REPORT ON ANALYSIS OF POTENTIAL FOR RELATIONSHIP BETWEEN THE CONSOLIDATED OIL AND GAS COMPANY HERREN GULCH #2 WELL AND ALKALI AND BOG CONDITIONS AT THE DAVIS RANCH NEAR GREYBULL, WYOMING

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This report is a review of the information the Wyoming Department of Environmental Quality has on file for the alkali and bog conditions at the Davis Ranch, Consolidated Oil and Gas Herren Gulch No. 2 Well, and the various opinions of the relationship between the well and field conditions at the Davis Ranch. The ranch is located in Section 33, T.53N., R.92W. and the well is located in Section 27, T.53N., R.92W. My review is from the perspective of a geologic hazards geologist. I am not a hydrologist, soil scientist, or climatologist, although I do refer to my limited experience with those subjects in my analysis. In my opinion, the problems in the area relate primarily to hydrology, soils, and climatology. As such, experts in those fields should review my analysis, and preferably provide their own.

I examined aerial photography from 1954 and 1975 in order to roughly determine both pre-drilling and post-drilling conditions in the Davis Ranch vicinity. In my opinion, alkali has been a problem for a number of years in the vicinity. In fact, in 1954, alkali deposits appeared to be either more widespread or just as widespread as in 1975. The alkali deposits in the northern portion of the Davis Ranch just south of the irrigation canal appeared to cover approximately the same areas in 1975 as in 1954. The 1954 photography was taken by the U.S. Department of Agriculture-ASCS. The frame number of the observed photography is BBN-7N-101 and the photo was taken on August 18, 1954. The 1975 photography was taken by the U.S. Bureau of Land Management. The frame number of the observed photography is WWIR 13-47-16, and the photo was taken on July 27, 1975.

The next step in my analysis was to review the interpretations of the bedrock geology and geologic structure in the area. A geologic map of the Devils Kitchen quadrangle (Geological Survey of Wyoming Map Series 18) by Calvin Reppe was used as a reference to the surficial geology and structure of the area. A geologic cross section of the area titled "Stratigraphic Cross-Section Through Davis Ranch and Herren Gulch No. 2 Well" by Geomax (Feb. 9, 1987) was included with the package of material received from The Wyoming Department of Environmental Quality. The Geomax cross section shows a reverse fault with suspected outcrop to the northeast of the oil well. A significant offset extending from below the Bighorn Dolomite through the Mowry Shale is inferred on the cross section. A fault of this magnitude could have a significant effect on the regional flow of ground water (see Figure A, page 5). Regional flow could be disrupted by the fault and, as shown on Figure A, the direct hydrologic connection between units in the hanging wall and footwall in the fault area could be severed. Ground water flow would most likely be around or up the fault if the fault zone is capable of transmitting water.

Alan Ver Ploeg (Stratigraphy Division), Rod De Bruin (Oil and Gas Division), and I examined data available in our office to determine if the fault was present, and if so what area would be affected by it. The most useful data were oil well records in the vicinity (Petroleum Information Corporation Well Data Cards), electric logs for the oil wells, and Petroleum Information Corporation structure contour maps of the Bighorn Basin sold by POMCO. An examination of the data did not give an indication of the existence of the reverse fault shown on Figure A or on the Geomax cross section included with the data from DEQ. Examination of aerial photography did not reveal the existence of the fault, which is shown on the Geomax cross section as having a surficial expression.

With the data and aerial photography we have available, I would not locate a reverse fault where shown on the Geomax cross section. If seismic data were used to locate the fault, we do not have immediate access to it. The electric logs of six wells were examined in the search for evidence of the reverse fault. Pertinent data used from the wells are as follows:

Reference #	Well Name	Company	Location
1	Medicine Wheel Unit #4	True Oil Co.	NW1/4 NW1/4 Sec. 3, T.53N., R.92W.
2	#1 Government-Davis	R.L. Manning Co.	SW1/4 NE1/4 Sec. 17, T.53N., R.92W.
3	#1 Herren Gulch Unit	Vanderbilt Resource Corp.	SW1/4, NE1/4, Sec. 21, T.53N., R.92 W.
4	Herren Gulch #2	Consolidated Oil & Gas Co.	SE1/4, NW 1/4, Sec. 27, T.53N., R.92W.
5	#1 Government	Zephyr Drilling Corp.	NE1/4, NE1/4, Sec. 5, T.52N., R.92W.
6	#1 Linderman	The Texas Co.	Center Sec. 10, T.52N., R.92W.

Using the reference numbers given above, the elevations of the tops of the formations penetrated by the six wells are given below. The elevations are in feet above sea level.

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
Muddy SS	3,675	3,651	3,749	3,819		
Cloverly Fm.	3,405	3,391	3,489	3,549		
Sundance Fm.	2,825	2,811	2,929	3,029		
Gypsum Spring Fm.	2,510	2,506	2,619	2,719	3,537	
Chugwater Fm.	2,325	2,311	2,434	2,529	3,342	3,612
Goose Egg Fm.	1,735	1,696	1,779	1,829	2,637	2,912
Tensleep SS	1,435	1,396	1,484	1,544	2,357	2,627

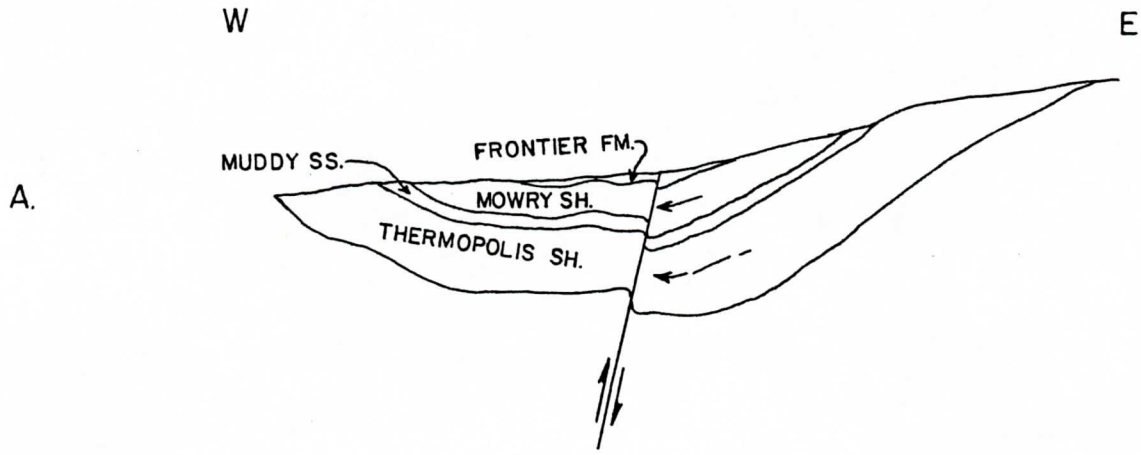
Based upon the above data, the inferred thickness (in feet) of the formations under study is as follows:

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
Thermopolis Shale	270	260	260	270		
Cloverly/Morrison Fm.	580	580	560	520		
Sundance Fm.	315	305	310	310		
Gypsum Spring Fm.	185	195	185	190	195	
Chugwater Fm.	590	615	655	700	705	700
Goose Egg Fm.	300	300	295	285	280	285

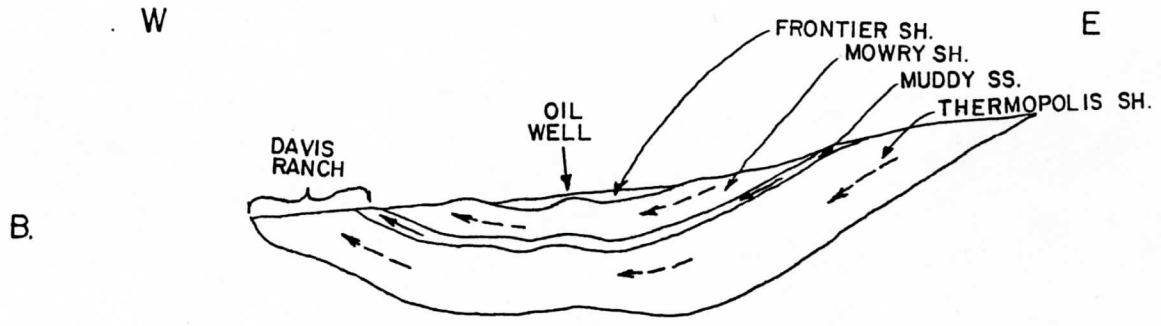
Most of the formations shown appear to have a rather uniform thickness, except the Chugwater Formation and Cloverly/Morrison Formations. The Chugwater Formation appears to thin to the north and the Cloverly/Morrison Formations appear to thin to the south. In the data examined, there was no indication of a missing or repeated section that would be expected if any of the wells encountered either a normal or reverse fault. The formation thicknesses shown on page 3 serve to illustrate this point.

If the reverse fault shown on the Geomax cross section is not present, the regional hydrologic scenario would be markedly different. Figure B (page 5) is an idealized diagram that shows how ground water could flow and discharge with the inferred reverse fault not present. There would be a tendency for any of the geologic units exposed in the vicinity of the Davis Ranch to discharge water if they were permeable enough to transmit it.

Unless new data are made available, I feel that the scenario shown in Figure B is the most likely for the area. In other words, with the data we have available, I do not feel that the well has to be leaking in order for seeps to appear in the Davis Ranch vicinity. By the same token, I do not have strong evidence that the well is absolutely not leaking and having some effect on the Davis Ranch, although the alkali problem appears to have been present long before the well was drilled, as mentioned earlier. In my opinion, the only definite way to tell whether or not the well is leaking is to open it up. If the water in the well is not leaking past any of the plugs present, the question is answered. If leakage is occurring, the well should be re-plugged. If the well is shown to be leaking, that still does not prove that it was having an effect on the Davis Ranch. In my opinion, a monitoring program would have to be established to define current conditions at the ranch, as well as to document diminishing adverse effects after the well is re-plugged.



Inferred flow of ground water with reverse fault present as indicated on Geomax cross section.



Inferred flow of ground water with reverse fault not present.

Figure A and B: Idealized sketches of inferred ground-water flow (not to scale).

Factors other than a leaking well and ground-water discharge could have an effect on the area. Those factors are precipitation and irrigation. Alternating wet and dry years could result in either the flushing or deposition of the salts present in the bedrock or soils. If conditions are right for the deposition of salts, the problem would only worsen with time. The area also appears to have a significant number of bentonitic geologic formations and soils. As would be expected, they would be difficult to drain. If irrigation or precipitation increased over a period of time, a perched ground-water table could rise or soils could become increasingly saturated. This would result in boggy conditions. By the same token, if any of the ground surfaces were lowered, the new ground surface could directly encounter the watertable or the capillary fringe associated with the water table.

A 30-year precipitation record for the Greybull area reveals some interesting trends. The annual precipitation (in inches) for Greybull during the period 1953-1984 is presented below. The data was derived from "Climatological Data-Wyoming". The data was generated by the U.S. Weather Bureau in the 1950's and by the National Oceanic and Atmospheric Administration in Ashville, North Carolina in later years. The 30-year yearly average is 7.3 inches. Deviation from this average is shown.

Climatological Data for the Greybull Area, 1953-1984

Year	Annual Precipitation (inches)	Deviation (inches)
1953	4.08	-3.22
1954	3.55	-3.55
1955	7.25	-0.05
1956	1.97	-5.39
1957	5.83	-1.47
1958	6.68	-0.62
1959	10.34	+3.04
1960	5.46	-1.84
1961	7.36	+0.06
1962	6.41	-0.89
1963	7.46	+0.16
1964	7.83	+0.53
1965	6.44	-0.86
1966	3.50	-3.80
1967	7.15	-0.15
1968	7.28	-0.02
1969	6.39	-0.91
1970	--	--
1971	--	--
1972	7.61	+0.31
1973	7.91	+0.61
1974	4.90	-2.40
1975	16.98	+9.68
1976	9.34	+2.04
1977	6.43	-0.87
1978	10.23	+2.93
1979	5.82	-1.48
1980	9.20	+1.90
1981	7.86	+0.56
1982	8.33	+1.03
1983	10.59	+3.29
1984	8.75	+1.45
Total:	218.93 inches	
Yearly Average:	7.3 inches	

The climatological data infers some trends that may have had an effect on perched water tables, ground water, or soil moisture in the Greybull area. For example, in the first fifteen year period (1953-1967) there was a total of 91.31 inches of precipitation. In the last fifteen-year period (1968-1984), there was a total of 127.62 inches of precipitation. This results in an average of 2.42 inches more of precipitation for each year in the last fifteen year period than

for each year in the first fifteen-year period. 1970 and 1971 are not included in the calculations, as yearly data was not available. From 1975 through 1984, the total precipitation was 93.53 inches. This is 20.53 inches more than would be expected for that period if the average amount of precipitation fell every year. If precipitation was the primary factor in the problems at the Davis Ranch, the most probable year for the wet field or bog conditions to initiate or worsen would be 1975 or 1976. 16.98 inches of precipitation (9.68 inches above the 30 year average) fell in 1975. 1976 was not as wet, but the precipitation in that year was still 2.04 inches above the 30 year average. In my opinion precipitation has not been fully considered as a causative factor in previous analyses. The potential effect of precipitation should be more fully investigated by soil scientists and climatologists.

Irrigation or an irrigation canal could also be having an effect on the Davis Ranch. Just as a long term increase in precipitation could have an effect on soil moisture and water tables, so could irrigation. I do not have access to irrigation records for the area, but I feel that they should be analyzed if available.

Many of the larger alkaline areas that can be delineated on aerial photography appear to be associated with the irrigation canal that traverses the northern portion of the Davis Ranch. A leaky canal could bring about many of the problems observed in the area. The trenching analysis that has been done should be expanded. In my opinion, if any future trenching is done it should be deeper than the first effort. The first efforts may not have penetrated the bentonitic slopewash materials. It is important to know what types of materials underlie the slopewash and to determine if they are more permeable than the slopewash cover and in hydrologic connection with the canal.

In summary, I feel that there is the potential for many factors to be affecting the Davis Ranch area. Alkali appears to have been a problem in the area before the Herren Gulch No. 2 Well was drilled. In my opinion, the effects of the Herren Gulch #2 Well cannot be determined until the well is opened. If the plugs in the well are leaking, they need to be sealed. The Davis Ranch area should then be monitored for some time in order to determine if the conditions at the ranch vary after the sealing. This will be a difficult endeavor as there is a strong possibility that other factors are having an influence on the ranch area. As we did not find evidence for a reverse fault in the vicinity of the oil well, regional ground-water flow in the area should not be disrupted. As a result, there is the possibility that a limited amount of ground water is discharging in the vicinity of the Davis Ranch. A hydrologist should review the available hydrologic data for the area to determine if the discharge is occurring. If it is, it should be determined if the discharge is significant enough to cause the observed problems. Precipitation may be a causative factor for the problems in the area. There appears to have been a significant precipitation increase in the area from 1975 through 1984 in comparison to the 1953 through 1974 period. A soil scientist should determine what effect this precipitation increase would have had on the soils in the area. If the irrigation canal in the area is leaking, it could cause alkali and bog problems in the vicinity of the leak. I suggest that a more detailed analysis of the canal be undertaken. If it is leaking, the flow route for the leaking water should be determined. The irrigation history of the area should be reconstructed if possible. An increase in irrigation could have had an adverse effect on the area. A hydrologist and soil scientist should address these last two problems. Finally, all available aerial photography for the area should be acquired. This will serve to reconstruct the history of the area more completely.

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