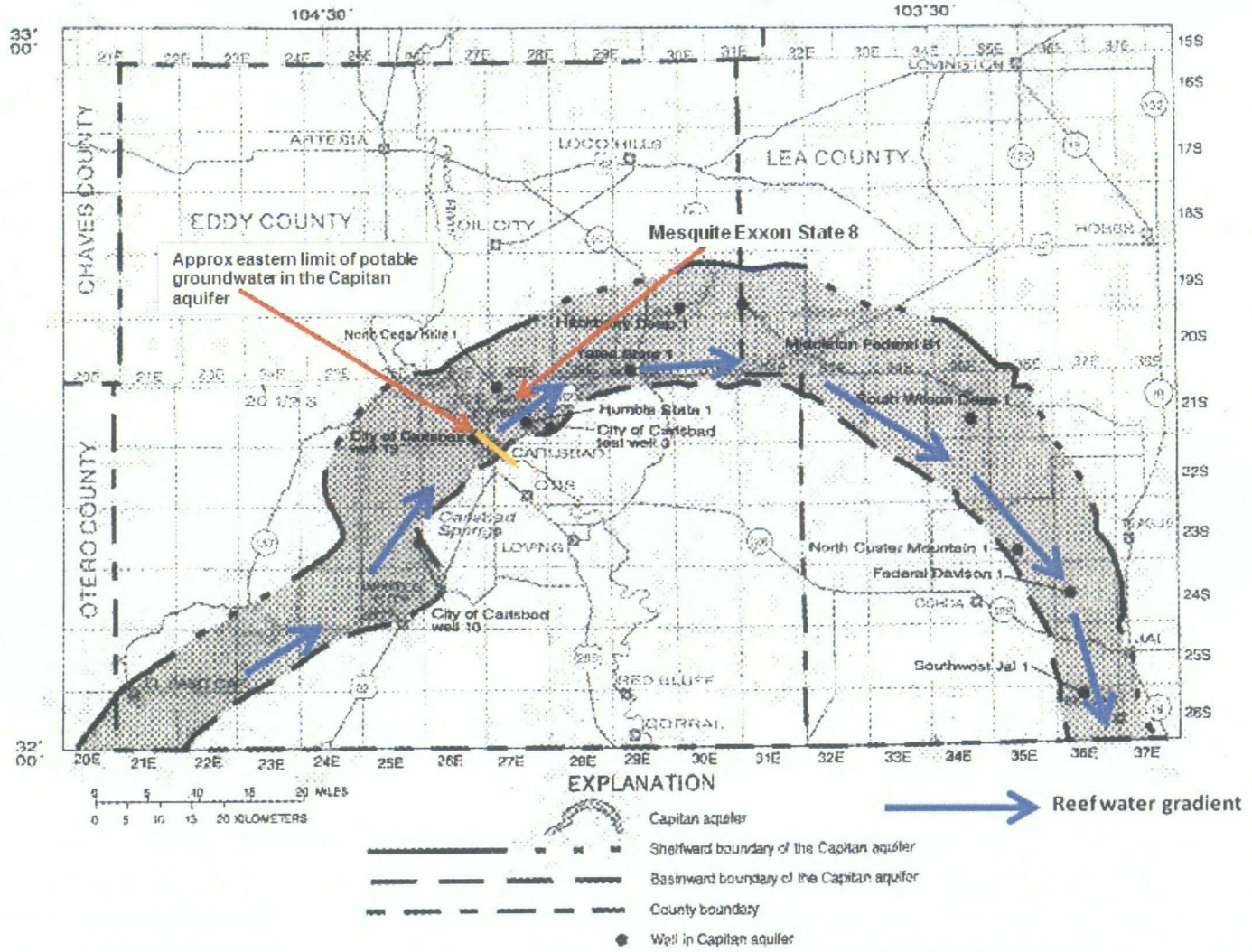

Figure 4.--Location of wells in the Capitan aquifer observation-well network as described by Hiss (1973).

Annotated from Huff (1997)
Havenor September 17, 2008

Notes on annotated reef diagram.

Huff, G. F., 1997, Summary of available hydrogeologic data collected between 1973 and 1995 and information on permeability data and aquifer tests for the Capitan aquifer, Eddy and Lea Counties, New Mexico, USGS Open-File Report 97-370, prepared in cooperation with the New Mexico State Engineer Office

The annotated map is Figure 4, page 6, of the Huff report. The outline of the Capitan reef is that of Hiss (1973). Huff compiled water data from Hiss (1973; 1976) and Richey, et al (1985). The gradient values used to determine groundwater directions (blue arrows) is that from nine (9) wells measured by Richey, et al (1985) and incorporated in Huff's report.

Huff states that the Hiss and Richey data is all that is available relative to water-level data for the Capitan reef complex. Huff's introduction makes an important hydrogeological disclaimer (not literally stated as such) on page 1 (emphasis added by me),

> The Capitan Reef **complex** is composed of the Capitan and Goat Seep Limestones and most or all of the Carsbad facies of the Artesia Group (Meissner, 1972), including the Grayburg, Queen, Seven Rivers, Yates, and Tansil Formations (Richey and others, 1985). The Capitan Reef **complex** functions as a single geohydrologic unit and is collectively called the Capitan aquifer (Hiss, 1973; 1976).

Huff only collect available data. No interpretations were presented.

The problem with this data, in my opinion, is that measuring water levels within one formation provides comparable information. Measuring water levels from different formations - most of which have no hydraulic connectivity - cannot infer or demonstrate the flow direction, source, or anything other than the individual formations contain groundwater. Unfortunately, hydrologists commonly claim this is an acceptable practice to demonstrate groundwater flow. This is pointed-out by Mazor, 1977, p. 118, Fig. 6-13, shown below.

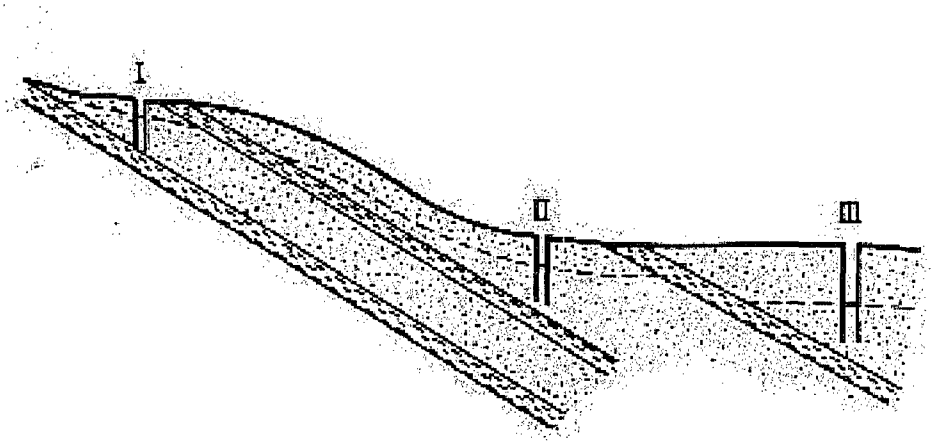

Fig. 6.13 Three wells with water tables similar to those seen in Fig. 6.12 but separated by aquicludes. They have no hydrological connections in spite of the apparent water table gradient.

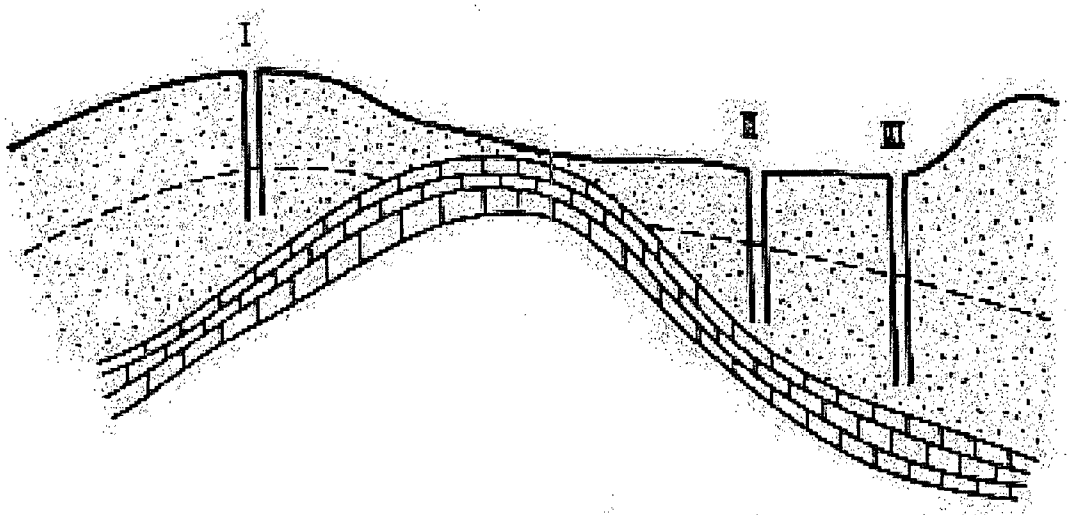

Fig. 6.14 Three wells with an apparent water table gradient of well I > well II > well III. However, a concealed folded structure isolates well I from wells II and III.

Mazor, E., 1997, Chemical and isotopic groundwater hydrology, Marcel Dekker, Inc., New York, 413 p.

An example of the Fig. 6.13 in the Huff report of Capitan water is the North Cedar Hills #1. That water level is 3084 ft msl (in Richey, 1985) compared to the 2000 measurement in the Exxon State #7 of 3060 ft msl. Sounds reasonable, but the TD of the open hole in the Exxon State #7 was 580 ft, whereas the bottom of the tested interval in the North Cedar Hills #1 was 1,014 ft (Huff, 1997, Table 6, p. 36, compiled from Hiss, 1976).

The point is that the water level (WL) in Exxon State #7 *appears* as reasonable for Capitan "reef" if compared to the North Cedar Hills #1. However, the open-hole in the #1 is 434 ft deeper! The top of the Seven River Fm in the North Cedar Hills #1 appears on logs to be at 712', +2567' - and the projected Seven Rivers in the Exxon State #7 would be about +2484' msl, 83' lower. This translates as comparing a water level in the Exxon State #7 coming from +2704' msl (Yates) with the Cedar Hills #1 at +2265' msl (Seven Rivers), from a different zone that is actually about 209' lower than the Exxon State #7. Mazor's Fig. 6.13 certainly applies here.

My favorite quote from Mazor, p. 117, is:

. . . one can never deduce flow directions from water levels alone.

Hydrologists hate that, but it is so true.