Brief Analysis of the Cause of Reduced Spring Discharge and Streamflow, Sinking Creek area, Lincoln County

by

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This Open File Technical Report presents the results of a hydrologic investigation by the Water Resources Program, Department of Ecology. It is intended as a working document and has received internal review. This report may be circulated to other Agencies and the Public, but it is not a formal Ecology Publication.

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INTRODUCTION

Recently, Mark Utting of the Pacific Groundwater Group, issued a report on the causes of reduced spring discharge and streamflow in and along Sinking Creek ("Sinking Creek Hydrogeological Assessment", 1989). In the following, I will discuss Mr. Utting's conclusions and present our interpretation of the hydrologic situation at Sinking Creek. Also, I will describe the hydrologic effects, in the watershed, of flowing and leaking (flow between two aquifers through a borehole) wells in the area, water-level declines caused by pumping, and non-compliance with water rights in both pumping rate and annual quantity.

MECHANISMS WHICH MIGHT ACCOUNT FOR REDUCED STREAMFLOW

Mr. Utting offered four hypotheses to explain the reduced streamflow:

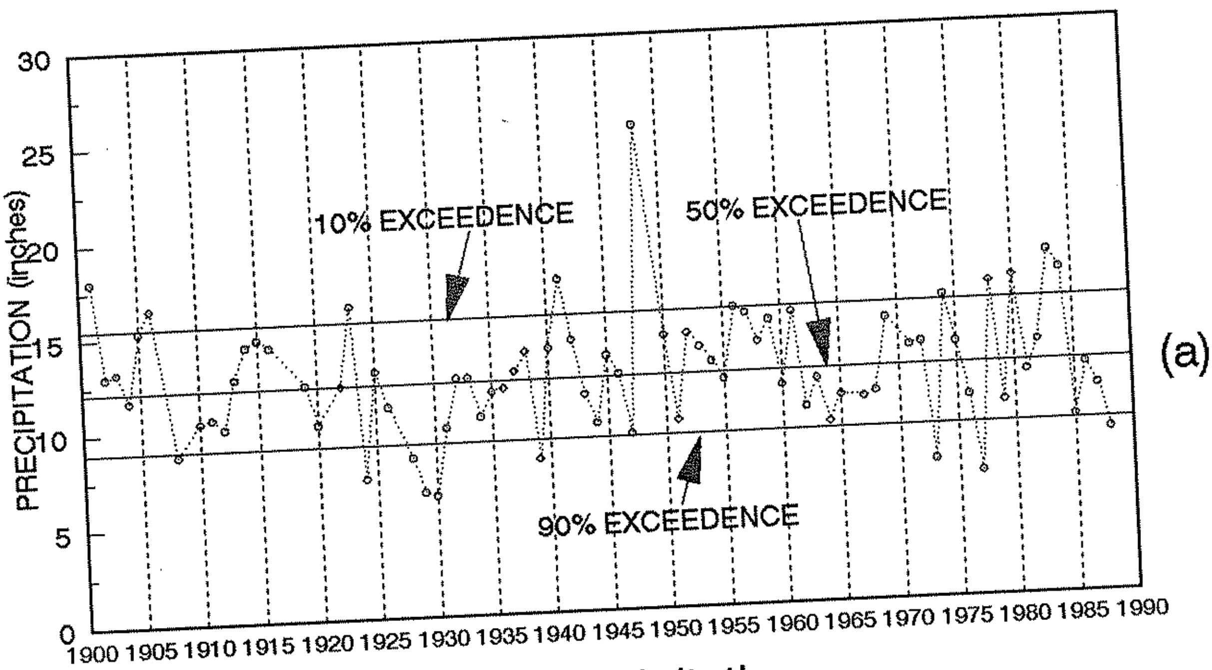
1. Below-average precipitation in recent years,
2. Relocation of the stream channel,
3. Farming, or more specifically, cultivation practices, and
4. Pumping large volumes of ground water for irrigation.

Adequate information is available to demonstrate that the first two hypotheses are not tenable. The latter two hypotheses rest on less certainassumptions about recharge, flow-system geometry (i.e. what are the geologiccontrols on where ground water occurs, how it moves, and where it is going),the sources of streamflow, the effects of cultivation practices in thisparticular watershed, and the effects of irrigation practices in the area.

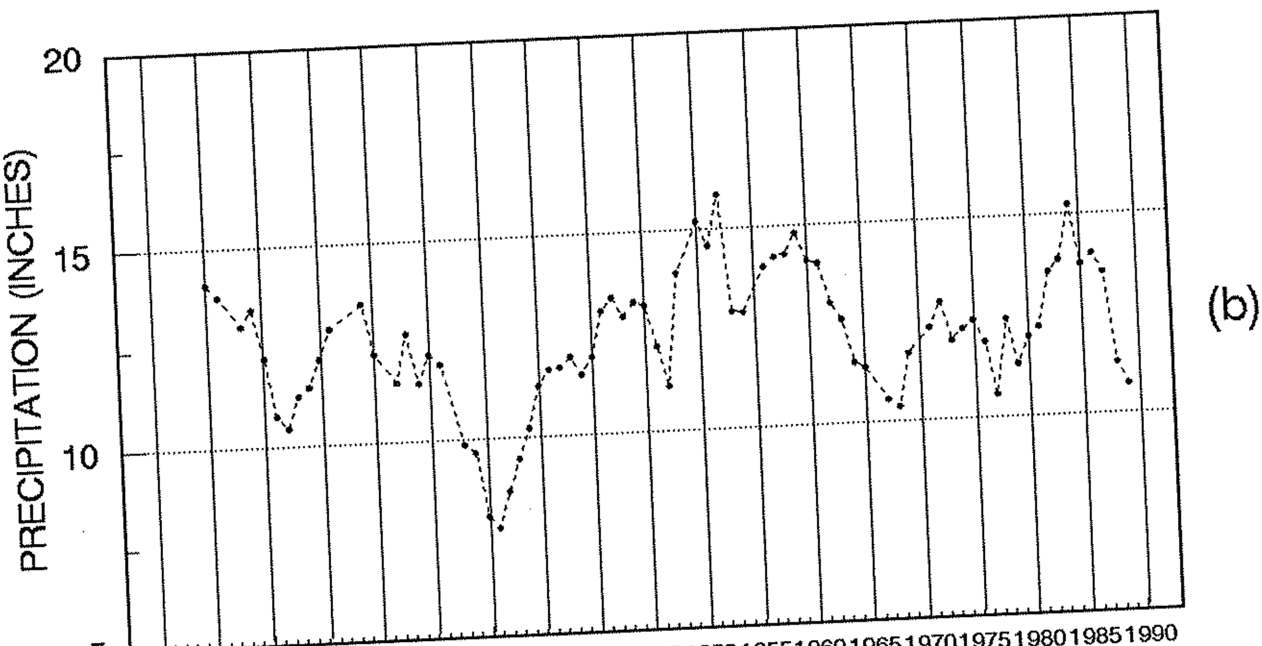
Below-average Precipitation

The first hypothesis, decreased precipitation, is readily examined in the attached graphs for annual precipitation and annual snowfall (Figure 1 and 2). The mean-annual precipitation and snowfall are, respectively, about 12.5 inches and 27.6 inches (using an 88-year period of record having eight years of incomplete snowfall records and nine years of incomplete precipitation records which are not averaged-in). The hydrographs illustrate high variability of total precipitation and snowfall from year to year. The moving, five-year and ten-year means of annual precipitation and snowfall smooth out this variability somewhat and provide a multi-year comparison.

The moving means of precipitation show below normal conditions in the late 1960's and 1970's but much better water conditions in the 1980's. The moving means of snowfall show a serious deficit in the 1960's, above average conditions in the 1970's, and only slightly below normal conditions in the 1980's.



Annual precipitation



5 YEAR MOVING AVERAGE OF ANNUAL PRECIPITATION

Figure 1. Wilbur Weather Station, Lincoln County

Water-Year Precipitation, October through September

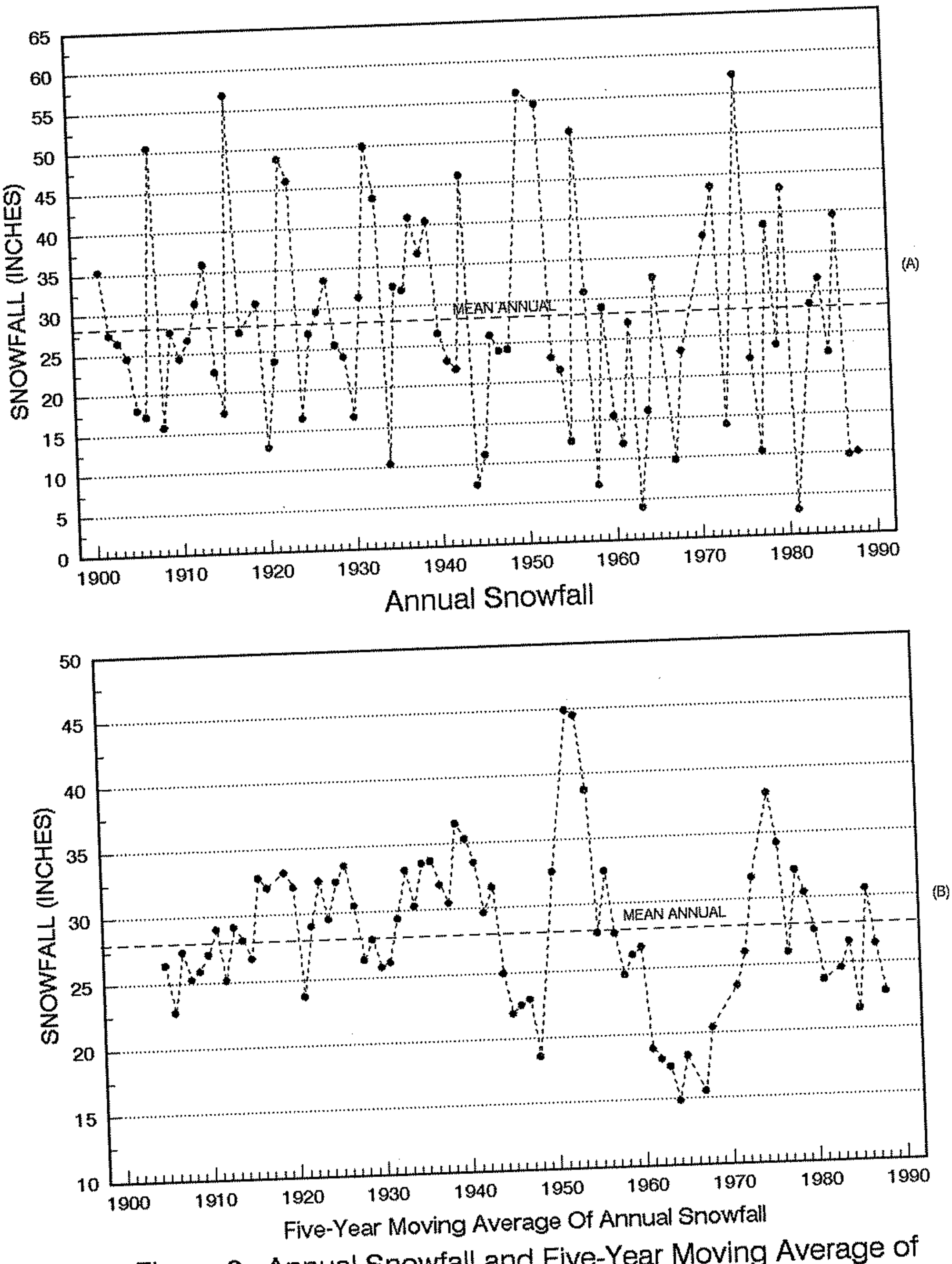


Figure 2. Annual Snowfall and Five-Year Moving Average of Annual Snowfall, Wilbur Weather Station, Lincoln County, By Water Year (Oct. to Sept.)

The reason I calculated the five-year moving means is that the ground-watersystem probably has a "memory" of the climate, as reflected in actual recharge, over a period of several years. Ground-water storage doesn't change as quickly in response to precipitation as does soil moisture, for instance. So the moving, five-year means of precipitation may be a better indicator of changes in ground-water storage than is annual precipitation.

In any case, the streamflow conditions are not correlated with the precipitation or snowfall variations, according to residents of the area and our records. The streamflow and spring-discharge declines first showed up in the early 70's and have gotten somewhat worse, with no noticeable periods of much improvement. If annual precipitation or snowfall were a controllingfactor, streamflow would have increased during the wetter periods.

Relocation of the Stream Channel

The second hypothesis is that moving the creek channel has reduced streamflow. First of all, I was surprised to hear that the channel had been moved as much as claimed. I have walked the creek numerous times and not noticed much of this type of disturbance. I have seen straightened reaches of channel and Mr. Bauer once told me that the channel had been shifted away from Wagner Lake, but otherwise I was not aware of the problem.

Mr. John Rosman attests that only about 12% of the creek channel on his property has been disturbed. The creek was diverted to a former channel and that channel was cleaned out. Mr. Bauer corroborates Mr. Rosman's explanation. This is far different than Mr. Utting's statement that " up to 90% of the creek bed passing through meadow may have been moved from it original course." Before we go much farther with this line of evidence we should make an accurate determination of which reaches have been moved and by how much.

Even if the channel has been shifted to higher elevation, I don't understand how the streamflow would be permanently reduced. Under pre-cultivated, natural conditions the discharge to the stream occurred mostly from the basalt aquifers. Assuming that this year-to-year, steady-state discharge were to continue and that the natural channel were filled-in, then the fill would become saturated, the water table would rise, and the flow would resume at the low point of the valley cross-section. The key point is that the water doesn't just go away because the channel is shifted.

The valley alluvium has become progressively drier over the years. In the early 1980's the cattlemen could provide stock water by digging watering holes in the alluvium after streamflow ceased for the summer. Now the cattlemen say that these holes are dry. Downstream of the Blenz spring on Rosman property the soils are consolidating as they desaturate and large shrinkage cracks have opened up. At the lower end of the

Rosman property the small amount of streamflow disappears into a "sink" in the alluvium.

My interpretation of this evidence is that the alluvium no longer recieves enough spring discharge to become or remain saturated throughout the year. Therefore, during any time of year, the desaturated alluvium absorbs most or all of any remaining streamflow. But not as a result of moving the streamchannel.

I agree that, during snowmelt, a new channel, constructed at higherelevation, will intercept runoff on that side of the valley and some of the water will leak through the stream bed because of the higher elevation. But somewhere downstream the water must reappear in what is left of the natural channel. In any case, there is no solid evidence that much of the channel has not been moved to higher elevations.

Cultivation Practices

Cultivation practices such as chiseling or subsoiling or leaving crop stubble will usually capture more water and hold it in the soil. Snowmelt runoff is also, no doubt, reduced. We have no information on how many inches of extra water is captured by these methods, though. Further, we have no information about how recharge is affected. Perhaps the captured water is only excess winter runoff and the remaining runoff is enough that recharge continues unabated. Alternatively, recharge through the loess soils of the uplands, which may not have occurred under natural conditions, may be generated by the enhanced infiltration of snowmelt into the soils.

Cultivation practices, however, are a particularly weak explanation of hydrologic changes in the upper watershed, upstream of the Rosman property. The creek has two branches up there. The north branch, extending from Greenwood Slough down through the Nelson property to Marquette Spring, and the shorter, east branch with headwaters on Nelson property and extending down to the former Mangis property, now owned by the Hougers.

Along the east branch there is no cultivation, only grazing, on the scabland or thin soils. Yet, all the springs on the Nelson property have nearly disappeared. Furthermore, the Nelsons noticed a reduced flow during the late 1960's, about the time the first Houger well came into production. How could cultivation have an effect in that area? The same can be said for the north branch where the Nelson spring near Greenwood Slough has ceased to flow. There is some cultivation along this branch but more than half of the runoff-contributing area is scabland.

These observations cause me to wonder whether cultivation in the lower watershed has had much effect. Certainly most of the contributing area is cultivated and runoff is probably greatly reduced. To this extent I agree with Mr. Utting and the irrigators who have written to us. But we also know that two of the largest springs, both on Rosman land, are directly reduced by pumping. Flow from these springs increases during the mid-summer wheat harvest when most of the wells are not pumping. I conclude that these large springs discharge from the confined aquifer which is pumped for irrigation.

Conversely, many springs of lesser discharge in the lower watershed are, reportedly, little affected. These likely are fed from the unconfined aquifer. Therefore, I propose that the recharge to this aquifer is not much reduced by cultivation practices.

Assuming that much of the dry-season streamflow issues from the large springs fed by the confined aquifers, then irrigation practices, not cultivation, have caused most of the streamflow reduction.

Pumping Ground Water

The only plausible explanation of reduced streamflow in the upper watershed is pumping effects. Two mechanisms are possible. The first, head drop in the confined aquifer due to pumping, may reduce the discharge from deep-source springs, as occurs in the larger springs on the Rosman property. The second mechanism, increased leakage from the unconfined aquifer to the confined aquifer, may cause the head to drop, thereby reducing flow from springs fed by this aquifer.

Direct effect of pumping on deep-source springs

The principal springs of the upper watershed are fed by either the unconfined or confined aquifers. If fed by the confined aquifer, then the pumping affect on spring discharge is direct, as demonstrated for the large Rosman springs (T25N/R33E-13 and T25N/R34E-8; see Figure 3). We also know from well water levels that this aquifer is greatly affected by pumping. The heads drop up to 20 feet during the irrigation season (observation well, 25N/34E-9F1; see Figure 4). This well is located more than two miles from the nearest irrigation well. Moreover, the water level in this well rises during July and falls again in August, in sequence with the schedule of wheat irrigation. No natural process can explain this mid-summer rise. In particular, not nearly enough rain falls in the summer to generate recharge.

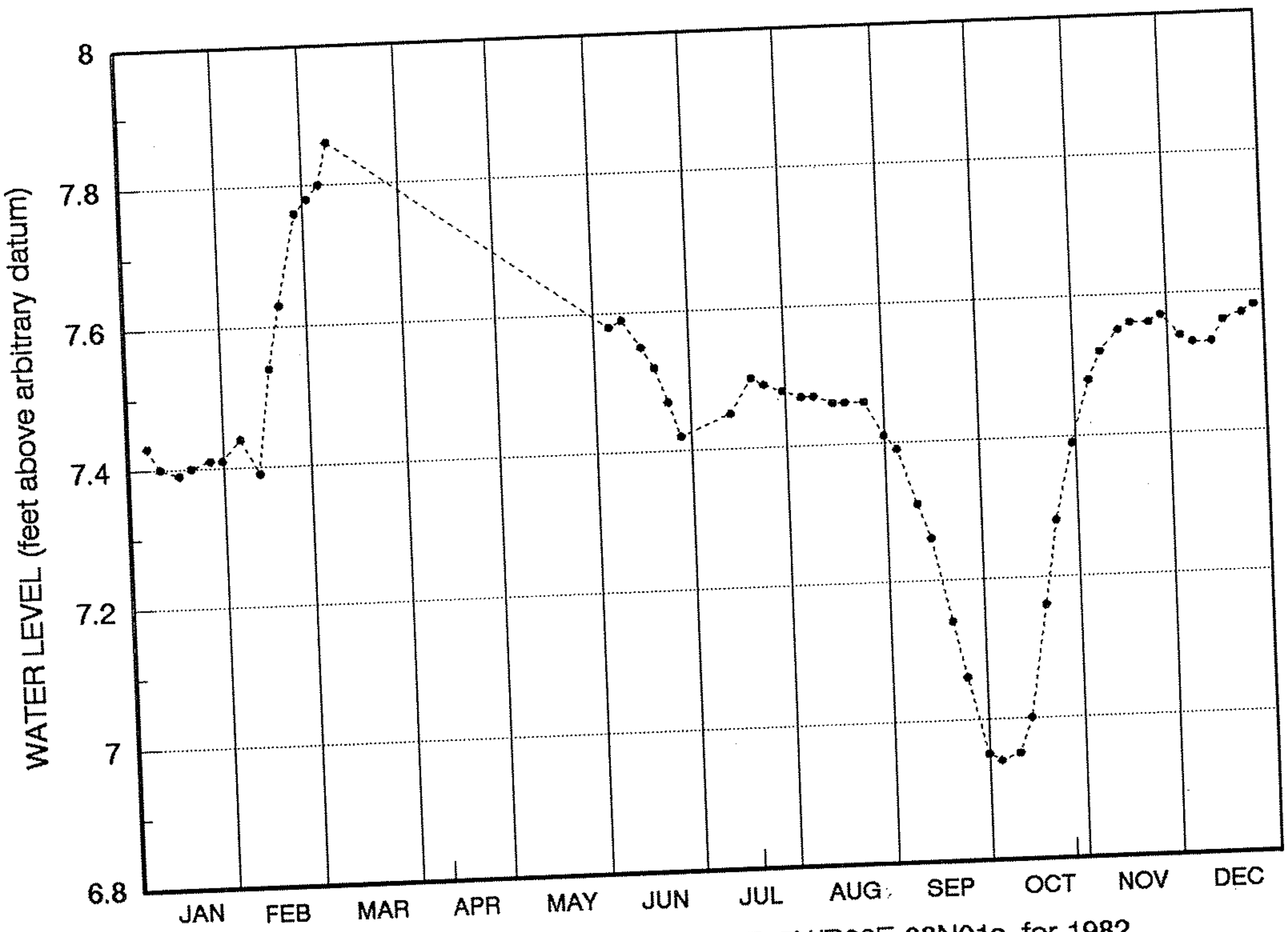


Figure 3: Hydrograph for spring T25N/R33E-08N01s, for 1982

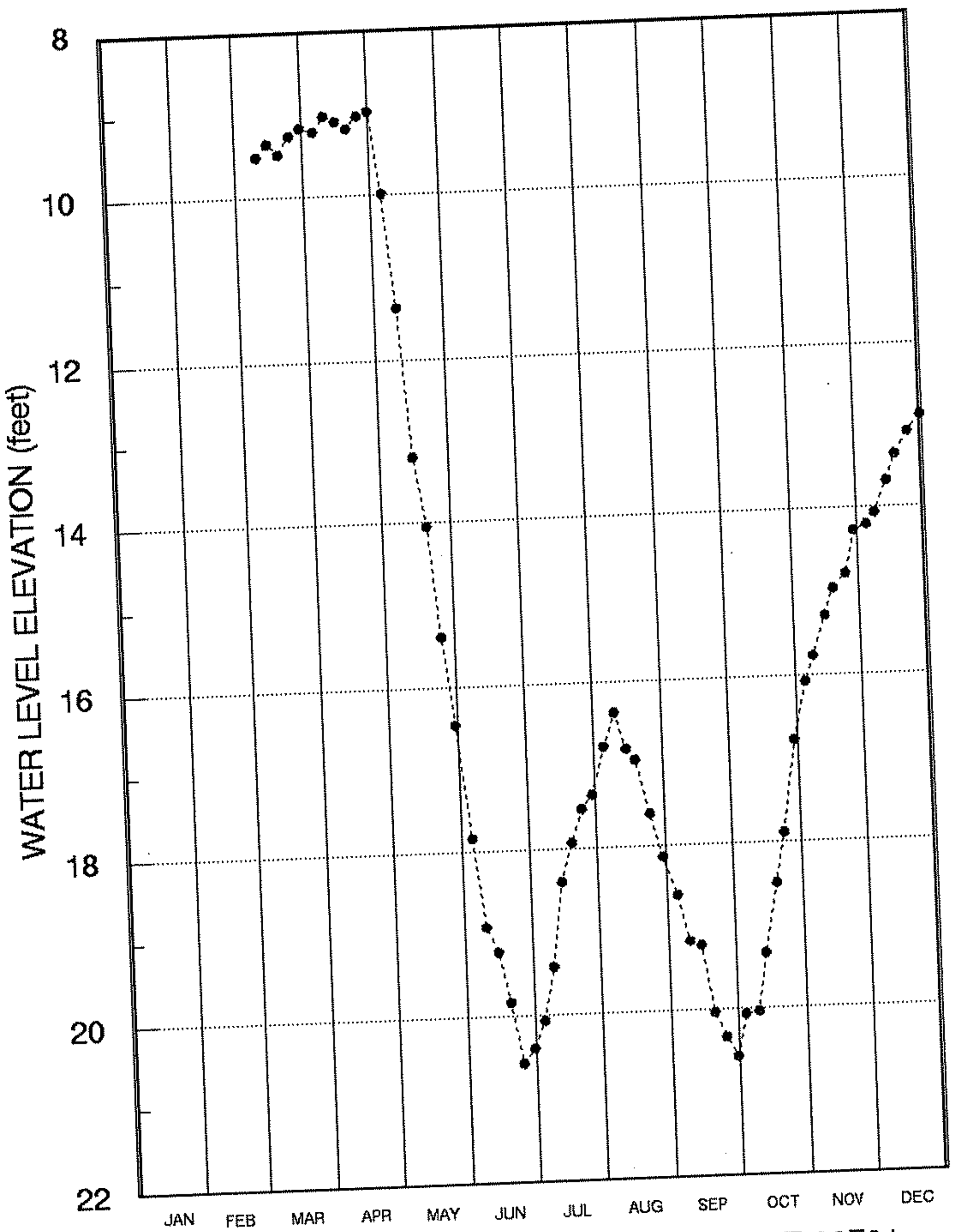


Figure 4: Hydrograph for Well T25N/R34E-09F01

for 1982

In my 1982 report, I concluded that the Houger irrigation wells were responsible for the reduction in discharge at the Rosman springs. This was based on the drawdown recorded in observation well 25/34-9F1 (see above), during an aquifer test involving the Houger irrigation wells. Since then I have learned that the Houger wells, irrigating mostly alfalfa, are pumped more-or-less continually during the irrigation season. Therefore, the Houger's pumping schedule does not account for the unusual pattern of water-level changes in our continuous, long-term records. However, the Houger wells do contribute to the seasonal head decline in the confined aquifer and are partially responsible for reduced spring discharge, especially in the upper watershed.

This congruence of pumping schedules and water-level changes indicates that the distant irrigation wells to the south and west all contribute to the drawdown throughout the watershed. Combined pumpage from these wells is 10 to 20 times the Houger pumpage. Therefore, the Houger wells probably cause only a small portion of the seasonal, water-level drop in the upper watershed.

Effects On Spring Discharge of Leakage From the Unconfined Aquifer To the Upper Confined Aquifer

If fed by the unconfined aquifer, the springs feeding Sinking Creek might still be indirectly affected by pumping. As recorded in the Houger observation well (ibid) the water level drops as much as 20 feet during the irrigation season. The natural component of this seasonal decline is probably less than 5 feet while pumping causes more than 15 feet of drawdown. Therefore, the pumping is increasing the head difference (hydraulic gradient) between the unconfined and confined aquifers by at least 15 feet. The natural gradient between these aquifers is about 50 feet, so the increase caused by pumping is 30% or more. Leakage to the confined aquifer is thus increased by a similar proportion.

The head changes caused by pumping are probably not immediately propagated from the confined to the unconfined aquifer. The head change must first translate through the Vantage "interbed", a claystone (see InSitu reports), before reaching the unconfined aquifer and will gradually increase with time, a typical aquifer response. Therefore, leakage is not appreciable for several days or weeks following the start of pumping. This hypothesis explains why the 2-day-long aquifer test produced no measurable head change in the unconfined aquifer. This also fits with Mr. Nelson's observation that the spring flow is not noticeably reduced until a few weeks after pumping starts.

Mr. Utting, on the other hand, estimates that the increased head difference is probably only a few feet at most, that the gradient is only increased by a small percentage, and therefore, that increased leakage is not great enough to affect spring discharge.

WATER LEVEL CHANGES

Upon reviewing our water-level records for the past decade I noted several changes which were not evident when I reported on conditions up to 1982.

Unconfined Aquifer

Water levels for wells completed in the upper aquifer show no long-term declines except, possibly, in Piezometer 6 of the Ecology Observation Well, 25N/34E-29J07 (Figure 5). However, water levels in several other wells also exhibit the unnatural, mid-summer rise and fall as wheat irrigation stops in July and resumes in August, respectively. These wells are located in the upper watershed. This is strong evidence that pumping in the confined aquifer is causing increased leakage from the unconfined aquifer. Similar changes may be occurring in other parts of the watershed where we are not monitoring the shallow wells.

Lower, Confined Aquifers

Water-level records for three irrigation wells, all located just southwest of the topographic divide, indicate some long-term decline during the last 8 years. The water level in the Wilbur Securities well, 25/32-35P1 [Figure 6(A)], operated by Sherwood Farms, has dropped about 10 feet. The water level in the Quirk well, 25/32-26G1 [Figure 6(B)], has dropped 20 to 30 feet. The water level in the Rettkowski well, 25/33-27A2 [Figure 6(C)], has dropped about 60 feet. Such declines are well known in the Odessa Subarea to the south. If these trends continue the aquifer will not sustain irrigation in the long term.

Some storage depletion (observed as water-level declines) is inevitable in all pumped aquifers as the hydrologic system adjusts to the changed discharge. But in this aquifer situation the adjustment may take many decades and end with the water levels too deep for affordable pumping.

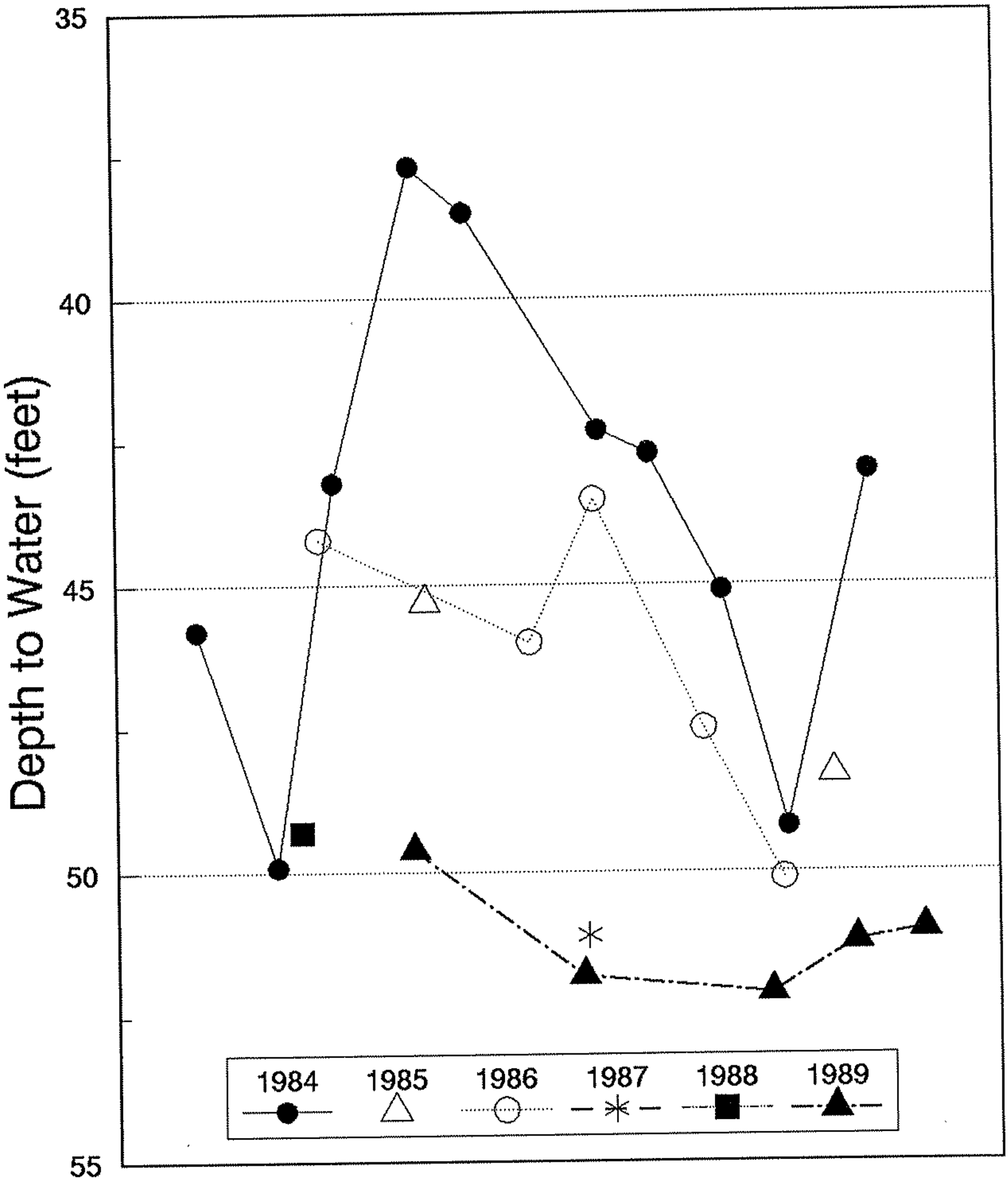


Figure 5. Water levels in piezometer 6, Dreger Observation well, 25N/34E-29J07

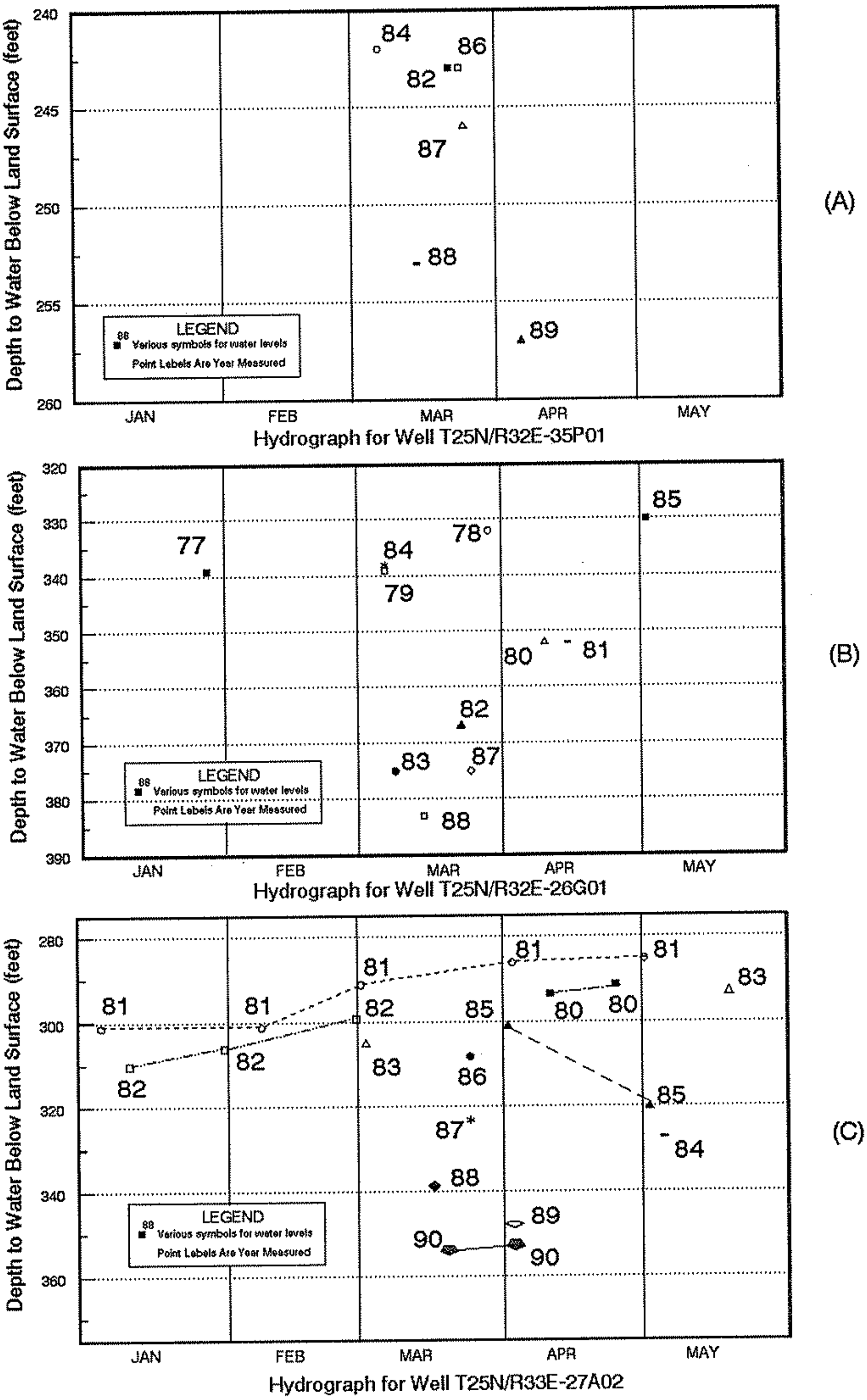


Figure 6: Water levels in various irrigation wells near Sinking Creek, Lincoln County

Recharge

The most recent recharge estimate for the area is about 1.6 inches per year. At this rate, recharge through 7.5 acres of land is needed to produce one acre-foot of water. Current appropriations for the area total about 18,000 acre-feet per year. Therefore, 135,000 acres, or 210 square miles, are needed to replace this much water. But, the area of pumping is only about 9 miles by 15 miles, or 135 square miles. Assuming water use is less than the appropriations there may be a rough balance between use and recharge. If this estimate is correct then water levels will drop until, eventually, all natural, aquifer discharge ceases. In such a condition no water will leave the area in the regional aquifer and little or no water will flow in the creek.

LEAKAGE FROM FLOWING WELLS AND BOREHOLE LEAKAGE IN UNCASED WELLS

We will be investigating unconfirmed reports of several flowing, artesian wells with water leaking around the casing at land surface. This leakage may be small in comparison to the amount pumped each year but, nonetheless contributes to head decline in the confined aquifer and, thereby, to streamflow reduction. The confined aquifer I have referred to in this letter is comprised of at least two head zones. There may be more at greater depth. Most of the irrigation wells are cased only through the unconfined aquifer. Thus, the uncased portions through the confined aquifer are a conduit for downward flow between the head zones. This borehole leakage occurs whenever the wells are not being pumped. Collectively the borehole leakage may be several hundreds of gpm and contributes to the reduction in spring discharge.

CONCLUSIONS

Pumping for irrigation is the principal cause of reduced streamflow in Sinking Creek during the past 20 years. The streamflow will continue to decrease if pumping continues at present rates. Leaking or flowing wells are contributing to the problem, though in minor proportion.

Water-levels in portions of the confined aquifer are dropping progressively from year-to-year. Pumping lifts, and costs, are increasing and ground-water storage in the confined aquifer is being depleted. Current pumping is approximately equal to estimated recharge so water levels are likely to continue to drop for many years if annual pumping continues at present rates.