RCP 189

Preliminary evaluation of the effects of a pumping well on existing surface water resources located in T. 12N, R. 2E, Sec. 23, Cache and Box Elder Counties, Utah.

By

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Introduction

This report contains the results of a preliminary study of the impact of pumping a well located in T. 12N, R. 2E, sec. 23, Cache and Box Elder Counties, Utah. A semi-analytical capture zone analysis was performed to determine if pumping at the well is likely to reduce flow in Willow Creek or any of three springs in the surrounding area. The well has been used from 1974 to present and is sometimes pumped at 90 gallons per minute (gpm) (verbal communication, Veibell, 1996).

A capture zone is the area contributing water to a given pumping well (Fetter, 1993). The shape and size of a capture zone is affected by the average initial ground water gradient and velocity, the rate of pumping from the aquifer, and the aquifer's hydraulic conductivity. The up-gradient extent of the capture zone is also dependent on how long the well is pumped. Capture zone analysis permits estimates of changes in aquifer head within the area of concern.

Three springs were included in the study area (fig. 1 and 2). These include a spring near Alton Veibell (Spring #1), a spring near Willow Creek (spring #2), and Twitchell Spring (spring #3). Twitchell Spring reportedly supplies water to five residences. Alton Veibell reported that before the well began operating, his spring had only a small trickle of flow. He believes the spring became clogged with sediment the same year the well began pumping. Neighbors believe the spring dried up. Although Mr. Veibell bulldozed and covered the spring, phreatophytes still grow at that location indicating the continued presence of moisture. Figure 1 is a map shows the relative locations of the springs and the well. All three springs are reported to exhibit seasonal and annual variation in flow rate.

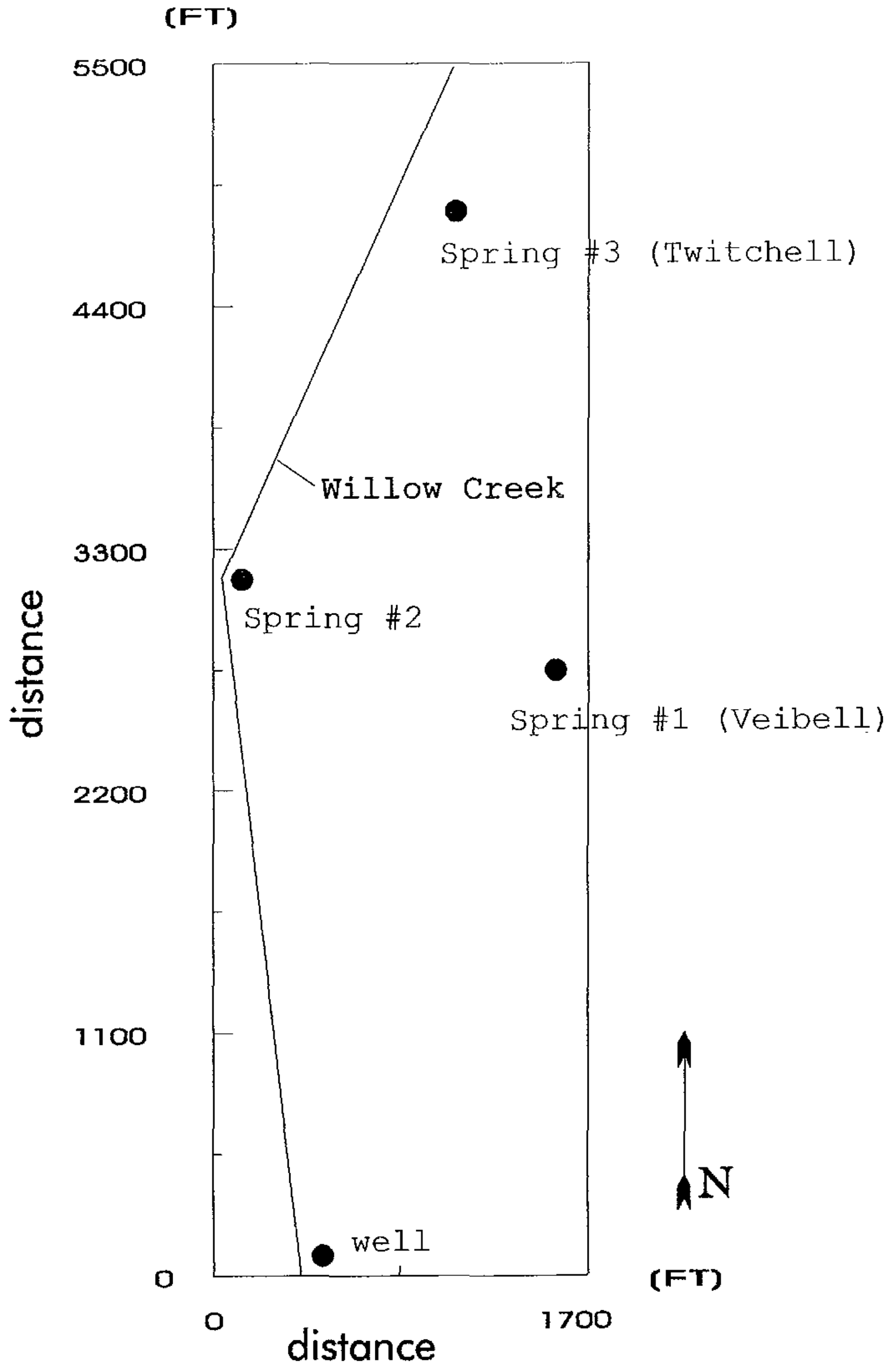

Figure 1. Map showing locations of springs relative to the well.

Hydrogeology

Hydrogeologic data available for the area includes: 1) the well driller's log, 2) an engineering drawing of the High Country Estates Special Services District, and 3) the USGS Cutler Dam, Utah 7.5 minute quadrangle topographic map. We visited the site to attempt to gather additional information.

The driller's log describes the stratigraphy as consisting of interbedded sandstone and shale units. From the ground surface down, the log reveals: a relatively thick soil (0 to 8 feet), a minor upper unit of "white sandstone" (8 to 30 feet), a thick "blue shale" unit (30 to 159 feet), a secondary "good sandstone" layer (159 to 170 feet), a thin shale layer (170 to 173 feet), the "good sandstone" of the aquifer (173 to 203 feet), and a lower shale (203 to 226 feet). For the analysis we assumed that these units are horizontal and exist everywhere within the area of concern.

The well is screened from 196 to 226 feet below ground surface. During installation, the well was supposedly pumped at 112.25 gpm for 24 hours, without the pumping rate declining due to aquifer inadequacy.

The ground surface elevation at the well was estimated from the topographic map as 5150 feet. The driller's log reported the water level to be 34 feet below the ground surface, resulting in an assumed water pressure surface elevation of 5116 feet. The ground surface elevations of the three springs of concern taken from a topographic map are assumed to be: 1) 5080 feet, 2) 5040 feet, and 3) 4980 feet respectively.

The springs and creek seem to occur in the soil overlying the whitish sandstone, and in that sandstone itself. This "white sandstone" has horizontal fracturing in some locations which may permit some horizontal flow. However, this material is generally a poor conductor of water especially in the vertical direction. The "white sandstone" is underlain by a thick shale unit that is a barrier to vertical and horizontal flow.

The springs probably derive water from the soil overlying the white sandstone. There is probably minimal hydrologic connection to the deeper aquifer beneath the shale in which the well is completed. If this is the case, it is unlikely that pumping at the well would significantly impact Willow Creek or any springs.

An alternative, albeit unlikely, scenario assumes that the springs originate from the same aquifer in which the well is completed. To evaluate this scenario, we applied a semi-analytical computer model. Assumed is a 30 foot thick confined aquifer tapped by the well and all three springs in their respective locations. The water table is assumed to slope in the same general direction as the ground surface (approx. N 20° E) (i.e. ground water was assumed to flow in the same direction).

The water table gradient was estimated using two points: the elevation of the water in the well, and the ground surface elevation at spring #1. The ground surface at the spring was assumed to equal the water level at that point because the spring was flowing at the time the well was drilled. This results in a water pressure surface gradient of 0.013. This is not unreasonable near a mountain front. Figure 2 shows the aquifer system used in this analysis. Elevations shown in figure 2 are for the ground surface except where noted.

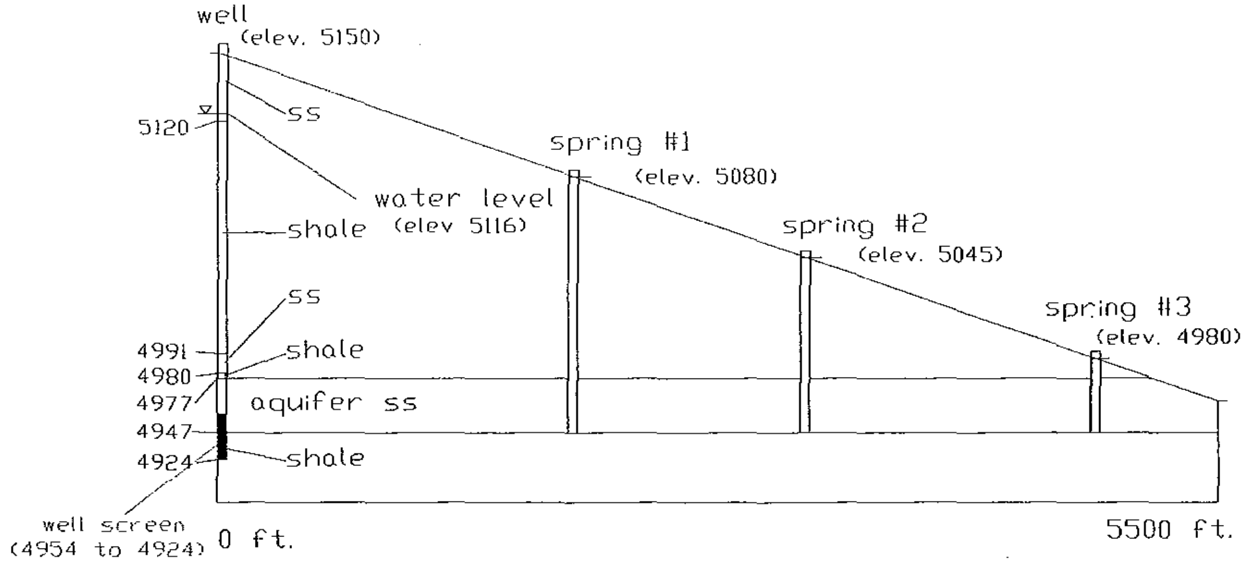

Figure 2. Cross section of aquifer system used for capture zone calculations.

Since the driller's log contains no pump data or well capacity information, we estimated a severe case aquifer transmissivity using the Thiem equation (see Appendix). We assumed a 0.25 cfs (112.25 gpm) well withdrawal rate; drawdown at the well of 169 feet (dewatering the aquifer to the top of the screen); and no drawdown at 10,000 ft from the well. This resulted in a transmissivity value of 201 ft^2/day, the minimum value that will support the reported withdrawal rate at steady-state for the assumed conditions. This value will result in a large are of ? for the well and is influence conservative estimate for this value.

To apply the computer model we assumed an areally infinite aquifer and a uniform initial hydraulic gradient (Fig. 3). No stream, impermeable, or constant-head boundaries were included.

We used assumptions in the simulations that caused a great area of possible drawdown (water level decline due to pumping) to be estimated. In addition, we assumed the well pumped continuously at its maximum capacity of 0.25 cfs (112.25 gpm). Lesser or discontinuous pumping will cause less water level decline.

Results

Water levels and the capture zone resulting from the near-worst case assumptions and maximum pumping are shown in Figures 3 and 4. For convenience and clarity, in these figures, water levels are adjusted values taken with respect to a zero elevation datum at 5045 feet of the true elevation. A forty-foot elevation in Fig. 3 corresponds to a true elevation of 5085 feet. Figure 3 shows that there could be a 2 foot decline at Spring #3 (Twitchell). However this 2 foot decline is less than the probable error resulting from the data. There could be a 10 foot decline in water levels in the aquifer deep beneath Spring #2. If this effect were transmitted to the shallow aquifer supplying Spring #2, that spring could have reduced flow.

Two factors reduce the possibility that the well will affect the springs or stream. First, if steady pumping were only 20 gpm, the water level decline in the wells aquifer would be only about 18% of the 112.25 gpm values.

Secondly, it is unlikely that the well, springs and streams tap the same aquifers. Well log data indicates that the well screen exists 196 to 226 feet below ground surface and that 129 feet of shale separates the ground surface and the well screen. There is probably no significant hydraulic connection between the aquifer and the springs or stream. Pumping the well is unlikely to significantly affect flow in the stream or from the springs.

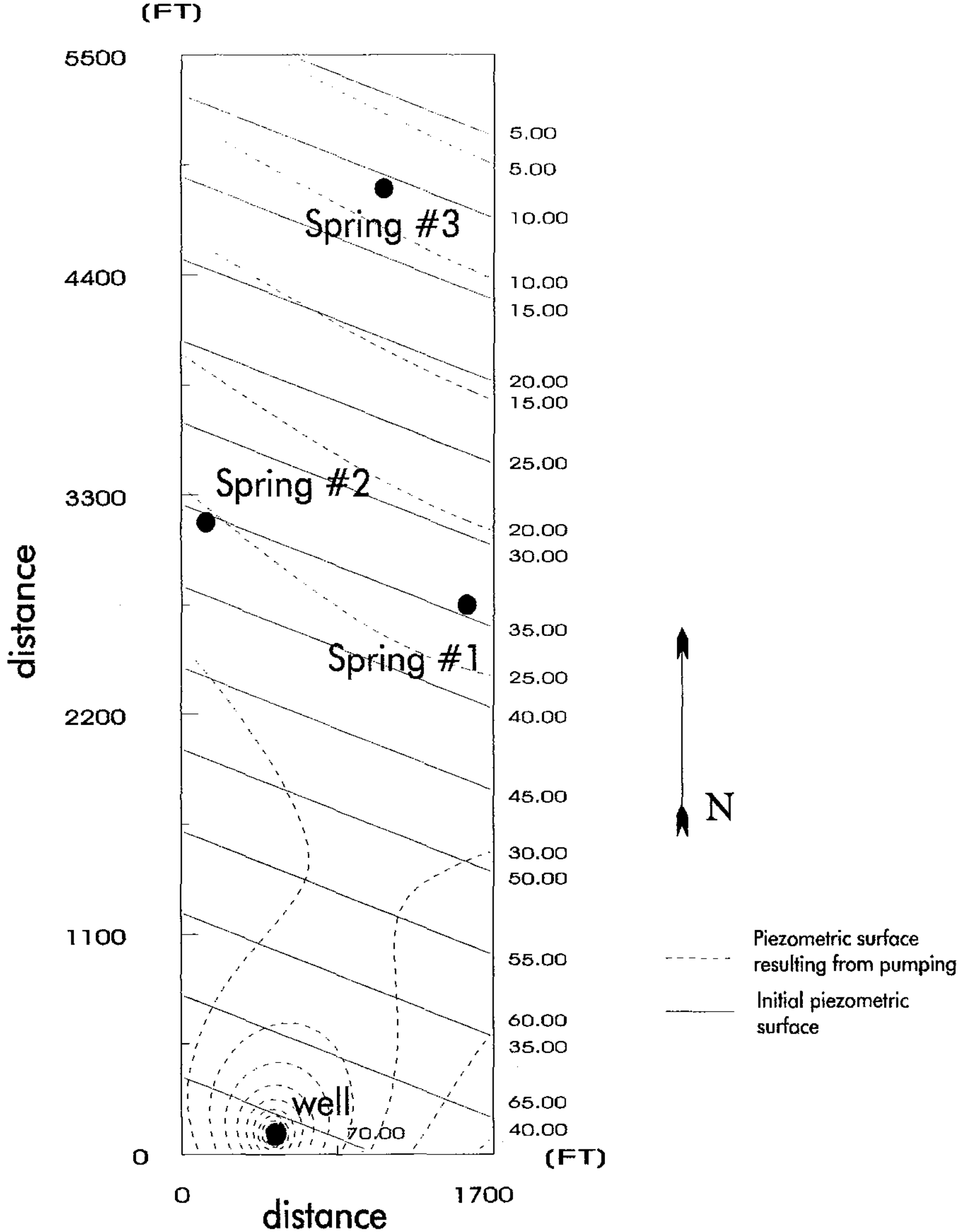

Figure 3. Water level change map showing initial and pumping water levels.

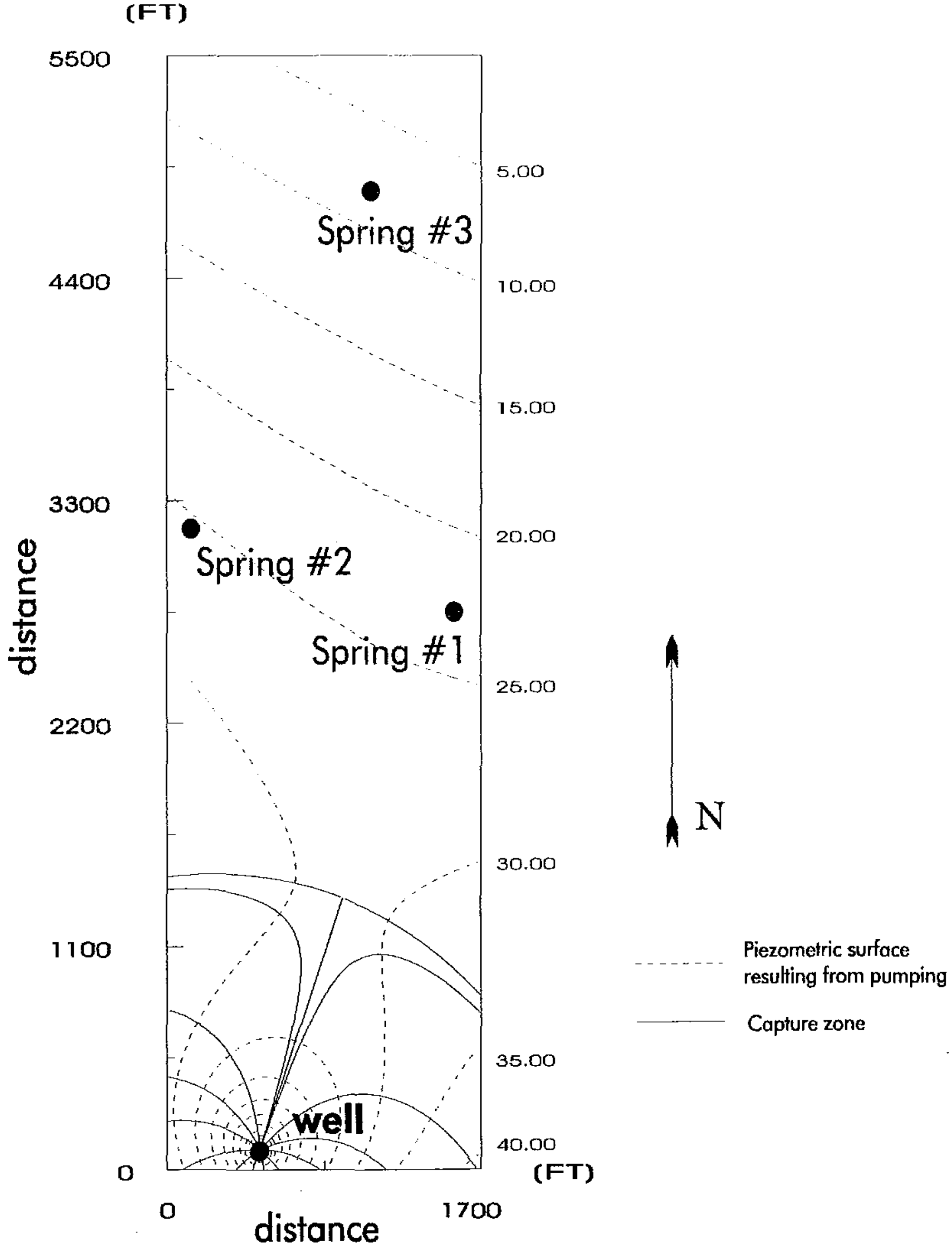

Figure 4. Steady-State capture zone for well

It is unlikely that pumping 112 gpm continually at the well will significantly have a major affect Twitchell Spring. The diagrams show that for the assumed scenario, water level will change probably not more than 2 feet. The water level change map shows more significant declines in ground water levels at springs nearer to the well. This could indicate a possibility of reduced flow in those springs. However, for this to occur, the well must be continually pumped at 112 gpm for a sufficiently long time, and the well and the springs must be in the same aquifer. As stated earlier, these conditions are unlikely to be met.

References

Fetter, C.W., 1993, Contaminant Hydrogeology, Macmillan , New York, NY

Appendix

Calculations

Estimation Transmissivity Using the Thiem Equation

$Q := 21600\,\frac{ft^3}{day}$	well dischaige
$s := 169\,ft$	maximum drawdown
$R := 10000ft$	radius of influence
$r := .5 \cdot ft$	well radius

$$T := \frac{Q}{2 \cdot \pi \cdot s} \cdot \ln\left(\frac{R}{r}\right)$$ Thiem Equation

$$\mathbf{T = 201.454ft^2 \cdot day^{-1}}$$ Result

INVOICE

To: Alton Veibell

Subj: Reimbursement for time and expenses incurred in the preliminary well study.

This is a bill in the amount of $500.00

Thank You.

11/20/96