookout	T. Elbert		
T. Grayburg	T. Montoya	T. Mancos	T. McCracken		
T. San Andrea	T. Simpson	T. Gallup	T. Ignacio Quartz		
T. Glorieta	T. McKee	Base Greenhorn	T. Granite		
T. Paddock	T. Ellenburger	T. Dakota			
T. Blinberry	T. Gr. Wash	T. Morrison			
T. Tubo	T. Granite	T. Todillo			
T. Drinker	T. Delaware Sand	T. Enravia			
T. Abo	T. Domo Springs	T. Wingale			
T. Wolfcamp		T. Chinle			
T. Penn.		T. Permian			
T. Cisco (Dough C)		T. Penn. "A"			

OIL OR GAS SANDS OR ZONES

No. 1, from \_\_\_\_\_ to \_\_\_\_\_ No. 4, from \_\_\_\_\_ to \_\_\_\_\_  
 No. 2, from \_\_\_\_\_ to \_\_\_\_\_ No. 5, from \_\_\_\_\_ to \_\_\_\_\_  
 No. 3, from \_\_\_\_\_ to \_\_\_\_\_ No. 6, from \_\_\_\_\_ to \_\_\_\_\_

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from PUT 110 GALLONS OF ACID IN WELL  
WELL TAKING WATER UNDER VACUUM  
STARTED WATER IN J. 9-20-77  
 No. 1, from \_\_\_\_\_ to \_\_\_\_\_ feet.

FORMATION RECORD (Attach additional sheets if necessary)

From	To	Thickness in Feet	Formation	From	To	Thickness in Feet	Formation
0	40		rb-sd	250	320		dolo and anh
40	75		gyp-rb	320	338		dolo 15 brn
75	80		dolo + anhy, hard gray	338	350		sand top yates
80	85		dolo + gyp, rb	350	354		dolo
85	95		anh gyp rd bd	354	385		sand
95	100		anh gyp rd bd	385	410		dolo
100	110		anh grap	410	439		sand
110	125		gray anh	439	488		dolo
125	130		gray han, brn clay	488	491		sand
130	145		lt gray anh	491	525		dolo
145	155		anh some rd gyp + sd	525	530		dolo and green shale
155	170		hard anh 8" pipe at 170/ 110 sx amt	530	551		dolo some green shale
				551	556		sand
170	200		lite limy anh	556	562		dolo, porous, oil saturate
200	210		brn dolo (shale brk at 205)	562	568		dolo, sat 5" csg/110 sax
				568	651		dolo
210	235		gray dolo, hard	651	654		sand
235	237		Bl sdy shale	654	683		dolo
237	243		hard lt brn dolo	683	684		sand
243	250		dolo and shale brks. fa sdy	684	694		dolo porous TD

Fig. 4 Copy of Magruder #8 Exxon State driller log.

detailed stratigraphic delineation more difficult, but certainly doable.

Important subsurface information was provided from Mesquite running a gamma ray - compensated neutron in the Exxon State #8 well. The e-log has been annotated with the driller's sample descriptions

(Figure 4) and is shown in three parts as Figure 5, and Figures 5a, and 5b, pages 9 to 10 respectively. This log enables good correlation with more recent wells that also have geophysical logs to the surface.

For reference, the top of the Magruder (Yates) zone, mapped in Figure 2, page 5, occurs at a log depth of 561 feet. This well elevation, along with all other not reported elevations, was obtained from USGS topographic sheets and DeLorme Xmap imagery. The tops are all consistent with the RGS map, Figure 2.

		COMPENSATED NEUTRON GAMMA RAY / CCL LOG					
Company Mesquite S.W.D., Inc. Well Exxon State No. 8 Field N/A County Eddy State New Mexico 18477	Company		Mesquite S.W.D., Inc.				
	Well		Exxon State No. 8				
	Field		N/A				
	County		Eddy		State New Mexico		
	Location		Unit Letter "O"			Other Services	
			Section 15	Township 21S	Range 27E		
	Permanent Datum		Ground Level	Elevation	N/A		
	Log Measured From		Ground Level		Elevation		
	Drilling Measured From		N/A		K.B. N/A D.F. N/A G.L. N/A		
	Date		05 - March - 2008				
Run Number		One					
Depth Driller		894 ft.					
Depth Logger		892 ft.					
Bottom Logged Interval		850 ft.					
Top Log Interval		25 ft.					
Open Hole Size		N/A					
Type Fluid		Water / Air					
Density / Viscosity		N/A					
Max. Recorder Temp		N/A					
Estimated Cement Top		N/A					
Time Well Ready		CA					
Time Logger on Bottom		See Log					
Equipment Number		WL - 9965					
Location		Hobbs, NM					
Recorded By		Danny Clabum					
Witnessed By		Mr. Clay Wilson					
Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
Casing Record		Size	Wdg Pt	Top	Bottom		
Surface String							
Prod. String							
Production String		5.500 in.		Surface	567 ft.		
Liner							

Fig. 5 Header for Mesquite #8 Exxon State log

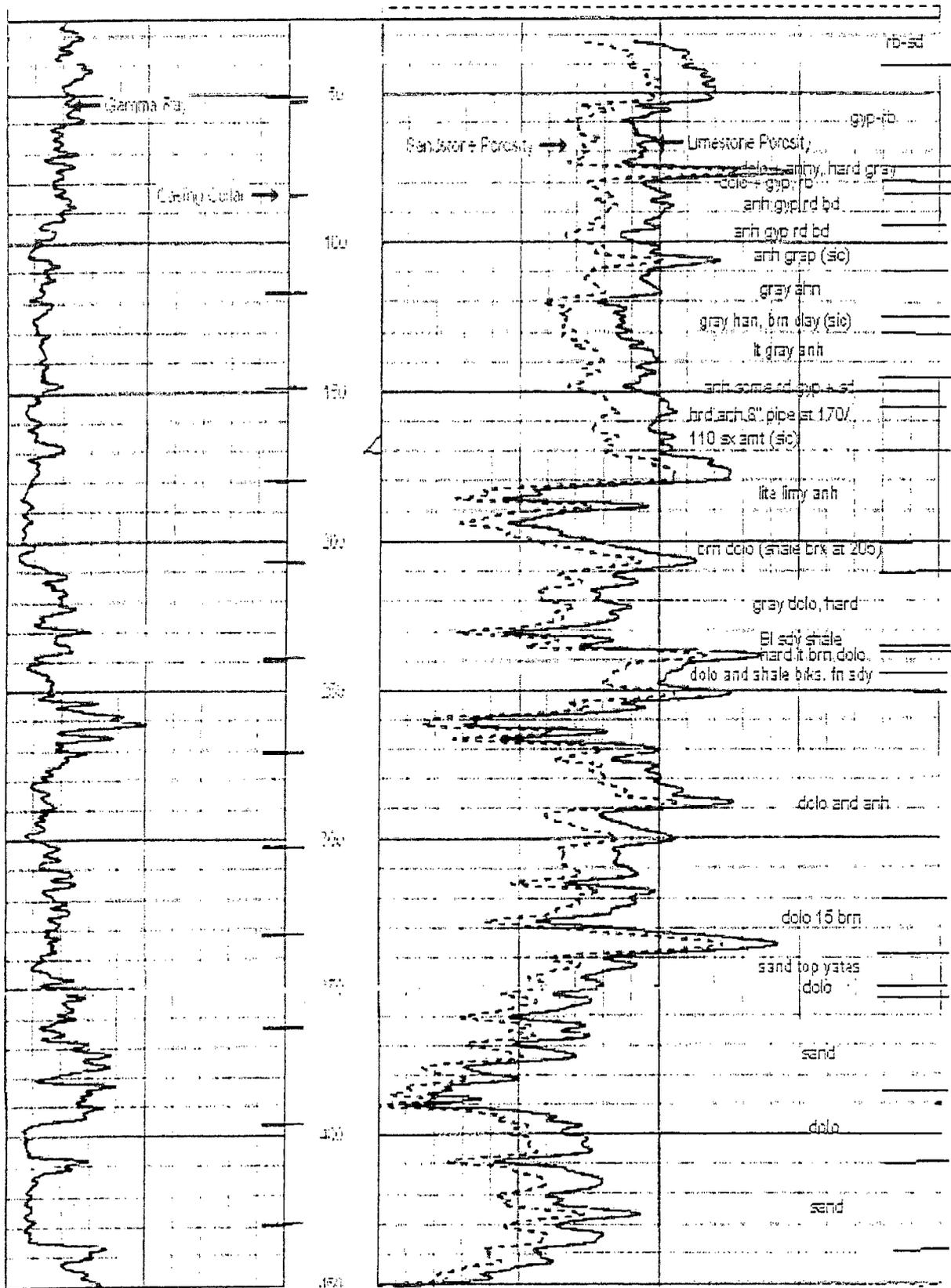


Fig. 5a Upper part of sample annotated gamma ray-neutron Mesquite #8 Exxon State

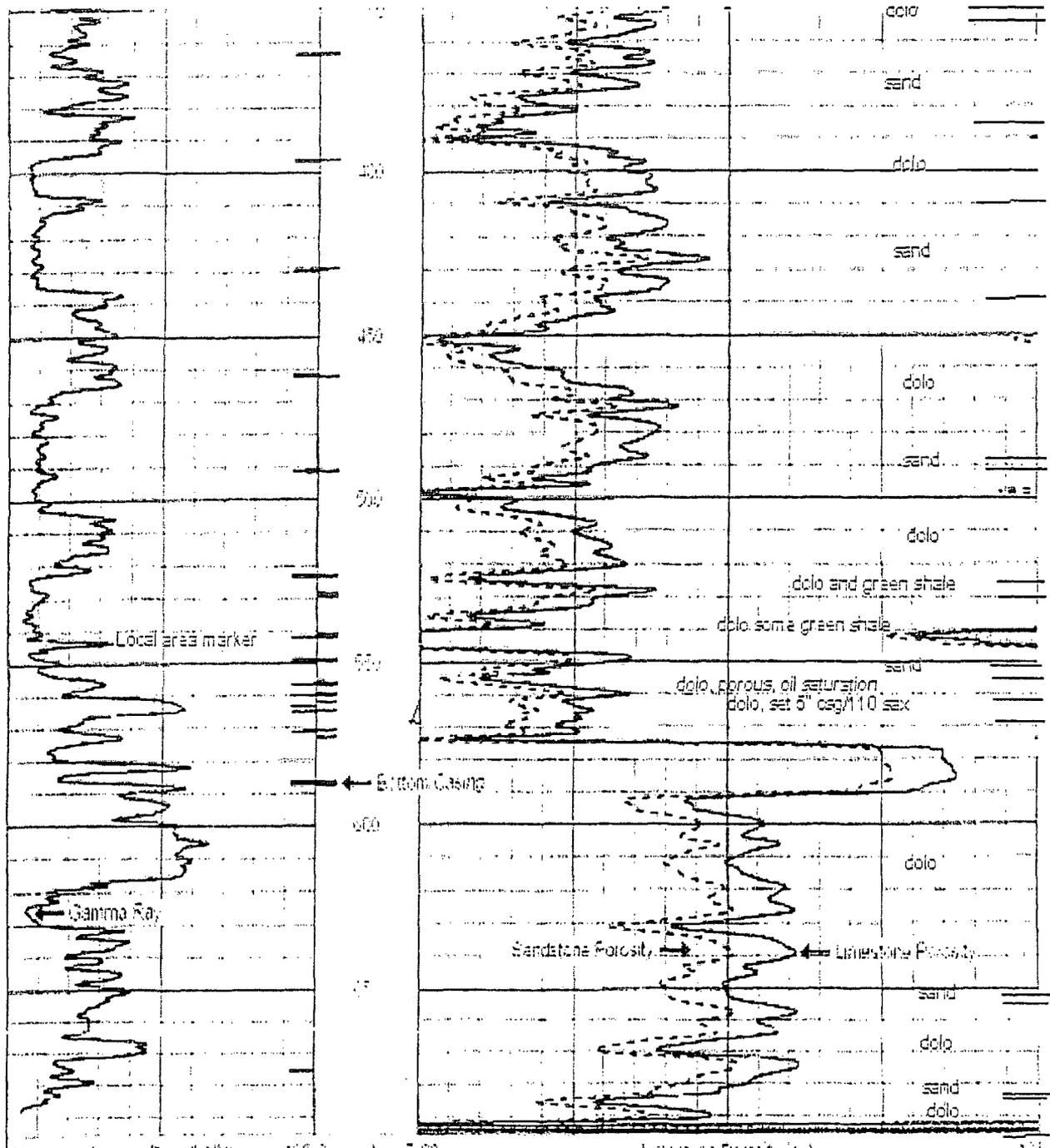


Fig. 5b Bottom portion of Exxon State #8 gamma ray - neutron log. Note: log overlaps Fig. 5a.

#### **D. Well log correlations in and beyond Section 15**

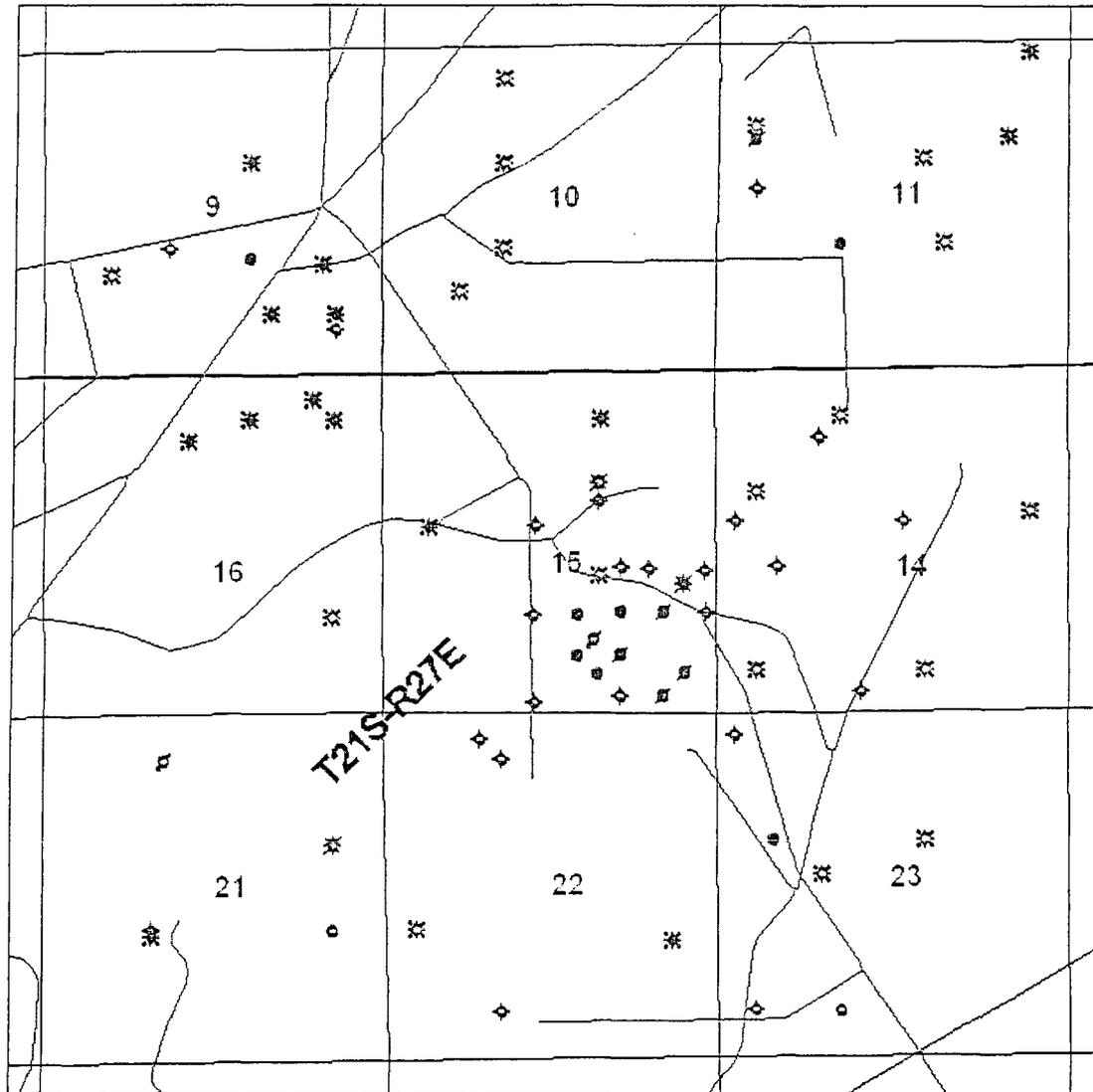
The Magruder (Yates) basis for log correlation within this study area of Section 15 and parts of adjoining sections was Goodger (1956). While the Magruder pay interval is important in the field itself, the most significant considerations for this report are the e-log characteristics both above and below the field wells. An important local area gamma ray marker zone for correlation within Yates Formation was found at 545' (e-log) in the Exxon State #8. This zone is described by Rains in his driller's log as dolomite and green shale. The sharp gamma ray inflection suggests a thin, very radioactive shale, probably bentonitic resulting from volcanic ash fallout. This marker zone is denoted on Figure 5b, page 10, and can be identified within the Yates Formation in all of the examined well logs.

Figure 6, page 12, is a location spot map of all OCD reported wells, plus two (described later) not reported in their records. This map is for reference to well spots outside the detailed Section 15 maps shown above in Figures 1 and 2, pages 2 and 5 respectively.

Well logs have been examined in detail from the wells shown in Figure 7, page 13. Formation tops were determined by correlating the known depths in the Section 15 Magruder (Yates) field and working outward. In-as-much-as many of the Magruder (Yates) wells were drilled with cable tools and samples were examined by company geologists supervising their company's farm-outs of acreage, the stratigraphy of the upper Permian in this (and other shallow areas) has been well developed.

The detailed lithology for the Mesquite #8 Exxon State well provides critical control points for expanding the correlations to well logs in which samples are not available. The gamma ray logs provide significant lithologic implications and greatly increase correlation confidence.

Mesquite SWD, Inc.  
 Study Area T21S-R27E, Eddy County, NM



Map source: USGS topo NAD27 base  
 DeLorme XMap 4.0

- ~ Lease access road
- ◊ Water Disposal well
- Oil well
- \* Gas well
- \* Gas - Oil well
- Abandoned Gas well
- \* Abandoned Gas well
- \* Abandoned Oil/Gas well
- + Dry hole

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**Roswell, New Mexico**  
**June 12, 2008**

Fig. 6 Well location plat for greater study area

API	OPERATOR	WELL_NAME	TD	Elevation	Top Magruder	Magruder MSL	Top Yates	Yates MSL
3001532647	MEWBOURNE OIL CO	ESPERANZA 14 STATE 002	11850	3265	578	2687	363	2902
3001531877	MEWBOURNE OIL CO	ESPERANZA 15 STATE COM 001	11835	3302	578	2724	367	2935
3001532718	MEWBOURNE OIL CO	ESPERANZA 15 STATE COM 002	11835	3320	569	2651	420	2900
3001521167	BEPCO, LP	BASS STATE COM 001	11700	3314	585	2729	358	2956
3001522055	MESQUITE SWD, INC	EXXON STATE WD-8	694	3281	561	2720	348	2933
3001501101	H.E. YATES CO	CEDAR HILLS COM 001	12812	3269	566	2703	324	2845
3001521492	H.E. YATES CO	CEDAR HILLS COM 002	11750	3315	500	2715	428	2887
3001532938	PURVIS OPERATING CO	ESPERANZA "22" STATE COM 001	11837	3242	581	2661	362	2880
3001521263	BEPCO, LP	STATE 22 COM 001	11760	3300	555	2735	394	2906
3001532415	MEWBOURNE OIL CO	ESPERANZA 14 STATE 001	11870	3244	581	2663	360	2884
3001532938	PURVIS OPERATING CO	ESPERANZA 22 STATE COM 001	11850	3242	545	2697	344	2898
API	Footage	Township & Range	Section	Marker Zone	Marker MSL	Top 7R/Capitan	7R/Capitan	MSL
3001532647	1830 FNL	21S -27E	14	560	2685	802	802	2453
3001531877	2232 FSL	21S -27E	15	578	2724	784	784	2518
3001532718	660 FNL	21S -27E	15	670	2650	853	853	2467
3001521167	1980 FNL	21S -27E	15	559	2755	793	793	2521
3001522055	1268 FSL	21S -27E	15	544	2737	NR	NR	...
3001501101	1980 FSL	21S -27E	15	530	2739	641	641	2428
3001521492	1650 FNL	21S -27E	15	630	2685	832	832	2483
3001532938	1775 FSL	21S -27E	15	542	2700	804	804	2438
3001521263	660 FNL	21S -27E	22	545	2755	814	814	2486
3001532415	685 FSL	21S -27E	14	560	2684	802	802	2442
3001532938	1775 FSL	21S -27E	22	544	2698	805	805	2437

Fig. 7 Well log identification and e-log tops correlated

#### **IV. Determination of Injection Formation Mesquite #8 Exxon State**

As stated above, the OCD indicated the Exxon State #8 has failed to confine injected fluids to the authorized injection zone or zones. This study is to examine and determine the stratigraphic position of the injection horizon in the well.

##### **A. Key facts concerning the Mesquite #8 Exxon State**

The Mesquite Exxon State #8 was drilled with cable tools and has a detailed sample log.

A sample supported e-log "marker" zone in this well is correlative over the local area.

The top of the Magruder (Yates) pay zone is defined by samples and e-log at 561'.

The Magruder (Yates) is unquestionably present in the well.

The bottom eleven (11) feet of the drill hole (683 - 694'), as shown by the driller's log, is composed of a thin sand underlain by porous dolomite.

At total depth of 694' the driller's log states "Well taking water under vacuum."

The greater Mesquite Exxon State #8 and the Magruder (Yates) field area contains and is surrounded by wells of other ownership that have e-logs confirming the correlations to the Magruder (Yates) pay zone and to the Exxon State #8's lower lithologic section..

There is a minor depth discrepancy of 2 to 4 feet between the e-log and the driller's log at the deepest e-log penetration. This is not unusual, but at its deepest the e-log only recorded to 690' for the porosity tool and 688' with the gamma ray, while driller descriptions are to 694'.

The penetrated thickness of the Yates Formation in the Exxon State #8, from Figure 7, page 13, is 346 feet (top Yates 348' to TD 694').

##### **B. Correlation Exxon State #8 with deeper wells**

Figure 7, page 13, lists the inter-correlated e-logs for this study. Figure 8, page 15, shows the correlations between the Exxon State #8 and one deep well approximately 1,000 feet north, and a second deep well located approximately 2,740 feet east-southeast.

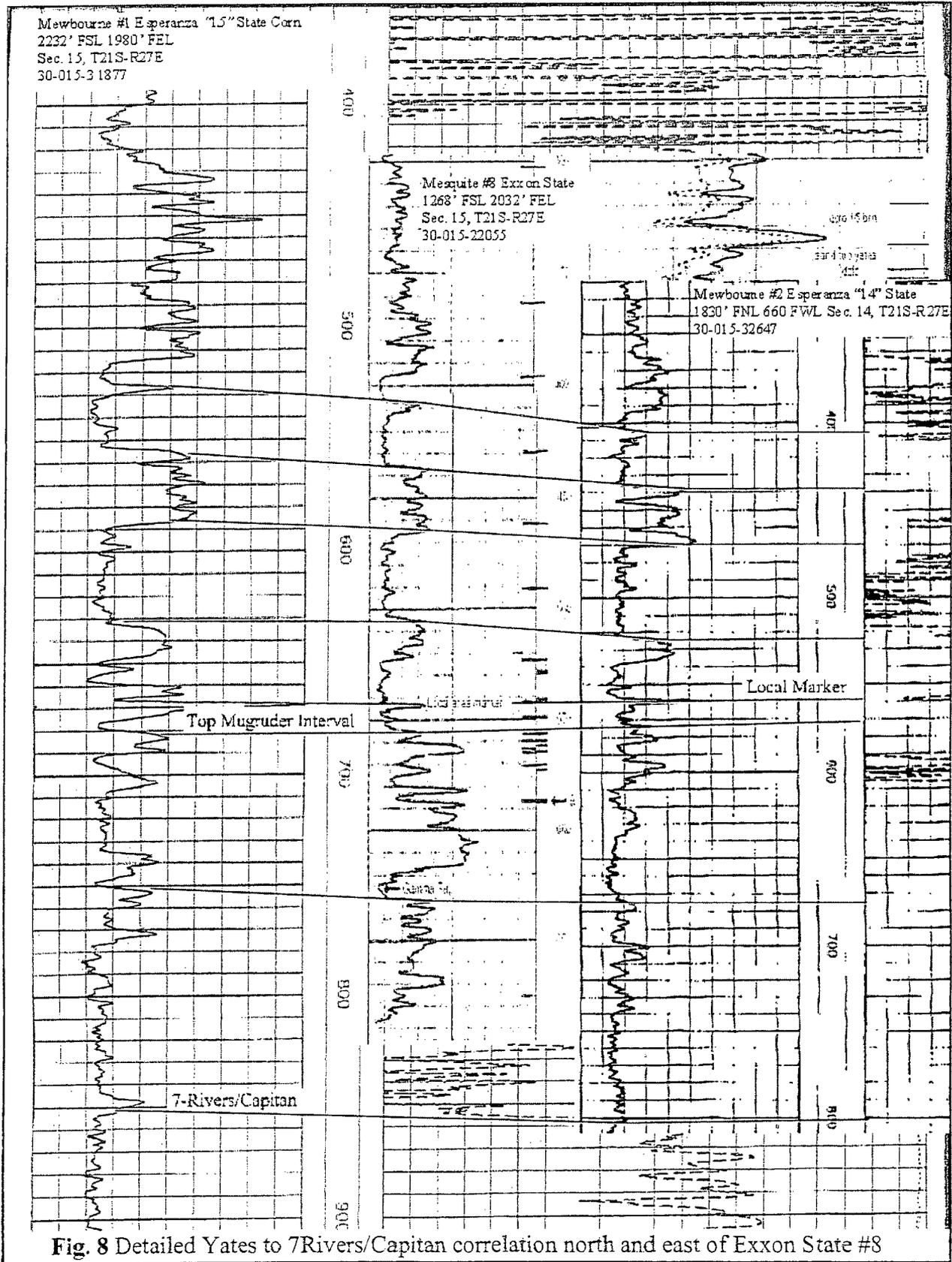


Fig. 8 Detailed Yates to 7Rivers/Capitan correlation north and east of Exxon State #8

(i) Comments on Well Correlations

There is a high degree of correlativity throughout most of the Yates Formation, as is illustrated above. One reason for the good correlativity is the present day availability of the log on the Exxon State #8. This enables correlation outward from the target well. Unfortunately, deep well logging is usually not interested in the "shallow stuff." Often the principal log run through the shallow formations is only a gamma ray without a porosity log because the shallow beds are usually behind casing. The gamma ray log alone provides considerable lithologic information for an experience user.

Correlating the three logs in Figure 8, p. 15, provides excellent markers and lithology indications that yield a high degree of confidence. This is especially true because the cross-section was prepared *after* all the logs listed in Figure 7, p. 13, had been correlated.

(a) Possible conflict with OCD interpretation

In working the OCD data for all the wells involved there was an OCD well tops sheet included for the Mewbourne #1 Esperanza 14 State, the right-hand log in the above cross-section. The note is shown in Figure 9. The Capitan Limestone is called at 632 feet. This zone can now be seen to clearly correlate with clastic horizons that are definitely in the Yates Formation of sandstone, siltstone, clay, and dolomite.

In order to further evaluate the Seven Rivers/Capitan reef correlations presented in Figure 7, p. 13, it was decided that conformation of the

**Mewbourne Oil Company**  
**Esperanza '14' State Com. #1**  
**Unit M, Sec. 14, T21S-R27E**  
**685' FSL & 660' FWL; (G.L.-3242', K.B.-3260')**  
**Eddy Co., N.M.**  
**30-015-32415**  
**GEOLOGICAL TOPS PER/BRYAN G. ARRANT-MUD**

Capitan Limestone	632'
Delaware Sands	3099'
Bone Spring	5397'
1 <sup>st</sup> Bone Spring Sand	6610'
2 <sup>nd</sup> Bone Spring Sand	7357'
3 <sup>rd</sup> Bone Spring Sand	8714'
Wolfcamp	9958'
Strawn	10248'
Atoka	10550'
Morrow Clastics	11310'
Barnett Shale	11732'

Fig. 9 OCD Formation tops in 3001532415 well file

Yates Formation thickness should be sought outside of well log and sample log observations. The closest Yates-Seven Rivers Formation outcrops are 12.7 miles northwest of the Mesquite Exxon State #8, near the former Lake McMillan in sections 28 and 29, T19S-R27E, Eddy County. Kelley (1971) reports that the Yates Formation is 405 feet thick at these outcrops. Additionally, Kelley (1971) describes, as most subsurface geologists that work the Permian Guadalupian of Chaves, Eddy, and Lea Counties recognize, “. . . as the reef is approached, dolomite and sandstone continue to the reef with gradual increases in dolomite. . . However, as the reef is approached, dolomite and sandstone increase, beds thicken . . .” (Kelley, 1971, p. 18). Eventually, south of the section 22 wells examined in this study, Kelley's (1971, p. 18) observation applies that eventually “As with the Seven Rivers, the Yates laps out or becomes a part of the structureless reef.”

The Yates thickens from north to south, and at Lake McMillan is 405 feet thick, then it is expected to thicken southward. Conservatively, using the 405 foot thickness figure to evaluate the Yates in the study area, it is apparent that the tops of Seven Rivers/Capitan are conservative as presented from Figure 7, p. 13. In the Mewbourne #1 Esperana 14 State, discussed above, the 405 foot thick Yates would place the base of the Yates to at least 765 feet deep. This study's e-log pick is at 802 feet for the base of the Yate and the top of the Seven Rivers/Capitan.

Working known surface exposures of Yates-Seven Rivers contact to the west in section 17, T21S-R25E and applying a known dip of 1.5 degrees southeast, the depth of the base of the Yates is estimated at about 900 feet below the Exxon State #8. Although this method is less accurate than the measured thickness, it certainly supports the conclusions as to the depth of the base of the Yates Formation in the area of the Magruder (Yates) field and therefore its thickness.

### **C. Conclusion as to Exxon State #8 injection formation**

With the above information it is a clear conclusion that the Mesquite Exxon State #8 disposal well at total depth (694') is within the Yates Formation and at least 50 feet - probably more - above the base of the formation. This leaves approximately 1/8th of the Yates Formation lithology separating the well from the Seven Rivers/Capitan.

The original driller's log clearly indicates the lowest penetrated dolomite to 694 feet was

porous and took fluid on gravity. The fluid survey on the well log showed fluid was being accepted in the Magruder area, 574 to 590 feet, and at 690 feet (the lowest logged point) fluid was moving past the tool toward the driller's described porous dolomite to 694 feet.

Examination of logs in the area demonstrates that interbedded sandstones, siltstones, clays, and dolomites are present in and below the Exxon State #8's stratigraphic total depth – some are porous, permeable, and water wet, whereas others are not. Fluid was moving past the logging sonde at 690 feet because there was porosity to 694 feet, the TD of the well, and the sonde could not penetrate fill to the bottom of the hole. There is no basis to infer the porous dolomite in the bottom of the Exxon State #8 is hydrologically connected to the Capitan reef.

#### **V. Other Wells Penetrating Injection Zone within Area of Review**

As per the requirements for C-108 Application, a tabulation of all known wells within the Area of Review that may have penetrated into the injection zone of the Exxon State #8 is shown below in Figure 11, p. 22. OCD records reflect 20 wells have been drilled within this area.

Examination of OCD logs and drilling data reflect that of these 20 well, 13 are reported as plugged, 2 are temporarily abandoned, and the remaining 5 are classified as active. Of the 5 active wells, three are deep wells with the shallow Yates behind casing, and the remaining 2 are shallow that questionably penetrated into the uppermost injection horizon of the Exxon State #8. Due to the lack of detailed well correlation data on these two wells they are listed here.

Two OCD unlisted wells have also been found within the Area of Review. The R.S. Magruder #1 Pacific Coast Land located 1980 FNL and FEL of Section 15, originally drilled to TD to 1553 feet by A & N Drilling. The original well was spudded June 30, 1934 and abandoned January 29, 1935. Magruder began rework February 19, 1945, set 7" casing at 2060' (probably due to water), drilled to TD 2350 in "lime" and temporary abandoned the hole August 6, 1945. The second unlisted well is the A & M Company #2 State located 2310' FSL and FEL Section 15. TD was approximately 580 feet. The only data is a sample log from The Texas Co.

## VI. Groundwater in the Study Area

### A. Distribution of water wells in the study area

Groundwater development and exploration within the two mile radius of the Exxon State #8 location is very sparse. A search of the New Mexico Office of the State Engineer's Waters Database found only eight wells permitted and drilled in a greater area than the 2-miles required. Of the wells drilled only three exceeded a total depth greater than 100 feet. One 490 foot well (Sec. 26, T21S-R27E, Figure 10, p. 21) drilled by the City of Carlsbad was a dry hole. No water was encountered. One 400 foot well was drilled for water supply for a drilling well and was plugged and abandoned. Well C-925 (Sec. 28, Figure 10, p. 21) was drilled and permitted but has since been plugged and abandoned. Were the drilling supply well of decent quality the probability is very high that the well would have been taken by the surface land owner for livestock or domestic use.

Figure 10, page 21, shows the distribution of the water wells and tests discussed above. While this is oil and gas country, it was originally - and still is - ranching land. The significant absence of livestock water supply wells attests to the general absence of potable shallow groundwater. Along the western tier of sections shown in Figure 10 there are alluvial deposits associated with the Pecos River that yield groundwater. Within the relevant areas of this Application, all of the sediments essentially above the top of the Yates Formation are simply not potential potable groundwater sources.

Driller's logs, mostly from cable tool holes, with and adjacent to the Area of Review, reflect water was encountered in or associated with oil show/production within the Magruder pay sand. One example of this was the Magruder #1 State (30-015-01102) located 660' FSL and FEL of Section 15. The driller reported a show of oil 550-552', TD at 561, and water/oil filled the hole 300' in 12 hours. Only water from the bottom formation was encountered.

The driller's log of the J. E. Metcalf #1 Magruder, Section 22, T21S-R27E, 30-015-01054, located about 2,200 feet southwest of the Exxon State #8, reported sulphur water from the bottom three feet of the hole (600-603). No other water was reported in the hole. Plugging operations reported on July 16, 1943 stated "Cemented water off at bottom of the hole with 10 sacks cement and then filled with mud within 5 ft of the surface and then cemented top with

marker." This cable tool hole, and others described above, are firm support for the conclusion that water of any quality is scanty or totally absent in the study area.

No underground drinking water sources or aquifers are present, or are known to have existed, in or beneath the injection well, or within more than a two-mile radius of the injection well, shown in Figure 10, p. 21. Because of the total absence of drinking water wells in the area no chemical analyses exist. The high number of cable tool holes drilled throughout this area provide strong confirmation of the lack of shallow water.

### **B. Comments on Capitan Reef aquifer**

The Capitan reef aquifer is a major potable water supply for municipal, domestic, and major agricultural users in the Carlsbad area of the Pecos River. Water in the Carlsbad basin is administered by the New Mexico State Engineer. This study area falls within the established boundaries of the Carlsbad basin.

The Capitan reef is a major geological feature of southeastern New Mexico and West Texas. It is noted for its many subsurface areas of high porosity and permeability from the City of Carlsbad east to Hobbs and south to the Sheffield channel in West Texas. Throughout the reef's porous aquifer the hydraulic gradient is from west to east and then south.

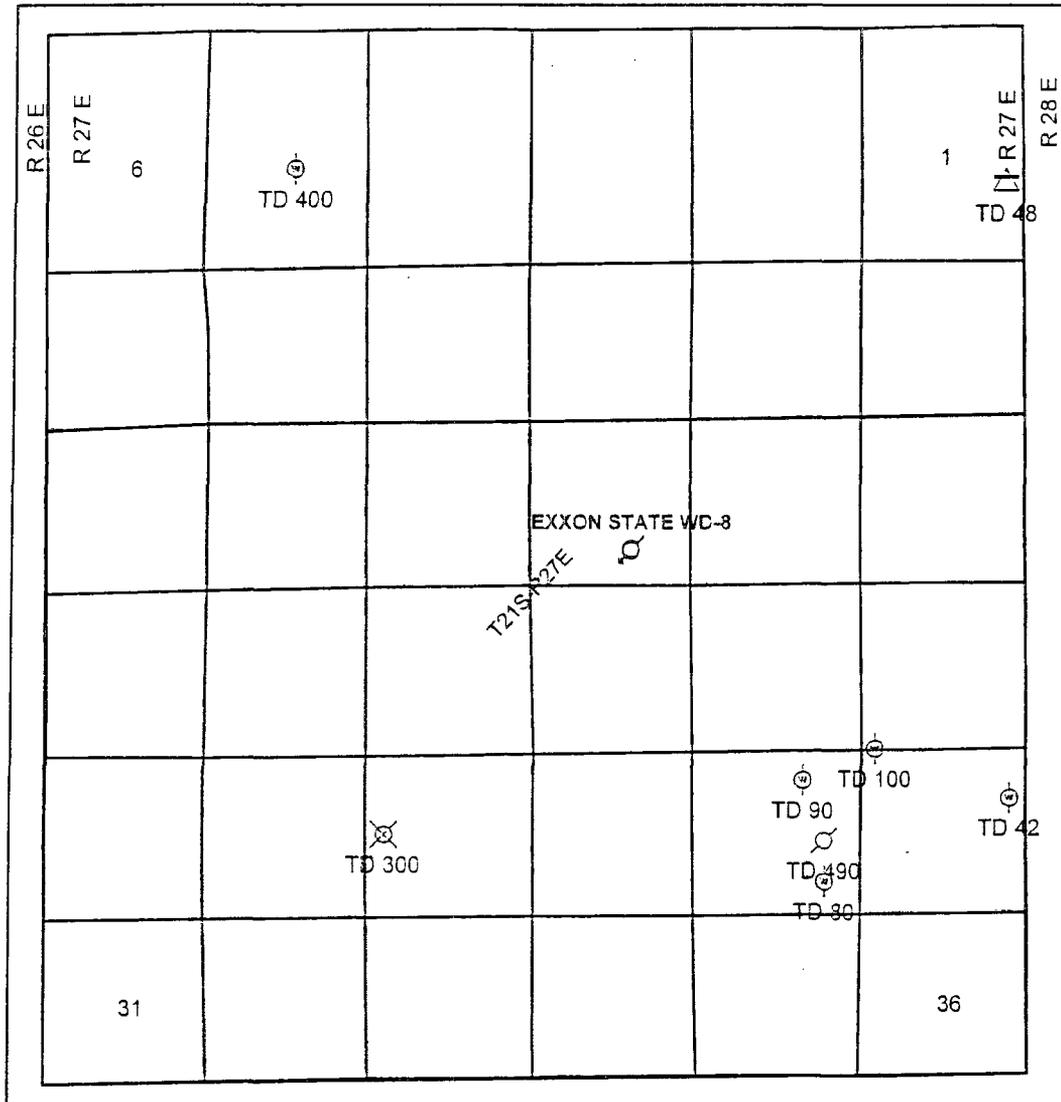
One notable condition in the Carlsbad area is that the salinity of the water in the porous portion of the reef immediately east of the City of Carlsbad rapidly degrades in the confined aquifer from potable to brackish (>1,500 mg/l).

## **VII. Faults and Hydrologic Connections to Potable Underground Water**

GeoScience Technologies on behalf of Mesquite SWD, Inc., affirms that thorough examination of available geologic, hydrogeologic, and engineering data found no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water.

# Mesquite SWD, Inc.

## Water Wells in Two + Mile Radius of Exxon State No. 8



Data source: NM Office State Engineer  
Waters Database June 12, 2008

- ⊙ Exxon State #8 SWD
- ⊙(W) Water Well
- ⊙(D) Dry Exploratory Water
- ⊙(L) Livestock Water Well
- ⊙(X) Plugged Oil Drilling Supply Well

Note: Water wells are present to the south and west of the Section 28 well, especially in Sections 19, 30, and 31.

**GeoScience Technologies**  
**Kay Havenor, Ph.D., RPG**  
**Roswell, New Mexico**  
**June 14, 2008**

Fig. 10 Water wells and tests in the study area

## VIII. Conclusions

### A. Discussion of Geology and Wells Drilled

Due to the original question as to the stratigraphic zone(s) receiving disposal water in the Mesquite Exxon State #8 disposal well, it was believed an up-to-date subsurface geological evaluation of the Magruder (Yates) field structure and stratigraphy was important. The remapping of the Magruder (Yates) field began with the original published structure contour map of the field. A new e-log on the subject well, the Exxon State #8, annotated with a detailed lithologic description from the original driller's log, provided the center point of correlation outward to other e-logs in the field and surrounding area of interest. The correlation network provided an excellent framework of the shallow stratigraphy. It also developed a very good shallow local area correlation marker throughout the mapped area. The high degree of correlativity across the Magruder (Yates) field, illustrated in cross-section, and into adjoining areas yielded a basis for definition of a minimum thickness of the Yates Formation.

### B. Determination of Injection Formation Mesquite #8 Exxon State

Considering nine key facts from analysis of the Exxon State #8 it was concluded that the well was substantially within the Yates Formation at its drilled total depth of 694 feet. Because this appeared to be in conflict with an OCD correlation of the top of the Capitan reef in a Section 14 well, 2,740 feet east-southeast, an additional evaluation from the measured surface thickness of the Yates Formation less than 13 miles north. Recognizing that the Yates Formation thickens southward toward the reef, using only the measured surface thickness of 405 feet, that value suggests a minimum depth of 765 feet in the Section 14 test. The OCD call in that well was 631 feet. The correlated top was 802 feet. The measured thickness of Yates was also projected from a surface outcrop of the base of the Yates trigonometrically to the Section 14 well that suggests a base of Yates at about 900 feet depth. These analyses are believed valid and reliable. The base of the Yates is projected to at least 744 feet, and probably deeper, in the Exxon State #8.

### **C. Other Wells Penetrating Injection Zone within Area of Review**

Within the Area of Review there are 20 OCD listed wells that are deep enough to possibly penetrate into or through the injection area beneath the casing in the Exxon State #8 well. Of these 20 well, 13 are reported as plugged, 2 are temporarily abandoned, and the remaining 5 are classified as active. Of the 5 active wells, three are deep wells with the shallow Yates behind casing, and the remaining 2 are shallow and questionably penetrated into the uppermost injection horizon of the Exxon State #8. Because of the lack of detailed well correlation data on these two wells they are listed here. Two wells not listed by the OCD also penetrated into and one through the injection zone, but no information was found as to plugging.

### **D. Groundwater in the Study Area**

New Mexico State Engineer well records indicates no water wells are present within the two-mile radius of the Exxon State #8 disposal well. Not even livestock watering wells are reported within the two-mile radius. Well data outside that radius testify to the general lack of any shallow potable water in or under the Area of Review. No known potable water aquifers have been found within the two-mile radius of the Exxon State #8 study area. The dry hole drilled by the City of Carlsbad in Section 26, T21S-R27E demonstrates that the Exxon State is more than two miles north of the high transmissivity lithology associated with the Capitan reef farther west. Enough cable tool holes have been drilled in this area to broadly confirm the absence of groundwater in general.

### **E. Faults and Hydrologic Connections to Potable Underground Water**

GeoScience Technologies on behalf of Mesquite SWD, Inc., affirms that thorough examination of available geologic, hydrogeologic, and engineering data found no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water

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## **X. Statement of Qualifications**

### **Kay Charles Havenor**

Ph.D. Geoscientist  
Certified Professional Geologist AIPG #673  
Registered Geologist Arizona #30438  
Registered Professional Geologist Texas #5806

### **Professional Experience**

Field, subsurface and research geology; regional structural, stratigraphy, oil and gas, hydrodynamics, environmental and hydrogeological investigations, with primary emphasis in Arizona, New Mexico, West Texas, and other portions of the western United States, Canada and Mexico. Mining experience in New Mexico and western Mexico. Professionally active in geology from 1958 to present. Geological consulting and independent oil/gas groundwater activities from 1962 to the present. Oil and gas production operator (Havenor Operating Company), Texas and New Mexico.

Geological research, exploration and development, extensive field experience in drilling, completion, testing, and evaluation of wells for hydrocarbons and water. Non-drilling geological field mapping, surface and subsurface exploration in New Mexico, Texas, Arizona, Colorado, Mexico and British Columbia includes geologic surface mapping, stratigraphic analysis, base metal prospecting, mining, environmental, groundwater, and geologic hazards evaluation.

Environmental and preconstruction site evaluations, dairy and cheese plants monitoring, discharge plans, isotopic determinations of nitrate sources. Hydrogeochemical forensics, hydrogeochemical and isotopic water mapping.

Adjunct Faculty Geology, Eastern New Mexico University, 1992 to the present.

Present and recent consulting areas include investigation and mapping of Ouachita overthrust area of portions of Terrell and Val Verde Counties, Texas. Structure, stratigraphy and hydrogeology of the northern Tularosa Basin, Otero County, New Mexico. Structure and subsurface stratigraphy of Mehsana area, Cambay Basin, Guarat, India.

### **Education**

Colorado College, Colorado Springs, Colorado, 1953-1957  
BS Geology, magna cum laude

University of Arizona, Tucson, Arizona, 1957-1958  
MS Geology  
Graduate Teaching Fellow  
MS thesis on The Pennsylvanian System of Arizona

University of Arizona, Tucson, Arizona, 1992 and 1995

Ph.D. Geoscience 1996

Graduate Teaching Assistant

Emphasis in hydrogeology, remote sensing, environmental geology.

Dissertation: The hydrogeologic framework of the Roswell groundwater basin, Chaves, Eddy, Lincoln, and Otero Counties, New Mexico

### Professional Affiliations

Geological Society of America, Senior Fellow

American Association of Petroleum Geologists, Member

American Institute of Professional Geologists, #673, Charter Member  
former State Chapter Newsletter Editor

Roswell Geological Society

former President, Vice-president, Secretary, and Treasurer

Arizona Hydrological Society

Arizona Geological Society

New Mexico Geological Society

Sigma Xi

### Publications in geology

Foster, R. W., Hawks, W. L., Parkhill, T. A., Smith, C. T., and Havenor, K. C., 1968. Mineral Resource Evaluation of State Lands in East-Central New Mexico: New Mexico Bureau of Mines and Mineral Resources, pp. 71 p., 5 tables, 26 figs.

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### **GeoScience Technologies**

GeoScience Technologies is owned and operated by Deborah Havenor. Kay Havenor is the geoscientist.

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### **Expert Witness Summary**

Qualified as an expert witness in various areas, including geoscience, hydrogeology, hydrology, paleoclimatology, hydrogeochemistry, groundwater, oil and natural gas, and economics thereof in hearings/trials before:

New Mexico State Engineer  
US District Court, Albuquerque, New Mexico  
Fifth Judicial District Court of New Mexico  
Twelfth Judicial District Court of New Mexico