WATER RESOURCES EVALUATION OF THE SPRING VALLEY SUB-DIVISION IN RICHLAND COUNTY, SOUTH CAROLINA

BY
Joseph A. Harrigan

Geology-Hydrology Division
South Carolina Water Resources Commission
P. O. Box 4440
Columbia, South Carolina

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WATER RESOURCES EVALUATION OF THE SPRING VALLEY SUB-DIVISION

IN RICHLAND COUNTY, SOUTH CAROLINA

Introduction

This report is written in response to a November 4, 1985 written request from the Lakes Committee of the Spring Valley Home Owners Association for technical assistance in evaluating their local water resource availability situation. On November 12, 1985, a meeting was held at the Spring Valley Country Club with the Lakes Committee designated contact person, Mr. Roger Rhodarmer, as well as several other interested persons, including Dr. Gerald Olsen, Mr. Buddy Sweet, and Mr. Joseph Rosen, as well as a South Carolina Water Resources Commission (SCWRC) staffperson to discusse the request in detail.

Three lakes are primarily the focus of this investigation:

1. Clark Lake in the East Spring Valley portion of the subdivision;
2. Park Shore Lake in the northeast portion of the older subdivision; and
3. the irrigation lake for the golf course, behind the clubhouse.

According to the facts presented, Clark Lake is the source lake for:

1. supplemental irrigation water for the golf course;
2. supplemental lake filling water for Park Shore Lake via Riding Ridge Pond.

The various subdivision residents who live on the first two lakes desire that the lake levels be maintained as close to full as possible. As has happened during this past dry year, (1985), water has been pumped out of Clark Lake to supplement both golf course irrigation and lake filling. This has probably aggravated both an already low water situation on Clark Lake and the lakeside residents. The filling of Park Shore Lake has only recently raised the lake level to a near-acceptable one and lowered the frustration level of these residents.

The principal request was for an analysis of the surface water availability situation, to be used in determining a suitable water management plan for the subdivision. At present a complete answer to the water supply problem has not been developed. The main problem encountered involves the relatively poor lake filling ability at Park Shore Lake and, to a lesser degree, Clark Lake. Nearby streamflow gages indicate that more than enough runoff should occur in both lakes drainage basins to fill the lakes each year. Since this is not happening, some immediate-vicinity rainfall-runoff data are needed.

To get a handle on the local rainfall-runoff relationship, it is recommend that Park Shore Lake be monitored for its response to precipitation. This can be used in conjunction with the data Dr. Olsen is collecting for Clark Lake to evaluate what percentage of rainfall is arriving in each lake. This will help determine if insufficient runoff is flowing into the lakes or if the lakes are recharging (leaking into) the underlying sand aquifer. If the latter situation proves to be the case, supplemental lake filling from wells may not be worthwhile.

Below are summarized the hydrologic and physiographic data obtained and how it applies to Spring Valley's situation. A discussion follows concerning the various background data applicable to this situation, their interrelationships and how they apply to the problem, and some possible solutions.

BACKGROUND DATA

PHYSIOGRAPHIC DATA

Spring Valley subdivision is located along the up-dip edge of the Coastal Plain province of the Southeastern United States. This wedge-shaped body of sediments, thickening towards the coast, overlies the crystalline rocks of the Piedmont province, which can be seen north of the Columbia area and are characterized by "red-clay" soils. The immediate vicinity of the subdivision is underlain by the sandhills sub-province of the Coastal Plain and is characterized by fine- to coarse-grained sand. These sand beds are considered part of the immediately underlying water-bearing sand and clay unit called the Middendorf Formation. Typically, the sand drinks up a large portion of the local precipitation, holds it in storage, and releases the water as spring flow, thus producing a year-round steady streamflow, much less erratic than streams to the north in the Piedmont.

The thickness of the Middendorf in the vicinity of the subdivision ranges from 150 to 250 feet. Yields from wells are reported to be between 15 and 50 gallons per minute, which is more than adequate for most household uses. The underlying crystalline rocks are only a poor to fair source of ground water in the vicinity of the subdivision.

HYDROLOGIC DATA

The map labeled Figure 1 a photocopied portion of the Richland County highway map, shows the location of Spring Valley subdivision and the locations of the various nearby water data gaging stations. Three miles east-northeast of Spring Valley is the Clemson University Sandhill Experiment Station, where both precipitation and evaporation are gaged. Twelve miles to the southeast is the Colonels Creek stream gage, and 9 miles to the southwest is the Gills Creek stream gage. The southwestern half of Spring Valley is located in the Gills Creek drainage, and the northeastern half is in the Crane Creek drainage. The headwaters of Colonels Creek are a mile southeast of Spring Valley.

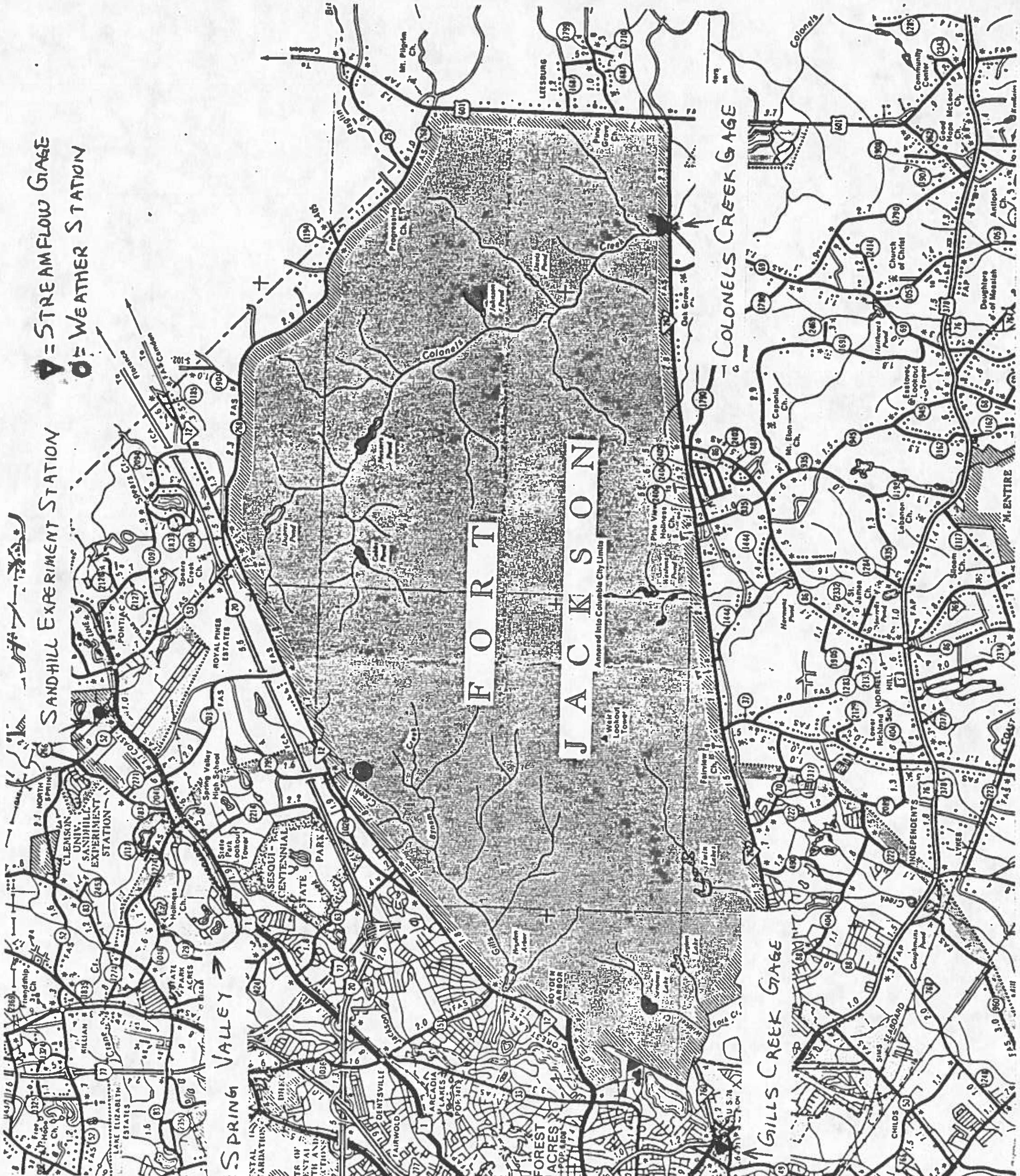

Figure 1. Location map of study area including streamflow and weather gaging stations.

Below, in Table 1, the long-term average monthly precipitation, evaporation, and streamflow values are listed in inches for the respective gages.

TABLE 1.

MONTH	CLEMSON UNIV PRECIPITATION INCHES	SANDHILL EXP STA EVAPORATION INCHES	USGS STREAMFLOW GAGES GILLS CR. INCHES	%	COLONELS CR. INCHES	%
Jan	4.66	1.64	2.27	48.7	1.88	40.3
Feb	3.81	2.44	1.97	51.7	1.61	42.3
Mar	5.20	3.88	2.36	45.4	1.88	36.2
Apr	3.69	4.86	1.60	43.4	1.58	42.8
May	3.57	5.59	1.21	33.9	1.33	37.3
Jun	5.03	5.66	1.16	23.1	1.11	22.1
Jul	5.49	5.53	1.32	24.0	1.16	21.1
Aug	4.13	5.07	1.20	29.1	1.28	31.0
Sep	3.50	4.12	0.91	26.0	1.02	29.1
Oct	3.00	3.46	0.91	30.0	1.11	37.0
Nov	2.76	2.25	1.11	40.2	1.28	46.4
Dec	3.68	1.78	1.58	42.9	1.58	42.9
Annual	48.52	46.27	17.58	36.2	16.79	34.6

In addition, listed with the streamflow data is the long-term average percentage of monthly precipitation that the monthly streamflow represents. For example, 1.11 inches of runoff in Colonels Creek during June represents 22.1 percent of the precipitation whereas the same runoff in October represents 37.0 percent of the precipitation. These data are also displayed graphically in Figure 2.

Summarizing the data in Table 1 shows the following:

1. precipitation highs occur in winter and summer;
2. precipitation low occurs in the fall;
3. evaporation is highest in the summer and lowest in the winter; and
4. runoff is highest in the winter and lowest in the fall.

The low summer runoff results from the high summer precipitation being dissipated by the high evaporation and related vegetation transpiration.

The runoff statistics for two streamflow gages are shown. Gaging at Colonels Creek, which is considered the better representative gage for Spring Valley's environmental conditions, was discontinued in 1980. Spring Valley's water supply analysis, however, needs up-to-date streamflow data as well as long-term streamflow statistics. The Gills Creek gage, which is still operating, is the next upper Coastal Plain gage site useful to Spring Valley. Its only drawback is the large number of lakes and other urbanization effects present in its

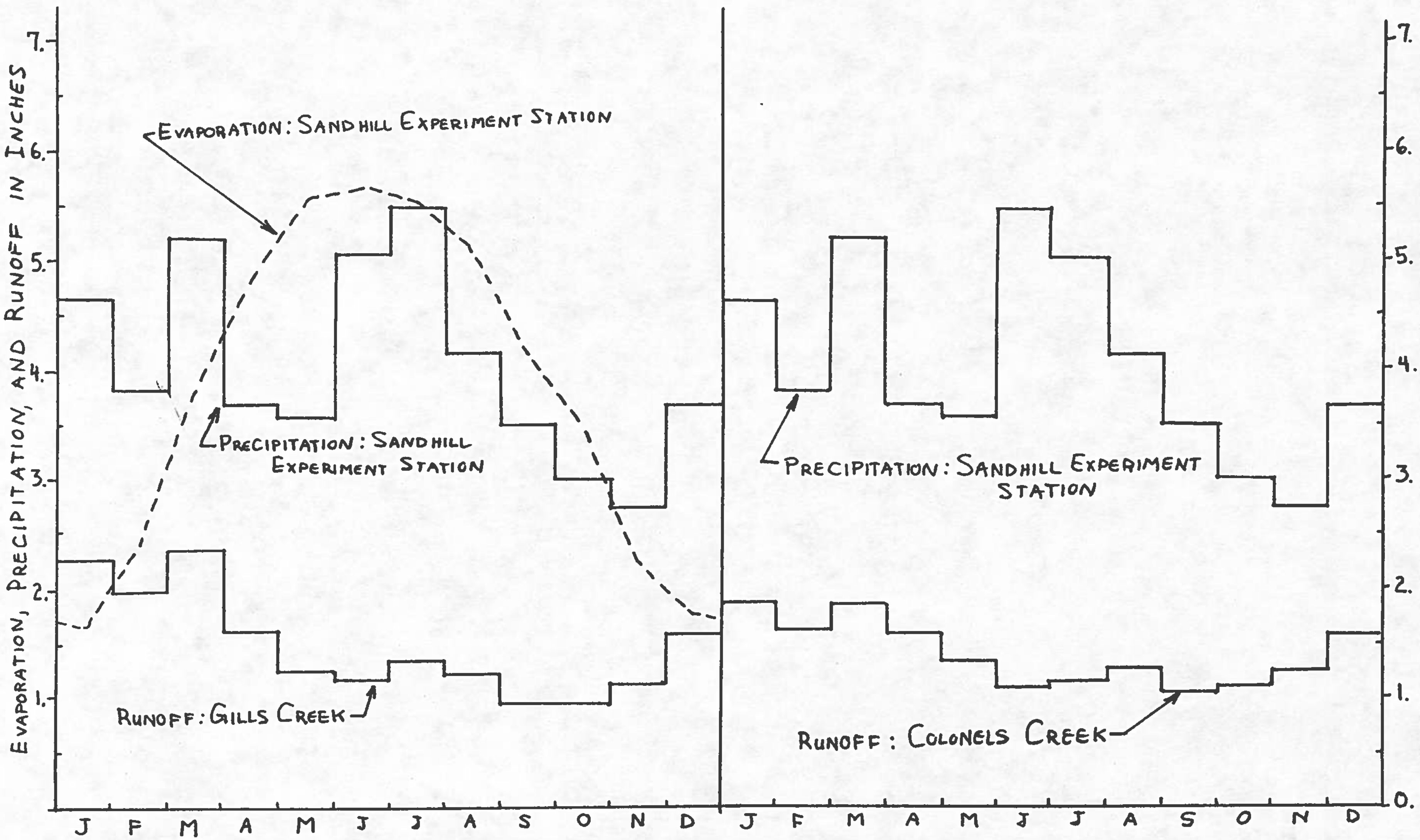

FIGURE 2. LONG TERM AVERAGE EVAPORATION, PRECIPITATION, AND RUNOFF, IN INCHES, FOR THE VARIOUS GAGES OF INTEREST TO STUDY.

drainage basin that are not identical to the situation in Spring Valley. Comparison of the streamflow statistics in Table 1, however, show that they are reasonably similar and should not pose any serious problems to this evaluation.

Another way of viewing these hydrologic data is to display them in time-line fashion, which shows how precipitation or runoff has varied over time. Also, to show how these monthly amounts vary in relation to the long-term monthly average, the data are displayed as cumulative departure from normal. The line goes up if the monthly value is greater than the average, goes down if less than average, and remains level if average. Figure 3 shows the cumulative departure from normal plots for precipitation at Sandhill Experiment Station and streamflow in Gills Creek for the period 1976 to mid-1985.

During the drought of 1980-81, a significant drop occured in both plots. With precipitation the following is noted:

* a drop of 25 inches below average precipitation during the drought;
* between mid-1981 to June 1983 precipitation remained fairly normal;
* from mid-1983 to mid-1984 precipitation accumulated greater than normal and made up the "lost" precipitation during this wet period;
* the current dry period followed, from August 1984 to June 1985, where precipitation difficiency has decreased the cumulative total lower than before.

This latest drought started in the normally dry time of the year in 1984 and continued through the normally wet winter which resulted in local soil moisture and aquifers not being replenished adequately. The onset of a dry spring and summer further depleted the natural water supplies and local lakes. With streamflow the following is noted:

* The 1980-81 drought produced a drop of 8 inches below average cumulative streamflow;
* streamflow returned to normal following the 1980-81 drought through 1983;
* cumulative total slightly recovered in 1984 due to higher than normal streamflow;
* and cumulative total streamflow decreased to a lower point than brfore by mid-1985.

This demonstrates that in this local area the runoff is responding fairly well to precipitation. It also shows that recent streamflow is continuing to remain below average levels. This means that less runoff is collecting in the lakes, and if even normal evaporation is occurring the net result could be an overall loss of lake water, particularly in the summer.

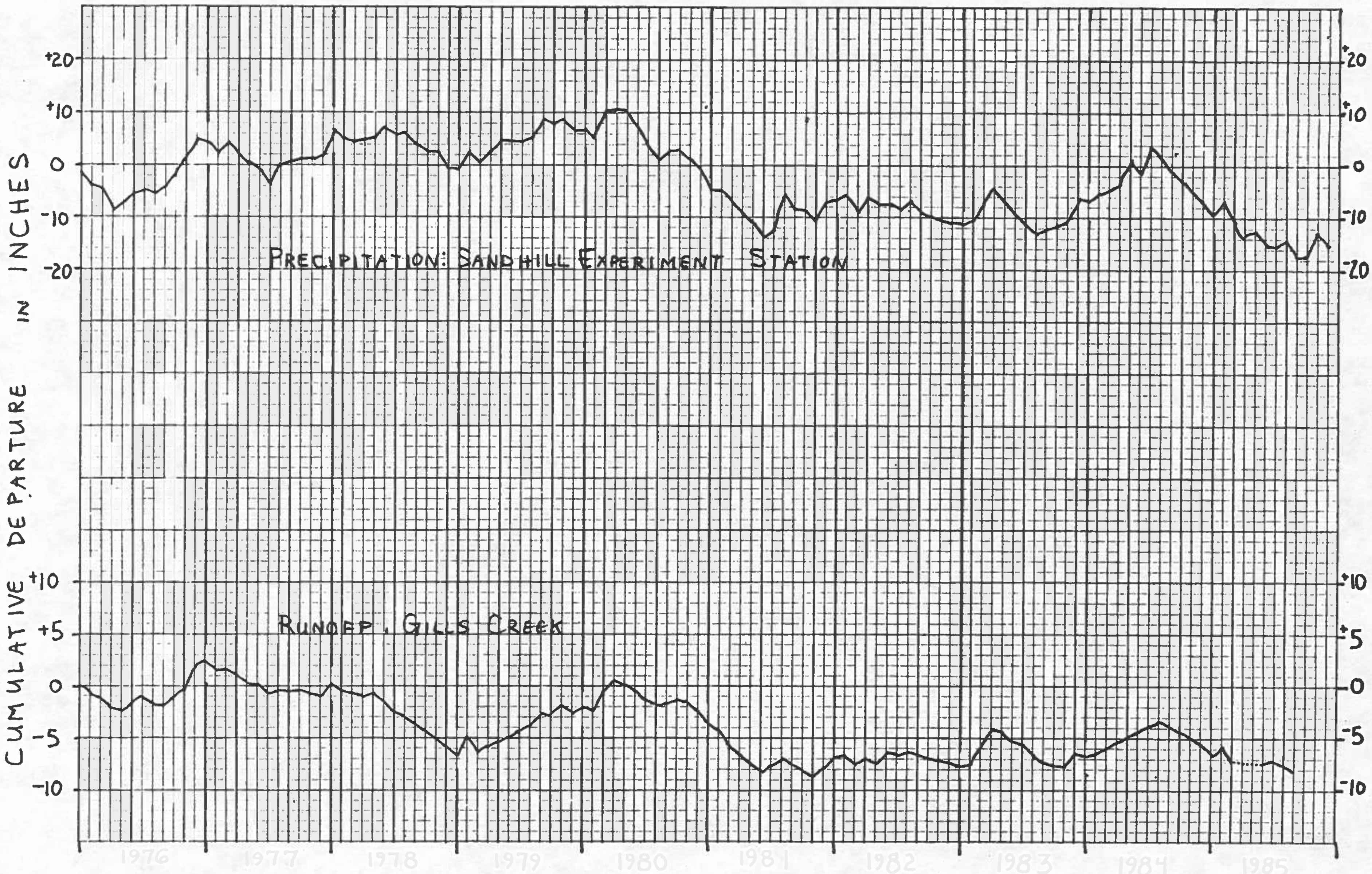

FIGURE 3. PLOTS OF CUMULATIVE DEPARTURE FROM MONTHLY NORMALS FOR PRECIPITATION AT SANDHILL EXPERIMENTATION STATION AT TOP, AND RUNOFF FOR GILLS CREEK, IN INCHES.

LAKE STATISTICS

A more detailed map of the Spring Valley area is shown in Figure 4, a photocopied portion of the Fort Jackson North 7 1/2-minute quadrangle. This map shows the lake locations and relative sizes, their drainage basin outlines and orientation, and the location of these lakes and their drainages in relation to the major drainage basins of the State. Clark and Park Shore lakes are located in the Broad River basin whereas the golf course is located in the Congaree River basin.

Two points are significant here. The first is that water pumped from Clark Lake to the golf course may constitute an inter-basin transfer, as specified by Act 90 of 1985. Mr. Buddy Sweet, the Greens Superintendent at Spring Valley Country Club, was notified 12/12/85 by letter from Mr. Paul League, Commission Leagle Council, concerning this matter. It is important that this matter be properly resolved prior to any future pumpage pumpage from Clark Lake to the Golf Course irrigation lake.

Second, and possibly important to the water problem, the lakes are located in the upper edges of two regional drainage basins in the Coastal Plain which are regional ground water recharge areas. Water entering the underlying sand could flow down the ground water gradient and out of the local drainage basin, thus decreasing the amount of water flowing into either of the lakes.

Further explanation of this recharge situation is related to the size of the drainage basins for the Spring Valley lakes and the streamflow gage. Table 2, below, lists the various statistics for the lakes of concern in Spring Valley, including the lake drainage basin sizes.

TABLE 2.

LAKE NAME	TOTAL DRAINAGE AREA (ACRES)	LAKE SURFACE AREA (ACRES)	RATIO: DRAINAGE AREA TO SURFACE AREA	EST. AVERAGE DEPTH (FEET)	EST. LAKE VOLUME (AC-FT)	RUNOFF RATIO: LAKE VOL TO DRAINAGE AREA (INCHES)
Clark	505.1	41.3	12.22	12.0	496.1	11.76
Park Shore	129.5	23.4	5.52	4.0	93.8	8.64
Irrigation	52.3	3.4	15.38	4.0	13.6	3.12

Clark Lake has the largest drainage area of the three lakes, 505 acres, which is less than 1 square mile (640 acres). The drainage area for Gills Creek is 59.6 square miles and for

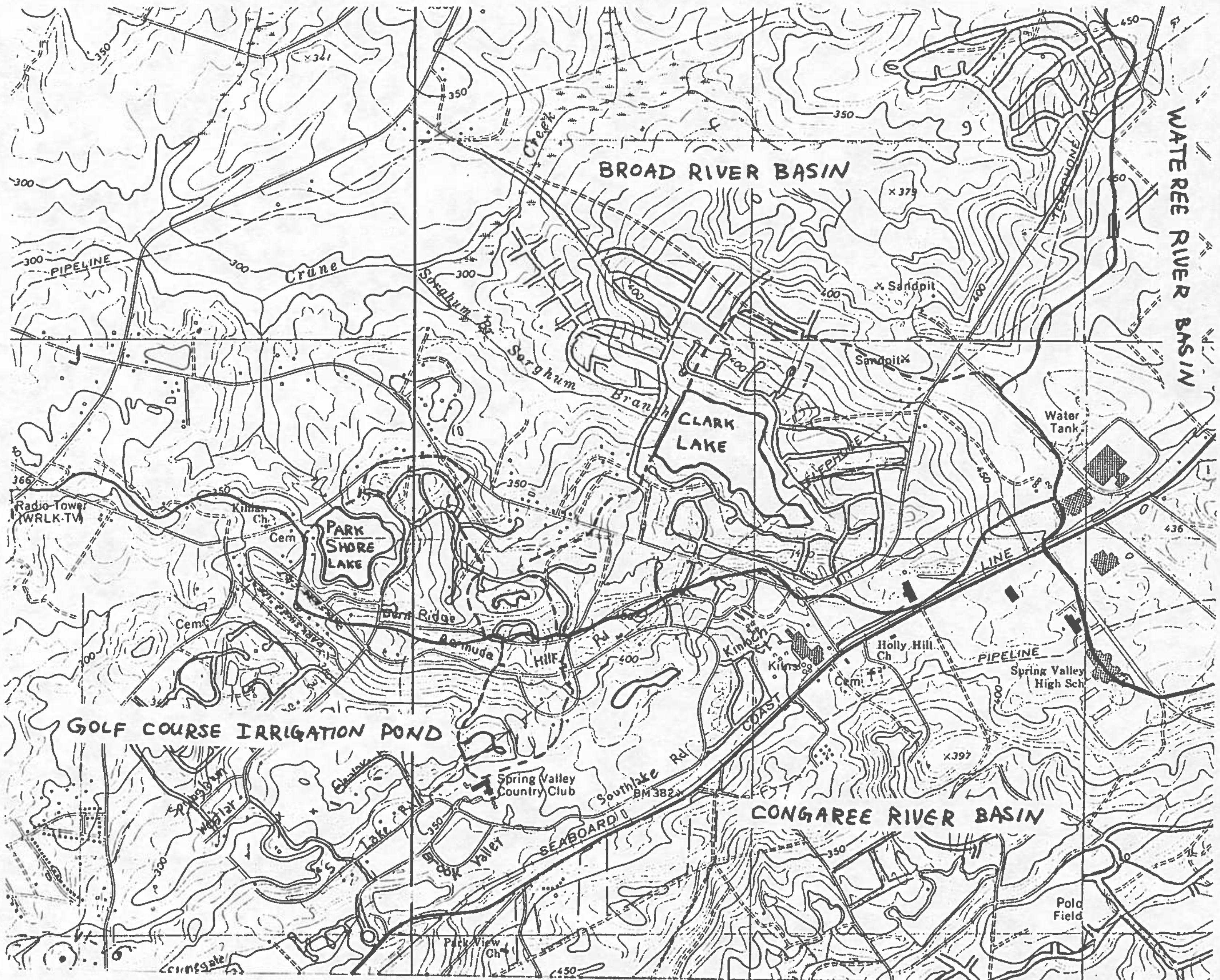

FIGURE 4. DETAILED LOCATION MAP FOR SPRING VALLEY SUBDIVISION SHOWING LOCATIONS OF LAKES OF INTEREST, DRAINAGE AREAS OF EACH LAKE, AND REGIONAL DRAINAGE BASIN DIVIDES.

Colonels Creek it is 38.1 square miles. These streams are considered to have relatively small drainages but are considerably larger than even that for Clark Lake.

The key point, however, is that a small stream in the upper Coastal Plain may recover, as ground water in-flow in it's lower basin, some of the ground water that percolated in the uppermost part of the basin. The tiny upper watershed basins may not. This results in the tiny upper watershed basins having a lower percentage of the rainfall occurring as runoff than the same stream a few miles downstream. This may well be the case in Spring Valley. For instance, the annual streamflow for Gills Creek, as listed in Table 1, is 17.58 inches per year. That flowing into Clark and Park Shore Lakes may be as low as 8 to 10 inches per year.

The drainage area contributing to each lake is an important factor to consider. The total drainage area for each lake and the lake surface area, when full, are listed in the second and third columns, respectively, of Table 2. The ratio of drainage area to lake surface area is listed in the fourth column. In general, for a given lake, the higher the ratio number the longer the lake will remain full and the faster it will refill after being lowered. The figures listed in the table indicate that Park Shore Lake only has 45 percent of the water-gathering capability, per acre of lake surface area, of Clark Lake. With all other factors being equal, this means that Park Shore Lake is more susceptable to drought than Clark Lake and thus would show more widely fluctuating lake levels.

Not all other factors are equal though. Clark Lake is about 25 feet deep at its dam whereas Park Shore Lake is only 8 feet deep. The lakes are not this depth throughout, however, and a detailed survey of the lakes is not available from which to determine the lake volumes. Therefore, from field visits and analysis of topographic maps, estimated average lake depths for the three lakes of interest and these are listed in the fifth column of table 2. If more acceptable assumed average depths can be determined, they should be inserted into the table and the corresponding corrections made in the next column to the right, lake volume. The estimated average depth directly impacts the estimated lake volume (surface area x depth) which, in turn, affects the figures in the last column: inches of runoff necessary to fill the given lake.

If filling totally empty lake beds, Clark Lake would appear to need five times more water than Park Shore Lake. This, however, translates to 11.76 inches of runoff from the entire drainage area of Clark Lake to fill the lake whereas Park Shore Lake needs 8.64 inches. This means that Clark Lake needs only 36 percent more runoff water from its basin than Park Shore Lake to fill a lake of five times the volume. This relationship is further demonstrated when the lakes are near full. Assume that the lakes are 2 feet below full. Clark Lake would require 1.96 inches of runoff to fill whereas Park Shore Lake would need 4.3

inches more than twice the runoff. In summary, Park Shore Lake has a natural hindrance to maintaining a full pool owing to its having too large a pool for the drainage area.

Case Example: Monitoring of Clark Lake

Below is summarized precipitation and lake level data, measured by Dr. Gerald Olsen for Clark Lake. Dr. Olsen has been gathering data since July 1985 but only November 1985 data are used in the examples below. The runoff ammount, and therefore lake-filling amount, from individual storm events is displayed in relation to the measured precipitation.

TABLE 3.

PERIOD	PRECIPITATION		RUNOFF		RATIO:	
	AMOUNT	BASIN VOLUME	LAKE RISE	VOLUME	RUNOFF/PRECIP	RUNOFF
	(INCHES)	(AC-FT)	(INCHES)	(AC-FT)	(%)	(INCHES#)
11/1- 11/11	0.56	23.99	1.31	4.52	18.84	9.14
11/12-11/17	0.33	13.89	0.25	0.86	6.21	3.01
11/18-11/23	3.09	130.05	5.88	20.30	15.61	7.75
11/28-12/1	1.21	50.93	1.63	5.63	11.05	5.36
Nov. Total	5.20*	212.43*	8.56	29.55	13.50	6.55

* - includes decrease for evaporative loss from lake
\# - annual runoff inches if RATIO percentage were applied to annual precipitation.

As can be seen from the above data, the runoff amount reaching Clark Lake is only four-tenths (6.55/17.58) of that for the nearby streamflow gages (Table 1). Please note that if any water withdrawal occurred during this time no power-usage data are available that would allow estimation of water usage to account for it. Any water withdrawals would have reduced the RUNOFF/PRECIP ratio. Also, November was the fifth month in 1985 with above-average precipitation in a year which is the second driest on record (40.69 in.) for the Sandhill Station. Most likely the soil moisture was low and possibly absorbed more of the precipitation than in an average situation.

This points up the need to continue monitoring Clark Lake and to begin the same type of monitoring for Park Shore Lake. If this monitoring indicates that the annual average runoff into the lakes is only about 20 percent of precipitation, or 9.70 inches, then this figure will need to be used for water budgeting purposes. Also, it is hoped that this monitoring will point out any local ground water recharging from the lake(s).

WATER USAGE

Water withdrawals from Clark and Park Shore Lakes are summarized below. Withdrawals are of two types:

1. withdrawals from both lakes by home owners for lawn irrigation; and
2. supplemental water withdrawals from Clark Lake.

Usage values for the first type of withdrawal can only be estimated. The estimation procedure is summarized below:

1. It is assumed that half of the lake-front home-owners have pumps in the lake;
2. It is assumed that the average pump will deliver 20 gpm (gallons per minute);
3. It is assumed that the pumps are operated 7 hours per week;
4. It is assumed that the lawns are watered during the period from April through September or 26 weeks; and
5. It is assumed that the lawns are actually watered half the weeks.

Below are summarized the water usage estimates for each of the two lakes of concern:

TABLE 4.

	Clark Lake	Park Shore Lake
No. of lots	50	30
x 1/2 = users	25	15
x 20 gpm = gpm / lake	500	300
x 60 min x 7 hour = gallons per week	210,000	126,000
x 13 weeks = gal / year	2,730,000	1,638,000
(= acre-feet / year)	(8.38)	(5.03)
(= feet of lake depth)	(0.22)	(0.21)
(= inches of runoff)	(0.20)	(0.47)

Those living in the neighborhood may be better able to judge the accuracy of these figures. It is thought that this sort of usage would occur during a dry summer and if the home owners were watering each week. Both of these values represent about 2-1/2 inches of lake lowering per year. Presenting these values in inches of runoff demonstrates that the impact on Park Shore Lake is greater than on Clark Lake.

The supplemental water withdrawals from Clark Lake were a little easier to estimate. The pump on Clark Lake has a dedicated power meter from which the power usage for each month can be converted to water usage. One point in the conversion needs your attention; the estimated pumping rate of the pump. This pumping rate is also important in relation to State laws concerning the reporting of water usage and the inter-basin transfer of water. No actual measurement of the pumping rate has been done, particularly with the pump valved down as it is now operated. According to Mr. Law of W. P. Law Co., that pump could deliver 500 to 600 gpm at full open valve. Mr. Sweet believes that the pump is delivering about 125 gpm with the valve open one-quarter of full. (Following the initial distribution of this report a pumping test was conducted indicating a pumping rate of 365 gallons per minute.)

Below is summarized the water withdrawl from Clark Lake calculated from the monthly power bills and the measured pumping rate of 365 gpm as supplied by the pumping test.

TABLE 5.

- 1984 -			- 1985 -		
MONTH	KW-HR	MILLION GALLONS	MONTH	KW-HR	MILLION GALLONS
Jan	3680	2.10	Jan	----	-----
Feb	----	----	Feb	----	-----
Mar	5920	3.36	Mar	2720	1.55
Apr	1300	0.74	Apr	15520	8.85
May	----	----	May	10080	5.75
Jun	8800	5.02	Jun	7200	4.11
Jul	1280	0.73	Jul	15520	8.85
Aug	3040	1.73	Aug	4800	2.74
Sep	----	----	Sep	9120	5.20
Oct	13440	7.66	Oct	7520	4.29
Nov	6240	3.56	Nov	no data	
Dec	----	----	Dec	no data	
ANNUAL		24.90			41.34
(Ac-Ft)		(76.42)			(126.87)
(inches of runoff)		(1.81)			(3.01)

As you can see, the water withdrawals for homeowner lawn watering is negligible. Also if the pumping rate from Clark Lake is found to be different than shown, then the usage values above would be correspondingly different.

Besides typical water usage, another known loss of water from each lake is evaporative loss. As shown in Table 1, above, the average evaporation in the Spring Valley area is 46.27 inches per year. The streamflow data also listed in the table represent the precipitation that has not been lost to various hydrologic "drains", with evaporation being the greatest. Once the runoff water gathers in the lakes it is again subject to evaporative loss. This is summarized below for each lake of consideration:

TABLE 6.

LAKE NAME	LAKE SURFACE AREA	LAKE EVAPORATIVE LOSS			PERCENTAGE OF RUNOFF	
			BASIN	LAKE		
	(ACRE-FEET)	(ACRE-FEET)	(INCHES)	(FEET)	(17")	(10")
Clark	41.3	159.40	3.79	3.86	22	38
Park Shore	23.4	90.42	8.38	3.86	47	84
Irrigation	3.4	13.11	3.01	3.86	17	30

Obviously, the larger the lake surface area the greater the water loss due to evaporation. The loss to Park Shore Lake, however, is much more significant than to the other two lakes in relation to the percentage of average annual runoff to the lake. During an average year, if 17.6 inches or runoff drained into the lakes, evaporation would remove nearly half of this inflow from Park Shore Lake. As noted earlier, the runoff to these lakes may be considerably less than the 17.6 inches, possibly as low as 10 to 12 inches. This latter case, described in the last column to the right in Table 4, would mean that over four-fifths of the runoff to Park Shore is lost to evaporation under normal circumstances.

In a related matter, if ground water were to be used to supplement the lakes, the amount needed just to replace evaporative loss from Clark and Park Shore Lakes is 249.82 ac-ft. If six water wells distributed around the lakes each pumped 30 gpm, a reasonable estimate for the area, they would need to be operated 24 hours a day for 314 days each year. The evaporative loss, however, may not be the amount of ground water needed, it may be less, but it points up a reasonable estimate of the ground water demand as it relates to Spring Valley's needs.

INTERRELATIONSHIPS

The various data elements presented above will be summarized here in order to illustrate the understanding of the situation and explain the need for additional data.

According to the data in Table 1, the average runoff in the Columbia Northeast area is about 17 inches per year. When compared with the runoff needed to fill each of the lakes, 11.76 inches for Clark Lake and 8.64 inches for Park Shore Lake, this indicates that sufficient water should runoff each year in both drainage basins to more than fill the lakes. The fact that this is apparently not occurring leads to suspecion that either less than the statistically estimated runoff is draining into the lakes or the lakes are recharging ("leaking into") the underlying stratum.

Below is a water budget for each of the lakes of concern using the figures described in the various sections above. The figures for Park Shore Lake do not include any supplemental infilling water from Clark Lake.

TABLE 7.

Case 1. Average annual runoff as gaged for Gills Creek:

	CLARK LAKE (AC-FT)	CLARK LAKE (INCHES)	PARK SHORE LAKE (AC-FT)	PARK SHORE LAKE (INCHES)
Annual inflow:...........	739.9	17.58	189.70	17.58
Annual out-flow:				
Evaporation............	159.4	3.79	90.42	8.38
Supplemental water use.	126.87	3.01	-----	----
Home-owner water use.....	8.38	0.20	5.03	0.47
+	294.65	7.00	95.45	8.75
-				
Remainder................	445.25	10.58	94.25	8.83
Expressed as percentage of lake volume..........	89.8		100.5	

TABLE 8.

Case 2. Average annual runoff estimated at 10.0 inches:

	CLARK LAKE (AC-FT)	CLARK LAKE (INCHES)	PARK SHORE LAKE (AC-FT)	PARK SHORE LAKE (INCHES)
Annual inflow:..........	420.88	10.00	107.92	10.00
Annual out-flow: (same as above)......	294.65	7.00	95.45	8.75
-				
Remainder...............	126.23	3.00	12.47	1.25
Expressed as:				
- percentage of lake volume..............	25.4		13.29	
- average lake depth...	3.05 feet		0.53 feet	

Case 1 indicates that enough runoff occurs annually, on the average, to refill each lake. Case 2 indicates that Clark Lake could be 3 feet low and refill whereas Park Shore Lake would only receive one-half foot of filling. The latter case appears to be closer to the real situation in light of the current water shortage.

So far only long-term averages have been delt with. In Table 9, below, are presented adjusted water withdrawals in relation to the actual yearly precipitation and runoff. The water withdrawls for 1985 were adjusted down so that they may be closer to an average withdrawal: 270 ac-ft from Clark Lake and 93 ac-ft from Park Shore Lake. Only the case of the lower runoff for the given precipitation is shown owing to the fact that the other case seems to result in more runoff than appears to be occurring.

In order to relate the runoff in the two basins to that in Gills Creek as it relates to the annual precipitation, a proportion was set up relating the assumed lower runoff into the lakes, (20 percent of precipitation), to the long term average runoff in Gills Creek, (36.2 percent of precipitation). This proportion, 0.5555, was used to multiply the annual runoff in inches recorded in Gills Creek. As can be seen in the data listed below, the runoff / precipitation ratio does not remain at 36.2 percent but varies widely. For this reason the proportion is applied. The column labeled "IN PROP" means inflow as a result of the proportion. The columns labeled "IN REMAN", meaning inflow remaining, shows the lake inflow minus the estimated withdrawals and the columns labeled "NET" lists the remaining inflow in terms of lake depth in feet.

TABLE 9.

	PRECIPITATION		RUNOFF		CLARK LAKE			PARK SHORE LAKE		
YEAR	AMT. (INCHES)	% OF NORM. (%)	AMT. (INCHES)	% OF RAIN (%)	IN PROP (A-F)	IN REMAN (A-F)	NET (FT)	IN PROP (A-F)	IN REMAN (A-F)	NET (FT)
1976	54.01	111.3	19.48	36.1	455	185	4.48	117	24.	1.03
1977	45.20	93.2	14.42	31.9	537	267	6.46	87	-5.8	-0.25
1978	41.92	86.4	12.39	29.6	489	219	5.30	74	-18.6	-0.79
1979	55.86	115.1	20.40	36.5	477	207	5.01	122	29.	1.24
1980	41.05	84.6	17.51	42.7	409	139	3.37	105	12.	0.51
1981	41.97	86.5	11.62	27.7	272	2	0.05	69	-23.6	-1.01
1982	44.88	92.5	17.96	40.0	419	149	3.61	108	15.	0.64
1983	53.27	109.8	18.31	34.4	428	158	3.83	110	17.	0.73
1984	47.83	98.6	17.58	36.8	411	141	3.41	105	12.	0.51
1985	40.69	83.9	14.73*	36.2*	(344)	(74)	(1.79)	(88)	(-4.7)	(-.2)

* - estimated runoff using long term average which thus affects remaning values to right, in parentheses ( ).

Even using this reduced runoff value, an estimated excess of runoff occurred every year in Clark Lake and in 6 of the 10 years for Park Shore Lake. During this 10-year period enough estimated excess runoff occurred in Clark Lake to fill it 3.1 times. Park Shore Lake only had an estimated excess runoff equal to 2.5 feet of lake depth, which is only 1/15 of that for Clark Lake. Again the poor lake filling ability of Park Shore Lake is pointed out in this manipulation of the data. More importantly, though, the data indicate that if the lake were 3 feet low in 1976 it should be roughly 1/2 foot below full now and would have to have had a net 0.2 foot drop from a year ago, with no supplemental lake filling.

It should be noted that Clark Lake was drained for dam and spillway repair within the past 3 to 4 years. Since that time, only enough runoff is estimated to have occurred to three-fourths refill the lake. If this is the case, then in future years the lake level may remain at or near full, varying with the runoff and evaporation throughout the year.

The results of this water budget work lead to the suspecion of one of several sources of error in the water budget equation:

1. The runoff into the two lakes may differ from the assumed average and/or from each other;
2. Since Park Shore Lake is much shallower than Clark Lake it may be a warmer lake and thus evaporate more water;
3. Both lakes may be recharging the underlying aquifer but:
   * Park Shore Lake is "leaking" more, or
   * Clark Lake's greater excess runoff exceeds the ground water inflow.

The above summarizes the reasons for recommending Park Shore Lake monitoring for both precipitation and lake level response. The simple calculations of runoff response to a given rain event, when compared with the data from Clark Lake, will answer point 1, above. Some calculations of evaporative loss in relation to lake depth may have to be done by a surface water engineer to see if point 2, above, should be considered. If the lake level appears to be lowering more than reasonable for evaporative loss, ground water recharge may be the likely suspect.

RECOMMENDATIONS

In light of the above findings, it is suggest that all of the following actions be pursued:

1. Continue monitoring precipitation and lake levels on Clark Lake for another 6 to 8 months;
2. Proceed with similar monitoring on Park Shore Lake for the period; and
3. Make the above calculations to determine which, if any, of the three suspected water withdrawals are consuming lake water.

The following suggestions are made concerning the management of the existing surface water resources:

1. If supplemental lake filling and/or golf course irrigation are to continue and Clark Lake residents desire a near-full lake level, install a system to initiate pumping from Clark Lake when the lake level exceeds a given level and shuts off when that level is reached. This would eliminate nearly all the potential lake spill and utilize it for Spring Valley's use;

2. Accept the fact that Park Shore Lake is oversized for its water resources and either live with the low-water situation or reduce the lake volume by either filling in deeper areas of the lake and/or reducing the lake perimeter to better accommodate the available water supply;

3. Pump ground water to supplement all three lakes listed herein. These pumps may have to be operated for nearly half the year to produce the necessary volume of water. As suggested earlier, if the lakes appear to be losing water to ground water recharge, this alternative may not be feasible.