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TITLE: WATER-LEVEL OBSERVATIONS DURING DRILLING AND VERTICAL HEAD DISTRIBUTION - - EXPERIENCE AT R-25, A DEEP REGIONAL WELL AT LANL

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R-25 is one of 32 wells planned by Los Alamos National Laboratory to refine the hydrogeologic conceptual model of the Pajarito Plateau. It was drilled in the southwestern part of the laboratory to fill a gap in the geologic and hydrologic data coverage. Although these wells target the deep regional ground water, occurrences of both shallow and intermediate perched saturation are also characterized as encountered.

When casing is advanced during drilling, as in this project, the well may be thought of as an infinite set of piezometers (open-bottom tubes for determining hydraulic head at given depths in a saturated zone). That is static water levels observed during drilling can be used to construct the isopotential field in the area. From this field, various hydraulic properties can be determined. However, obtaining true static water-level measurements during drilling is difficult. The full data set often includes worthless readings that must be "filtered" out in order to construct isopotentials.

"Noise" in the water-level data for R-25 was filtered out by considering 1) the length of open hole at the time of measurement (was the hole a true piezometer at the time of measurement?), 2) the pre-measurement activity in the well (was it especially disruptive of water level?) and 3) the time elapsed between that activity and the measurement (had there been enough time for the water level to recover to a static level?). The intersections of isopotentials with the borehole were determined by plotting the filtered water-level elevations at the associated borehole depths at the time of measurement in cross section. Interpolating between water-table elevations at R-25 and two adjacent wells, one on the west and one on the east, gave approximate positions for the intersections of isopotentials with the water table on the cross section. The isopotentials were then sketched using these two sets of intercepts. Vertical exaggeration must be taken into account for any quantitative use of such sections.

Such analysis at R-25 not only confirmed the downward vertical gradient expected in this recharge setting, but provided data needed for determining the approximate rate of easterly flow. This kind of information is critical for evaluating migration of contaminants to nearby water-supply wells.

External Reviews: Hydrogeologic Workplan External Evaluation Group, March 1999

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((Abstract))

INTRODUCTION (FIGURE 1)

R-25 is a deep well, drilled to the regional aquifer in Technical Area 16, a high-explosives research and testing facility at LANL. Hydrologic conditions at this well are of special interest as high-explosives components were detected in samples of deep ground water underlying the site.

EXPECTED CONDITIONS (FIGURE 2)

Perched ground water was expected at R-25 at a depth of 770 ft (elev. 6742"), based on a nearby well (SHB-3), and regional water table was expected at a depth of 1350' (elev. 6167'), based on a projection from the nearest down-gradient wells (DT-5A and others).

OBSERVED CONDITIONS (FIGURE 3)

Saturated conditions were encountered slightly higher than projected, at a depth of 747ft (elev. 6770'). Saturation was observed to continue to total depth (1942 ft), except for a zone of alternating wet and dry conditions between depths of 1181 ft and 1286 ft. Although this zone could be a perching interval, the presence of contaminants in deep ground water suggests it is not sufficiently tight to completely isolate the shallow water from regional saturation.

RAW WATER-LEVEL DATA (FIGURE 4)

To better understand the vertical head distribution, the relationship between water level and borehole depth was examined. Normally this would be determined by a group of piezometers (simply tubes open at bottom). However, a well like R-25, in which casing is advanced while drilling, is an infinite set of piezometers. So, water-level observations taken at various borehole depths should suffice. Although many water-level observations were made during the drilling of R-25, these are measurements of opportunity (made whenever drilling activities permit), so not all are representative and the data are "noisy".

SCREENED WATER-LEVEL DATA (FIGURE 5)

It was decided that the data could be filtered or screened using three criteria:

- # The length of open hole when the measurement was taken (does value represent a discrete narrow interval?)

- # The activity in the hole prior to measurement (was it something that would have impacted water level?) and

- # The amount of time elapsed between that activity and the measurement (was there sufficient time for water level to equilibrate?).

On the resulting plot the vertical gradient is seen to be variable: gentle at the top, steep in the interval where unsaturated conditions were observed and gentle again at depth.

CONSTRUCTION OF ISOPOTENTIALS (FIGURE 6)

The screened head values were plotted at the depth the borehole was when they were measured. Then, using these values and the water levels at up- and down-gradient wells, contours of equal head (isopotentials) were drawn in cross section.

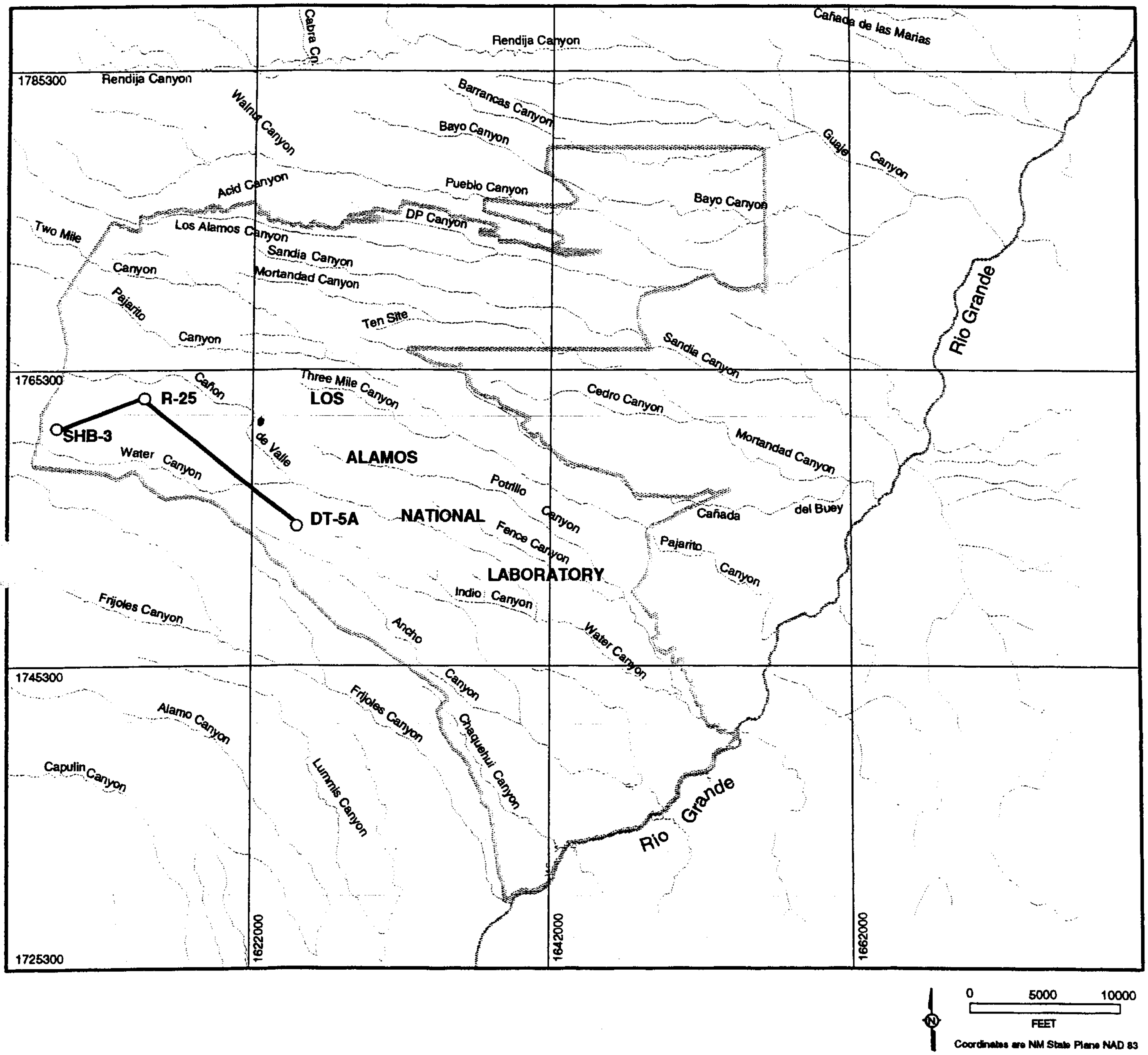

Figure 1. Location Map for R-25 and Line of Cross Sections.

VALUE OF VERTICAL HEAD DISTRIBUTION
It contributes to the understanding of local ground-water flow:

 # improves the conceptual hydrogeologic model

For Example: **the isopotentials document a downward gradient and confirm that R-25 is located in a recharge area,**

 # the change in head per unit length gives hydraulic gradient (I)

For Example: **between R-25 and DT-5A, water table drops 835 ft over a horizontal distance of 12,500 ft, giving a hydraulic gradient of 0.07 ft/ft and**

 # ground-water flow velocity (v) may be determined using hydraulic conductivity (K) and hydraulic gradient (I): v = KI. . Such information is needed for ground-water-flow and transport modeling.

For Example: **Across most of the section between R-25 and DT-5A ground water moves through the Puye Formation (Figure 6). Although hydraulic conductivity of the Puye is not known, it is presumably greater than that reported for the Santa Fe Group at depth in DT-5A: 2.635 x 10-5 ft/s (Purtymun, 1995). Thus, v would be greater than the 58.2 ft/yr that is obtained using that K and a value of 0.07 for I.**

CONCLUSION
Water-level observations made at various depths can be used to construct vertical head distribution in holes where casing is advanced during drilling, provided such data are screened as outlined above.

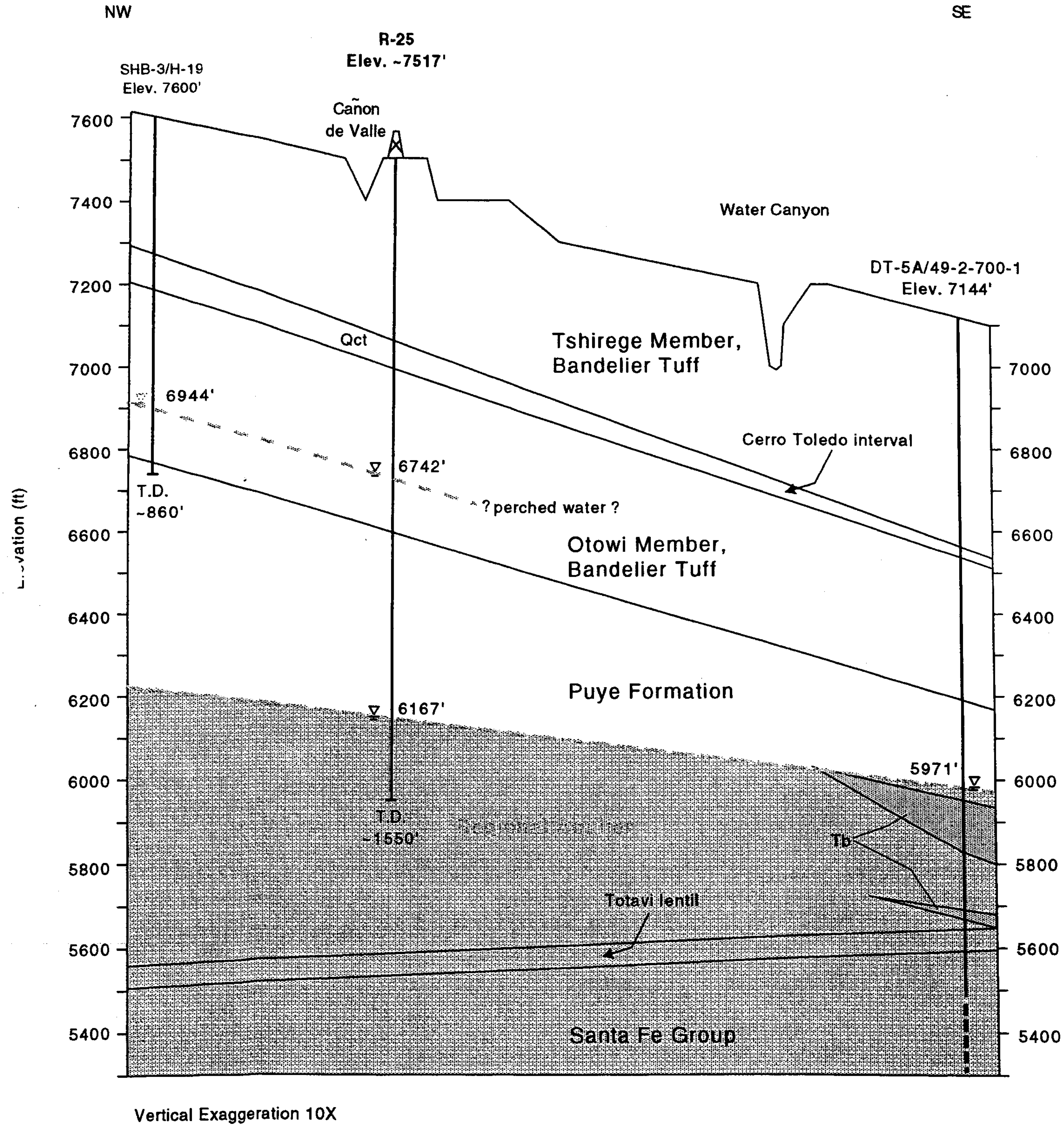

Figure 2. NW to SE Cross Section Showing Expected Conditions at R-25.

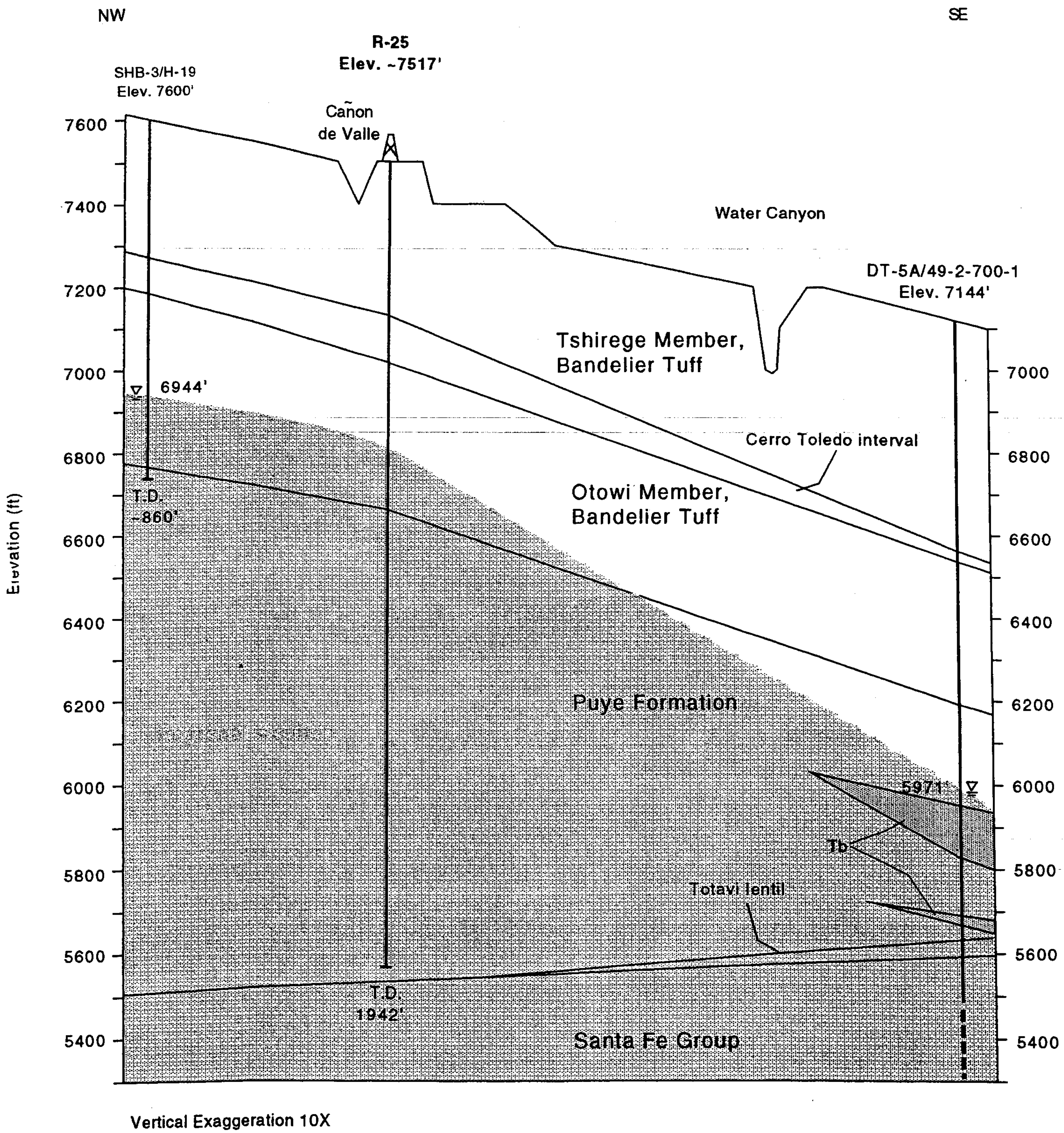

Figure 3. NW to SE Cross Section Showing Observed Conditions at R-25.

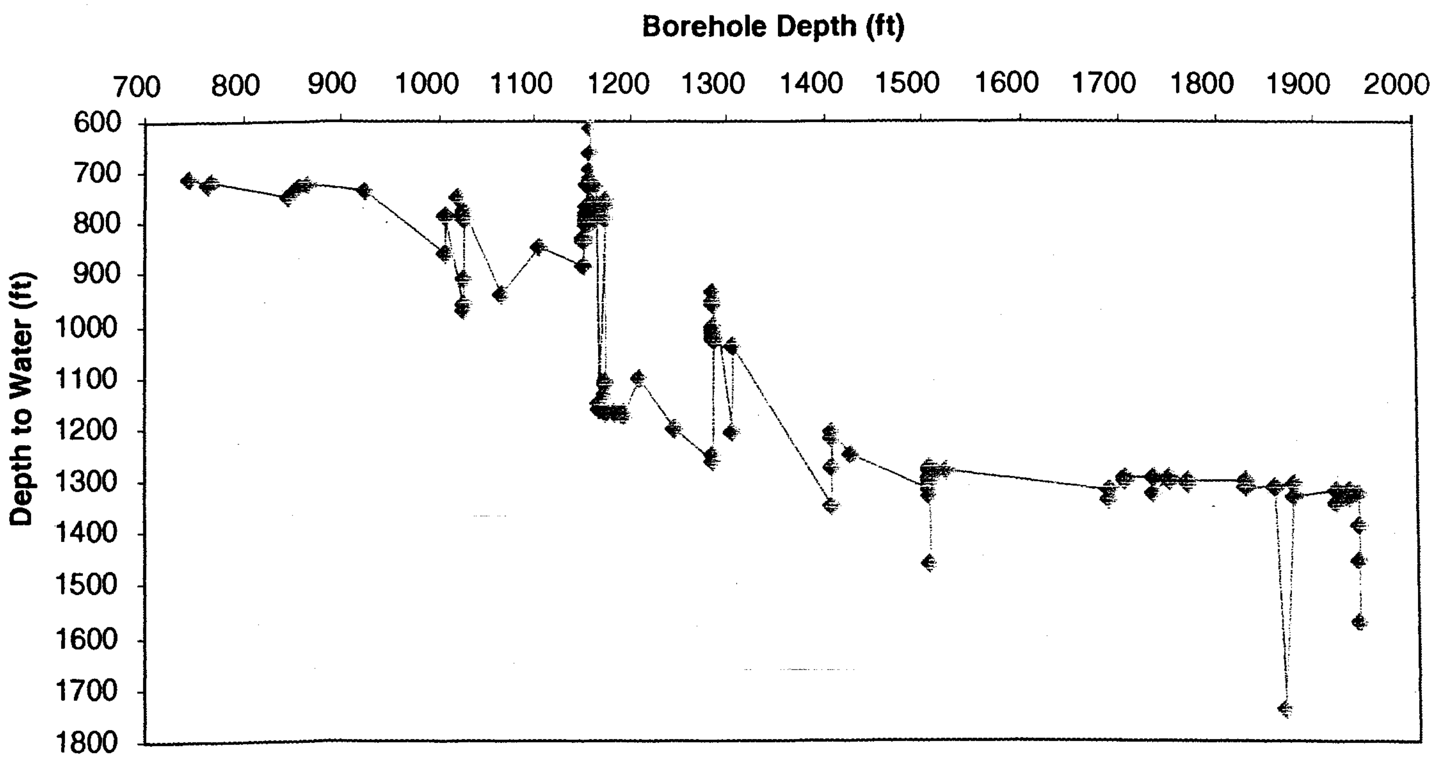

Figure 4. Raw Water-Level vs Borehole-Depth Data for R-25.

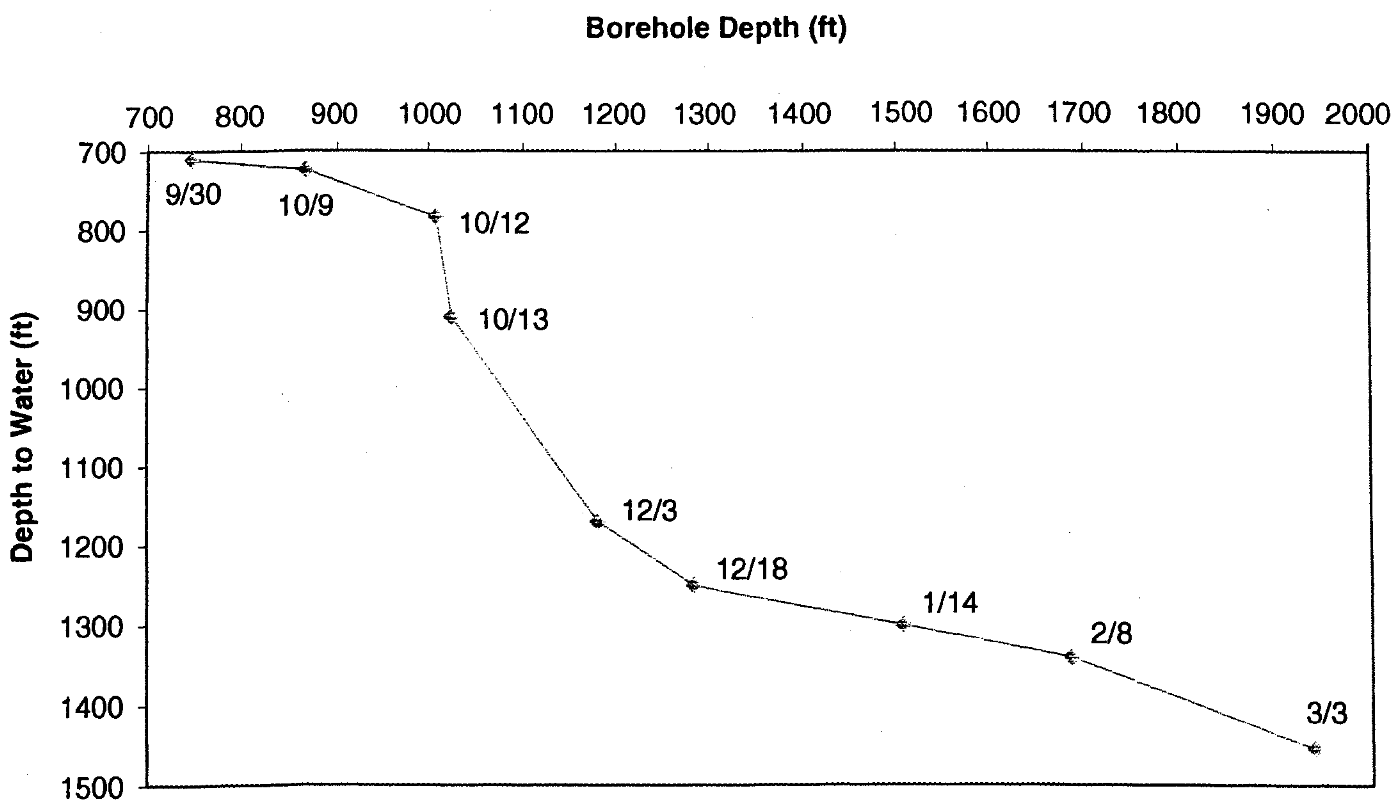

Figure 5. Screened Water-Level vs Borehole-Depth Data for R-25.

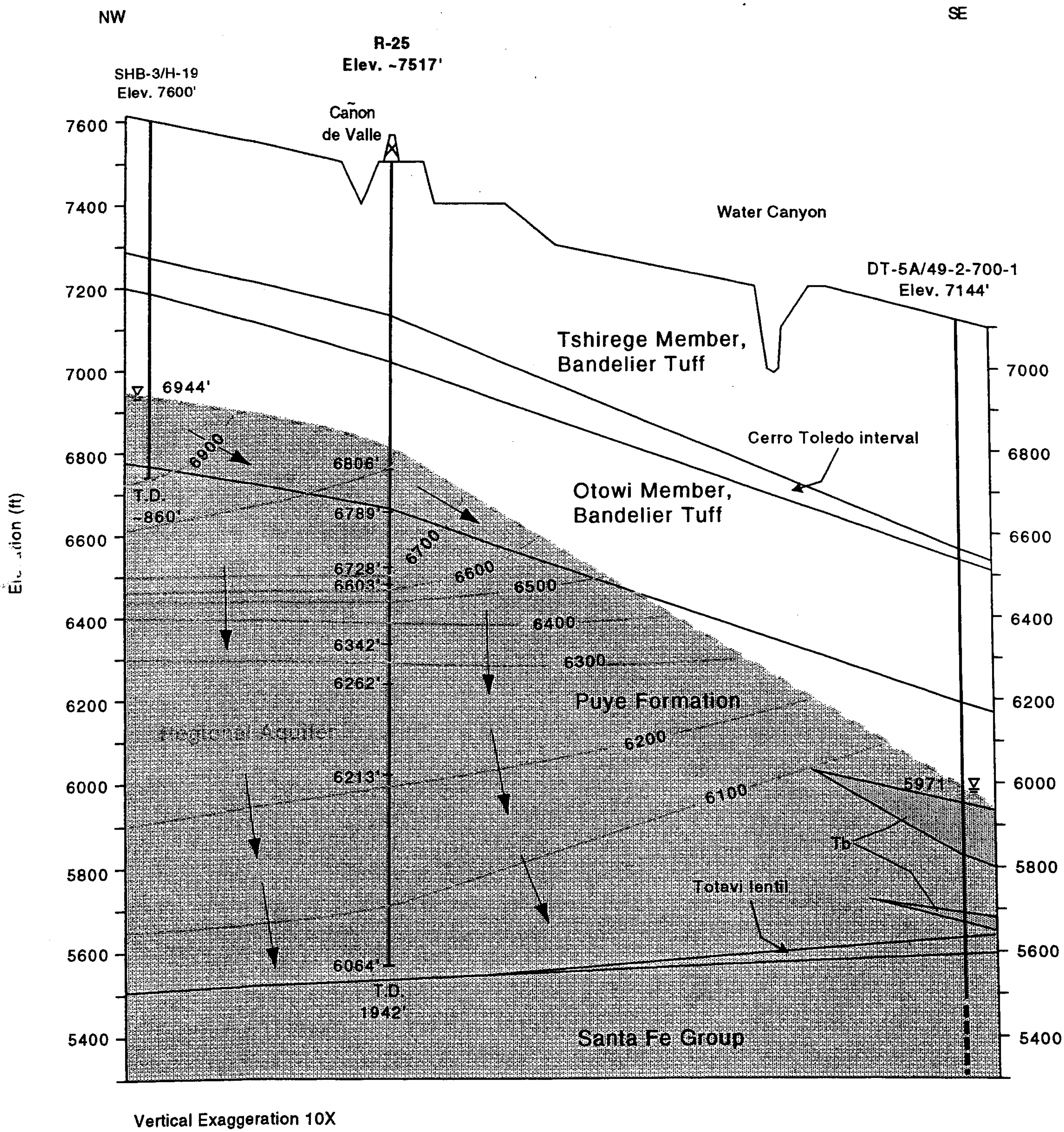

Figure 6. NW to SE Cross Section Showing Isopotentials and Flow near R-25.