AQUIFER TEST OF FLOWING WELLS

IN THE PARKE CREEK AREA

by E.A. Nemecek

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WELLS IN THE PARKE CREEK AREA

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E. A. Nemecek

Department of Ecology

Olympia, Washington

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BASIC DATA

Clerf Well Test

Mkarzel Well Test

Driller's Logs

Chemical Analyses

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INTRODUCTION

In an attempt to define the relationship between a flowing artesian well and a spring 200 feet to the east which may have been caused or enhanced by the drilling of the well, aquifer tests were conducted on the well and on a second flowing well in the immediate vicinity. A secondary objective was to attempt to determine the characteristics and extent of the aquifer(s) tapped by the wells in order to guide future development via permitting. The tests were conducted in March and April, 1977.

PHYSICAL AND GEOLOGIC SETTING

The area is located approximately 10 miles east of Ellensburg in the Parke Creek drainage, Township 18N, Range 20E, Sections 22, 23, 26 and 27. See Figure 1. The wells are in the narrow valley of Parke Creek which is cut into the foothills of the Wenatchee Mountains. Maximum relief is approximately 700 feet and the relatively flat floor of Kittitas Valley lies a mile to the south of the southernmost well.

All three wells in the area are completed in the Yakima Basalt which is present throughout the immediate area. The Vantage (?) Sandstone is present near the southern boundary of the area. Structural features may be present but are as yet undefined. Geophysical and driller's logs suggest a typical sequence of solid basalt flows interbedded with "softer" zones or layers of cinders. These intermediate permeable layers contain water which, in this area, is under artesian pressure.

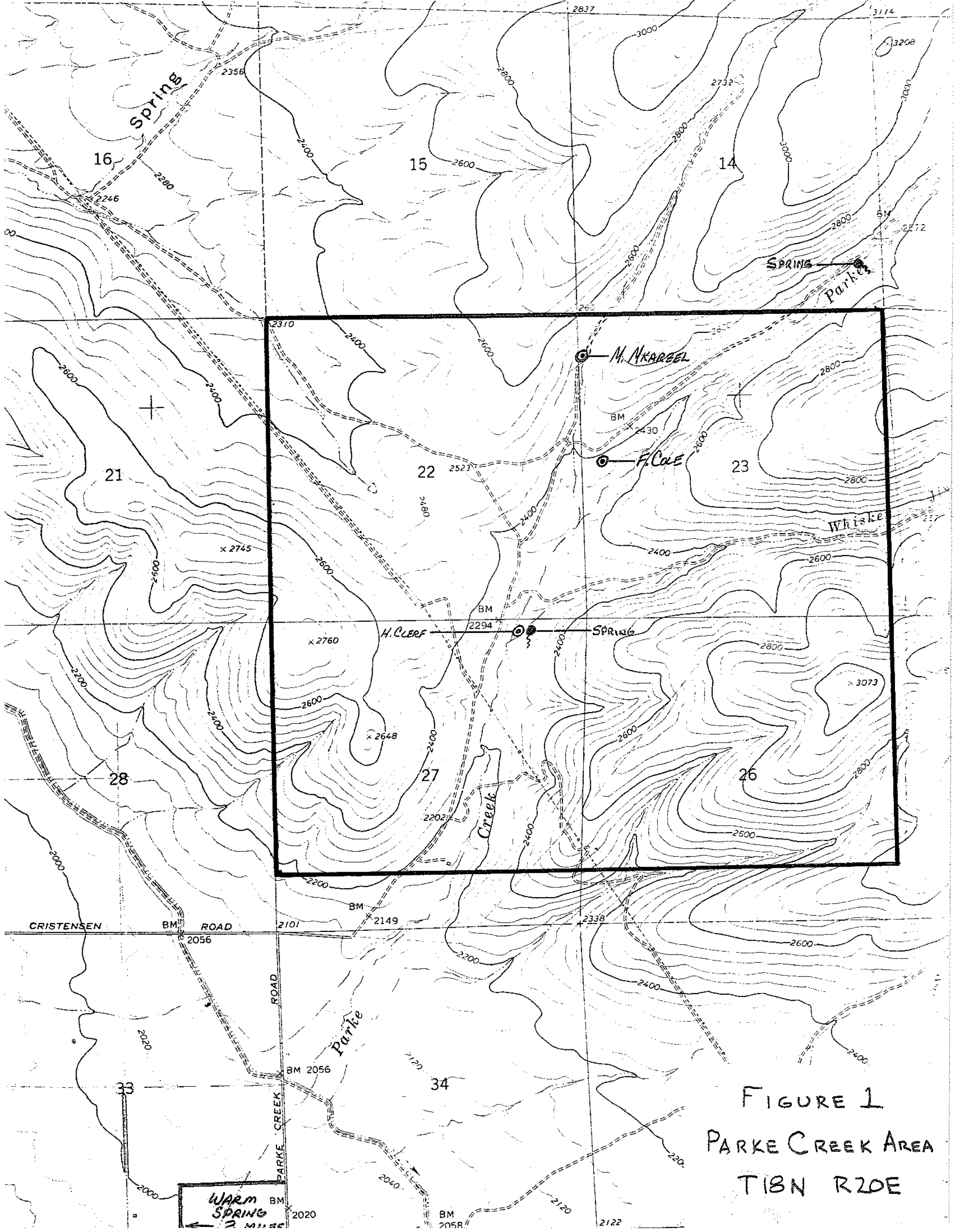

FIGURE 1
PARKE CREEK AREA
T18N R20E

HYDROLOGIC SETTING

Surface water supplies in the area are minimal. Parke Creek is intermittent and a few small springs are the only perennial surface water sources in the area. At present the springs are used for stock watering. The source of the springs is thought to be ground water, under pressure, leaking upward through small cracks and fissures in the basalt and eventually finding its way to the surface. Observed spring flows during March and April in the immediate area of the wells were small. However, Warm Springs, a large spring a few miles to the southwest, well into the valley area, flows an estimated 2000-3000 gallons per minute and residents state it has done so for thirty years "or more". This spring may be an expression of the ground water which underlies the Parke Creek area. Evidence concerning the spring next to the well is conflicting in relation to its history (whether or not it did exist) but it is now readily observable and flows 250 gpm. A line of small seeps, parallel to Parke Creek, extends south for approximately one-half mile from the Clerf well.

The ground water in the Parke Creek area occurs in the interflow zones in the otherwise solid basalt sequence which underlies the area. The only available information is summarized in Table 1 below:

Table 1

Selected Well Data

Well	Owner	Depth	Elevation 1/	Pressure	Discharge	Use
18N 20E 23D 2/	Mkarzel	600	2480	40 psi	2000 gpm	Unused
23E	Cole	240	2390	30 psi	220 gpm	Domestic
27A	Clerf	465	2260	100 psi	2200 gpm 3/	Irrigation

NOTES: 1/ 20±
2/ See attached map for locations
3/ Initial discharge 3500 gpm, sustained 2200.

In addition, driller's logs, geophysical logs, and chemical analyses of the water are available and may be found in the attached data. The driller's logs are of little interpretative value and the additional data will be discussed in a separate section.

Due to the possible presence of geologic structure(s) plus the regional dip of the rocks and/or that of individual flows, it is not possible to say with assurance that the individual wells penetrate the same units. It is probable that the Cole well does not penetrate the complete sequence tapped by either of the other wells because of its relatively shallow depth and its relatively low shut-in pressure. The other two wells present more of a problem because they are deeper, are a mile apart, lie within rocks which at least appear to dip to the south, and have explainable pressure differences if a reasonable ground water gradient is assumed. Possible connection of the wells will be discussed in a later section.

The source of the ground water, based on an assumed gradient between the Mkarzel and Clerf wells, appears to be infitration of precipitation which falls in the Wenatchee Mountains which lie to the north and possibly from the hills which lie to the east of Parke Creek. Without knowing if the two wells are in the same system and having only two wells, this is somewhat speculative.

AQUIFER TESTS

Both the Clerf well and the Mkarzel well were tested in an attempt to define the transmissivity and storage coefficient of the respective units they tap, to define any boundaries which might exist, and to see if the two wells were connected to the same system. The testing met with limited success or limited failure depending on one's point of view.

The Clerf well was tested first. A Sparling totalizing meter, with a sweep hand which, with a stopwatch, enabled instantaneous measurement of discharge was used for discharge recording. The spring flow was measured by installing a 90° V-notch weir and diverting all the spring flow through the weir. The initial spring flow was 263 gpm. The well was initially allowed to flow at a constant rate of 1400 gpm for 20 hours and 45 minutes. This test, for analytical purposes, was probably invalid, yet in a qualitative way was of some use. The spring flow was constantly monitored by periodic checks on the head at the weir. The discharge fell to a minimum of 189 gpm. Following a 7 hour 15 minute recovery during which the pressure returned to within 1.25 psi of the original 100 psi reading, a second discharge test was commenced. The spring flow was monitored during recovery and during the second phase of testing. During this test the well was allowed to initially discharge at its maximum capacity. As time progressed, the well discharge naturally decreased toward quasi-equilibrium conditions. Following this abbreviated 4 hour and 25 minute falling discharge test, recovery was measured for 1 hour and 40 minutes. Again, springflow was monitored via the weir and the discharge went from 241 gpm at the beginning of testing to 106 gpm at the end of 4 hours 25 minutes. During this phase of testing the initial well discharge was approximately 3500 gpm and fell to approximately 2300 gpm with a projected equilibrium discharge of about 2200 gpm.

As can be seen on Figure 2,the spring discharge is an inverse function of the well discharge. Although in itself this does not prove that the

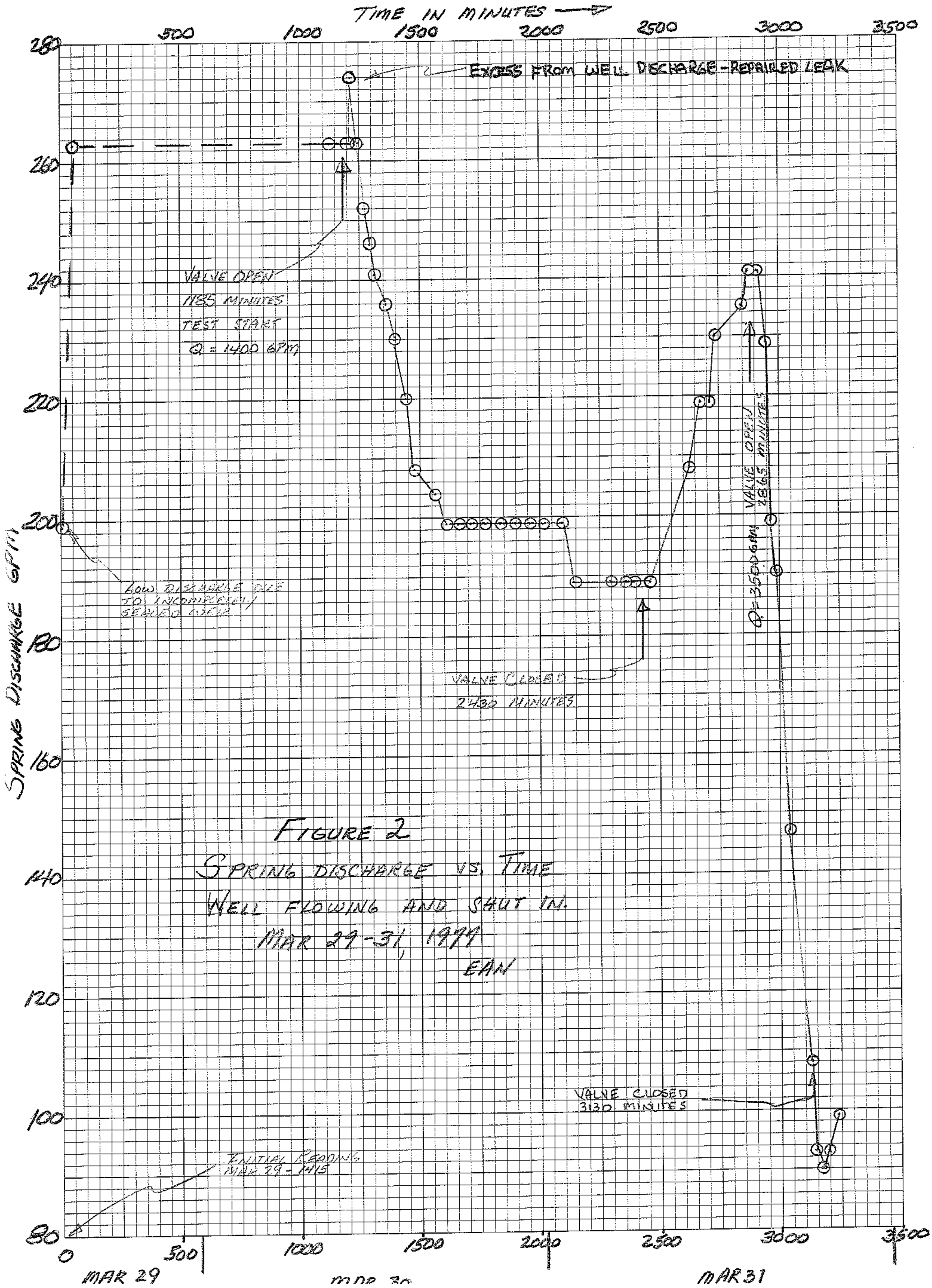

FIGURE 2
SPRING DISCHARGE VS. TIME
WELL FLOWING AND SHUT IN.
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spring was caused by the drilling of the well, it does indicate that the well and spring derive at least some of their flow from a common source.

No apparent effect was noted at either observation well (Cole and Mkarzel). This was an unexpected development which hinders a complete analysis and raises questions which will be discussed later.

Results of the analyses of the tests by several methods are shown in Table 2.

Table 2

Results of Aquifer Tests - Clerf Well

Test	Discharge GPM	Analysis	Transmissivity (gpd/ft)1/	Storage Coefficient
Drawdown 2/	1400	Jacob Modified Non-Equilibrium	32,000	- -
Recovery 2/	- -	Residual Drawdown	21,000	- -
Falling Discharge	Variable 3500-2300	Jacob-Lohman	14,700	.058 3/
Recovery	- -	"	11,400	- -

1/ Divide by 7.48 for units of ft^2/day
2/ Probably not valid in a strictly quantitative way
3/ Not a reasonable S for an artesian system.

The calculated transmissivities (T) are an order of magnitude smaller than what is commonly encountered in basalt interflow zones in Eastern Washington. A possible explanation, based primarily on the short duration of the test, will be discussed later.

The storage coefficient (S) is much too large for an artesian system and, as above, will be addressed in a later section.

The Mkarzel well, one mile to the north, was tested next for 44 hours and 30 minutes with 7 hours recovery. Pressure recovery was within 1.0 pounds of the original. The same discharge monitoring system was used and only the falling discharge and subsequent recovery were used for analysis. Again there was no noticeable effect on either of the other wells used for observation (Clerf and Cole). The initial test on the Mkarzel well had two distinct changes in the rate of discharge separated by a period of relatively constant discharge.

The early limb of the curve yields a T of 238,000 gpd/ft while the second limb gives a value of 180,000. These values are much more realistic than the Clerf well values when compared to typical basalt T's in Eastern Washington. As might be expected the recovery curve has two limbs also. One yields a T of 130,000 gpd/ft and the other 422,000. These values have greater disparity but again are at least in the expected order of magnitude. Calculation of the storage coefficient yields a nonsensical 2.78×10^{-36} for which no explanation will be attempted.

GEOPHYSICAL LOGS AND CHEMICAL ANALYSES

Several types of geophysical logs were run on the Clerf and Cole wells. The valve system on the Mkarzel well prevented logging at this time. The logs are useful in a qualitative sense but lack of detailed lithologic knowledge does not permit truly objective interpretation.

Nothing, as indicated by the geophysical logs, is readily correlative between the Cole and Clerf well. The Cole well is cased to 63 feet and below that depth the logs indicate a series of flows with four or five interflow zones which probably all contain water. The driller's log and conversations with the driller tend to confim this interpretation. The Clerf well logs are somewhat more enlightening at least in regard to the problem of the spring flow. This suite of geophysical logs is crudely correlative with the driller's log and his verbal description of conditions encountered.

The caliper log is perhaps the most useful as it gives a good indication of the solid flows vs. the softer interflow zones, which tend to "cave" or collapse more easily. Thus they are indicated as large breakouts on the log while the solid zones and cased interval are essentially solid lines. This log readily shows the casing to 110 feet, then a 20 foot interval of breakout (hole diameter from 8" to 10 3/4") noted on the driller's log as producing 75-80 gpm. This is followed by a solid interval from 130 to 240 feet with two small breakouts of 5 feet thickness at 138-143 feet and 172-177. The rest of the sequence to the total well depth of 465 feet is interpreted as thin solid flows and thicker porous zones with hole diameter ranging up to 18" from a nominal well bore of 8". These zones, according to the driller, produced progressively more water and pressure with depth.

From the fluid temperature and resistivity logs, keeping in mind the upper porous zone at 110 to 130 feet, a suggestion of possible upward water movement in the borehole can be drawn but the evidence is slight and other conditions may cause the noted anomalies. Expert interpretation of the well logs may shed some light on this aspect of the problem.

The radioactive logs tend to confirm the density/porosity relationships of the caliper log interpretation, that is, the postulated flows are denser and less porous than the interflow zones. Beyond such qualitative inferences little information, due mainly to a lack of suitable expertise in geophysical interpretation, can be deduced from the logs.

The key log which would have essentially answered the problem of whether the drilling of the well caused the spring flow was not run. A vertical velocity profile of the well bore would have delineated any possible zones of inflow-outflow, and further, approximate calculations of the volume of water in transit, assuming flow is occurring, would have been possible. Perhaps this log can be run in the future and indeed this is suggested in the recommendations.

Five chemical analyses were run on water samples gathered in the vicinity of the flowing wells in an attempt to note any similarities or differences in chemical quality of the water at the five sites. The analyses are included with the data. The sample sites included the three wells, a spring in Parke Creek approximately 1.0 miles above the Cole well (See Figure 1) and Warm Spring, located a few miles to the southwest in Kittitas Valley, T17N, R20E, NE¼NE¼NE¼ Section 6.

The chemical analyses are very similar from all five sites with relatively small explainable differences notably from the two surface water sites. The analyses suggest the waters are derived from similar geologic environments but are not hard evidence they are from the same source.

SUMMARY AND CONCLUSIONS

Three wells have been drilled in the Parke Creek area northeast of Ellensburg. All three are flowing artesian wells with varying shut-in pressures. Although they are physically within one mile of each other and all tap basalt, the vertical and lateral extent of the aquifer(s) is unknown and, in fact, it is unknown whether the wells tap the same system(s).

Results of aquifer tests are inconclusive. No interference between wells was detected during the longest test of over 44 hours. This fact, plus what may be a boundary effect noticed on the subsequent analysis of the discharge and recovery curve of the Mkarzel test suggest a possible hydrologic boundary, but little surface evidence is available. Quantitative analytical answers are variable, are not within typical expected ranges for Eastern Washington basalts, and, in some cases are totally unrealistic. Some of these problems may be due to relatively short duration of the test, the possible, but unknown, boundaries, lack of a hydraulic connection between units tapped by the wells, possible "sinks" or thief zones between wells or a combination of any or all of the possibilities. The unrealistic analytical results, particularly the storage coefficients, strongly suggest that the basic criteria of the analytical equations have not been met and are simply not applicable in this case. This, of course, leads to the suspicion that nothing, in a quantitative sense, can be reliably estimated from these tests. A discussion of possible reasons for the invalid results is beyond the scope of this discussion.

In a qualitative sense some estimations of aquifer productivity can be made. Unless unseen boundaries appear, the aquifer appears to be able to yield a sustained 2200 gpm to the Clerf well alone for a long, though indefinite period of time. With the Clerf well off, the Mkarzel well would appear to have a sustained yield of 2000 gpm. Assuming no mutual interference, this would be a combined yield of 4200 gpm or 6700 acre-feet per year if the recharge to the area were sufficient to supply that amount, and if the system is areally extensive. Crude estimation of areal recharge yields a range of 5000 to 10,000 acre-feet per year which is probably the right order of magnitude. Of course the size and extent of the system is not exactly known at the present time.

The well-spring problem is as yet not resolved. Although the test of the Clerf well indicated a common source for the well and spring flow, a causal relation between the well and spring cannot be absolutely confirmed. The geophysical log evidence, though lacking a key log, is suggestive, but not conclusive, of conditions which could be conducive to leakage from the well bore.

It is concluded that the aquifer system(s) tapped by the wells may be areally extensive, may be the same for all the wells and local springs, and its characteristics are, as yet, undefinable except in a qualitative way. Normal testing procedures may not yield satisfactory results and further drilling should be on a one well at a time basis. Each new well thought to tap the system should still be rigorously tested in a quantitative way even though only a qualitative analysis may be the result. An effort should be made to ascertain, with reasonable accuracy, the withdrawals from the system (monitor pumpage or flow) and, when the wells are shut in, routinely monitor the shut in pressures. Further, after the irrigation season, if so desired, a long term (10-20 day) test of the system should be conducted to attempt to gather reliable information with which to better define the system(s) parameters.

As regards the well-spring problem, it is concluded that no substantial evidence to prove cause and effect is available, although the bulk of evidence to date suggests a common source and suitable conditions for well bore leakage to occur. A vertical velocity profile of the well bore under static conditions should be run. Such a profile would document any flow occurring within the well bore, where it enters and where it exits. If such a test is not possible a dye injection test is suggested wherein a dye is introduced into the well bore and the spring flow is monitored to detect if the dye appears in the spring flow. Either one or both of these tests should provide conclusive evidence as to whether or not the well is "leaking" into the spring. The volume of suspected flow from the well bore is calculable from the velocity profile and can be estimated from the dye dilution. In this manner the wells relative contribution to the spring flow could be evaluated.