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HYDROLOGIC ANALYSIS

of the

FALLEN LEAF LAKE WATERSHED

and

OPERATION PLAN

for

FALLEN LEAF LAKE

PREPARED BY: William Toby Hanes — 6/5/81
TOBY HANES, Hydrologist — Date

REVIEWED BY: William N Johnson — 6/5/81
WILLIAM N. JOHNSON, Watershed Staff Officer — Date

APPROVED BY: W. A. Morgan — 5 June 81
W. A. MORGAN, Forest Supervisor — Date

U. S. FOREST SERVICE

REGION 5

LAKE TAHOE BASIN MANAGEMENT UNIT

JUNE, 1981

WATER RESOURCES CENTER ARCHIVES

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PREFACE

This document was prepared in conjunction with another report, titled "Minimum Flow Study for Taylor Creek With Special Reference to the Taylor Creek Kokanee Fishery." The U.S. Forest Service operates the dam for varying purposes, some of which are not compatible. The sum of these documents will allow the Forest Service to operate the dam in an efficient and consistant manner in order to maximize the benefits associated with both Fallen Leaf Lake and Taylor Creek, within the constraints imposed by man and nature.

This report identifies the water available from the watershed and, in conjunction with the minimum flow study, an operations plan is presented. For a complete understanding of the instream flow needs which affect management of the dam, the minimum flow study is a prerequisite to this report. The Daily Operations Plan is basically a revision of an existing document. It is now intended as a field document to be used by the dam operations staff.

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INTRODUCTION

Fallen Leaf Lake (actually a reservoir) is an approximately two square mile body of water located near the community of South Lake Tahoe. Operation of the dam on the lake is under the jurisdiction of the U.S. Forest Service. Taylor Creek, the outlet to the lake, is a tributary to Lake Tahoe. The reservoir and the creek provide for a multitude of the uses, some of which are incompatible. Previous management of the reservoir was accomplished without a full knowledge of the water available from the Basin or a precise understanding of amount of water required to support instream flow uses. This report utilizes existing data to identify the Basin's water resources. Based on this information, an operations plan is presented. It is intended that operating the dam under this plan will provide the maximum benefits for all uses within the constraints imposed by the hydrologic processes at work and the hydraulic characteristics of the reservoir.

Existing Uses

The lake has both private and public recreation facilities whose users derive benefits from having certain levels during certain seasons of the year. Reservoir levels can effect the following uses associated with the lake:

1) Usability of established recreational facilities, both public and private, such as boat docks and launching structures and beaches.

2) Esthetic. High summer levels avoid the "bathtub ring" appearance of many reservoirs and provide truly lakefront homes for those residences located adjacent to the lake.

3) Flood and wave damage control. Low lake levels insure that adjacent lakefront properties and structures will not be damaged by flooding and/or wave action in conjunction with high winds.

The following are the instream flow uses associated with Taylor Creek. They are listed by priority. It was found that assigning a priority was necessary because of the limited water available for instream uses. Thus, in a dry year, water necessary to fully satisfy a use of lower priority will be forgone in order to provide satisfactory flow levels for a higher priority use.

1) Maintenance of the Kokanee salmon fishery. This fishery was established in the mid 1940's. Instream flows are required from October through March to provide for spawning habitat, egg incubation, fry development and migration into Lake Tahoe.

2) Maintenance of Bald Eagle habitat. The Bald Eagle, an endangered species, rely on the Taylor Creek Kokanee as a food source during and after the spawning run. Continuance of the Kokanee fishery will provide needed habitat for this endangered species.

3) Maintenance of aquatic ecosystems.

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4) Operation of the U.S. Forest Service Stream Profile Chamber. The chamber, located in the Forest Service Visitor Center adjacent to Taylor Creek, consists of a manmade diversion channel and pond. It provides exhibits and an under-water-level view of aquatic ecosystems and the Kokanee spawning run. Water from Taylor Creek is needed to provide aerated water at temperatures similiar to that in the creek itself.

5) Maintenance of the Brown Trout and Rainbow Trout fisheries. Flow is needed to provide for spawning habitat, egg incubation and fry and fingerling habitat.

6) Recreational & Esthetic. Property adjacent to Taylor Creek is entirely in the public domain under the auspices of the Forest Service. Numerous Forest Service recreational facilities in the area give rise to heavy use of the Taylor Creek stream environment zone for such uses as sightseeing, hiking, biking, picnicing, nature study, cross country skiing, and fishing.

There have been considerable problems in the past in providing for these numerous and diverse uses. Some of the uses are incompatible, and the problem is aggravated by the limited live storage capacity of the reservoir.

As an example, it is desirable to lower the lake in the fall to provide for flood control. However, to do so results in a large risk that water needed to sustain future flows for Kokanee egg incubation will be unavailable after the reservoir is lowered. The converse of this situation leads to the risk of receiving flood damage that might otherwise have been attenuated by lower antecedent water levels.

Fluctuating management direction and the lack of knowledge as to the water resources of the adjoining basin have led to less than optimum management of the water resources.

History

In 1951 the Forest Service acquired title to the property on which the dam is located and since that time, the dam has been under Forest Service jurisdiction. Over a period of time, there has been an increasing emphasis toward protection of existing instream flow uses by government agencies. This is a reflection of prevailing public attitudes. As a result, operation of the reservoir began to be directed toward providing for the above listed instream flow uses in the public interest. This led to the type of conflicts mentioned earlier with increasing frequency.

The Fallen Leaf Lake Protection Association was formed as an organization of homeowners whose common interest lie in attainment of certain lake levels. These levels fluctuated over the course of the year to provide the benefits cited earlier. The Association voiced their grievences to the Forest Service. They claimed that by not providing the lake levels

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they sought, the Forest Service was denying them of rights they acquired under the riparian doctrine under California water law. The Forest Service argued that the riparian rights asserted by the Association were subserviant to a prescriptive right the Forest Service acquired with title to the properties on which the dam is located. This dispute led the association to file suit in the United States District Court so that, in part, a finding could be made of the respective parties legal rights as to regulation of the lake. In lieu of formal adjudication, an out-of-court settlement was reached. This culminated a legally binding agreement entitled "Memorandum of Understanding Between the Forest Service and Fallen Leaf Lake Protection Association Regarding Operation of Fallen Leaf Lake" (U.S. Forest Service and Fallen Leaf Lake Protection Association, 1972). The document is a negotiated compromise between the two parties and sets forth high and low water levels within which the Forest Service is free to operate. The Association, however, continues its efforts through a steady correspondence and communication with the Forest Service to achieve the specific water levels it desires. In addition, the Forest Service itself has at times been unable to meet the instream flow requirements because of a lack of data on these uses, and a lack of clearcut objectives as to how the reservoir will be operated.

Statement of Policy and Objectives

The Watershed Staff of the Lake Tahoe Basin Management Unit took over responsibility of the operation of the dam on January of 1980. The above mentioned scenario has led to the recognition of the need for a well defined policy as to how the reservoir will be operated in order to provide for consistent management. This policy is as follows:

> Management of the reservoir will be directed toward fullfiling four objectives. These objectives have a definite heirarchy associated with them and no objective of lower order will be met until those of higher order are substantially fullfilled. These objectives, listed in decending order are:
>
> 1) Abide by the rules set forth in the Memorandum of Under standing.
>
> 2) Provide for the instream flow uses in Taylor Creek.
>
> 3) Provide for flood protection.
>
> 4) Provide for other specific water levels desired by the Association.

In order to operate effectively under this policy it was felt that there were certain items that needed to be determined and others that needed to be presented, which are the objectives of the remaining portion of this report. They are:

1) Identify the water available from the watershed and identify its temporal disposition.

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2) Integrate the above data with the demands for the water and formulate an operating plan composed of specific target reservoir levels that will best meet the needs for all uses within the heirarchy of the policy as stated above.

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HYDROLOGY OF THE FALLEN LEAF LAKE WATERSHED

The Fallen Leaf Lake watershed is located in El Dorado County near South Lake Tahoe. It lies just south of the southern apex of Lake Tahoe. The area of the watershed is 15.7 square miles and it is located within the Lahontan drainage basin (see the map on p. 9)[1]. The dominate portion of the watershed is that drained by Glen Alpine Creek at the south end of the lake. A sizeable portion of the basin lies within the Desolation Wilderness.

The watershed is steep and somewhat narrow and rises from 6380 feet to 9970 feet at Dicks Peak. Most of the Basin has undergone alpine glaciation. About 30% of the Basin in forested with soils of glacial or residual origin. The remaining portion supports thin residual soils or is composed of exposed granodiorite bedrock and talus slopes.

The climate can be described as typical Sierra montane. Summer temperatures are warm during the day and cool at night. Winter temperatures are cold but extended daytime temperatures below 20 F are uncommon.

Precipitation is highly affected by topography and orographic effects are common. Mean annual precipitation is approximately 30 inches near the dam and may exceed 60 inches at the top of the basin. Approximately 80% of this precipitation falls as snow in the headwaters. Mean April snowpack water content at Lake Lucille, which is located in the basin at an elevation of 8200 feet, is 54 inches. Most precipitation is caused by frontal type events associated with Pacific weather systems. Major floods are usually associated with rain events that occur during November through January. Convective type thunderstorm events may take place from July through September. However, they occur with neither the intensity or frequency that areas supported by a Gulf of Mexico summer maritime airflow experience (i.e. the Basin and Range province).

The snowpack in the Sierras is frequently termed "warm". The snow falling on the Sierras is much denser than snow that falls in the Rockies. This wet snow, in conjunction with the generally mild winter climate, results in a pack that usually does not develop a significant cold content and the temperature of the snowpack is generally at or near $0^{o}C$. The snowpack will therefore commonly yield melt throughout the winter.

The rocky nature of the watershed does not provide for much soil water storage. There is some surface detention storage provided by a number of small alpine lakes whose total surface area is approximately 0.5 square miles. The lakes provide for some attenuation of small storm peak flows. In terms of the annual flow regime, the lack of soil water storage leaves Glen Alpine Creek without a significant base flow component. The stream is semi-ephemeral and during dry years there will be no flow in August and September. Annual peak flows usually occur during the spring as a result of snowmelt runoff. Commonly, a steady winter

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1. Some of the descriptive information contained herein was derived from "Phase I Safety Investigation: Fallen Leaf Lake Dam" prepared for the U.S. Forest Service by Wahler Associates, 1979.

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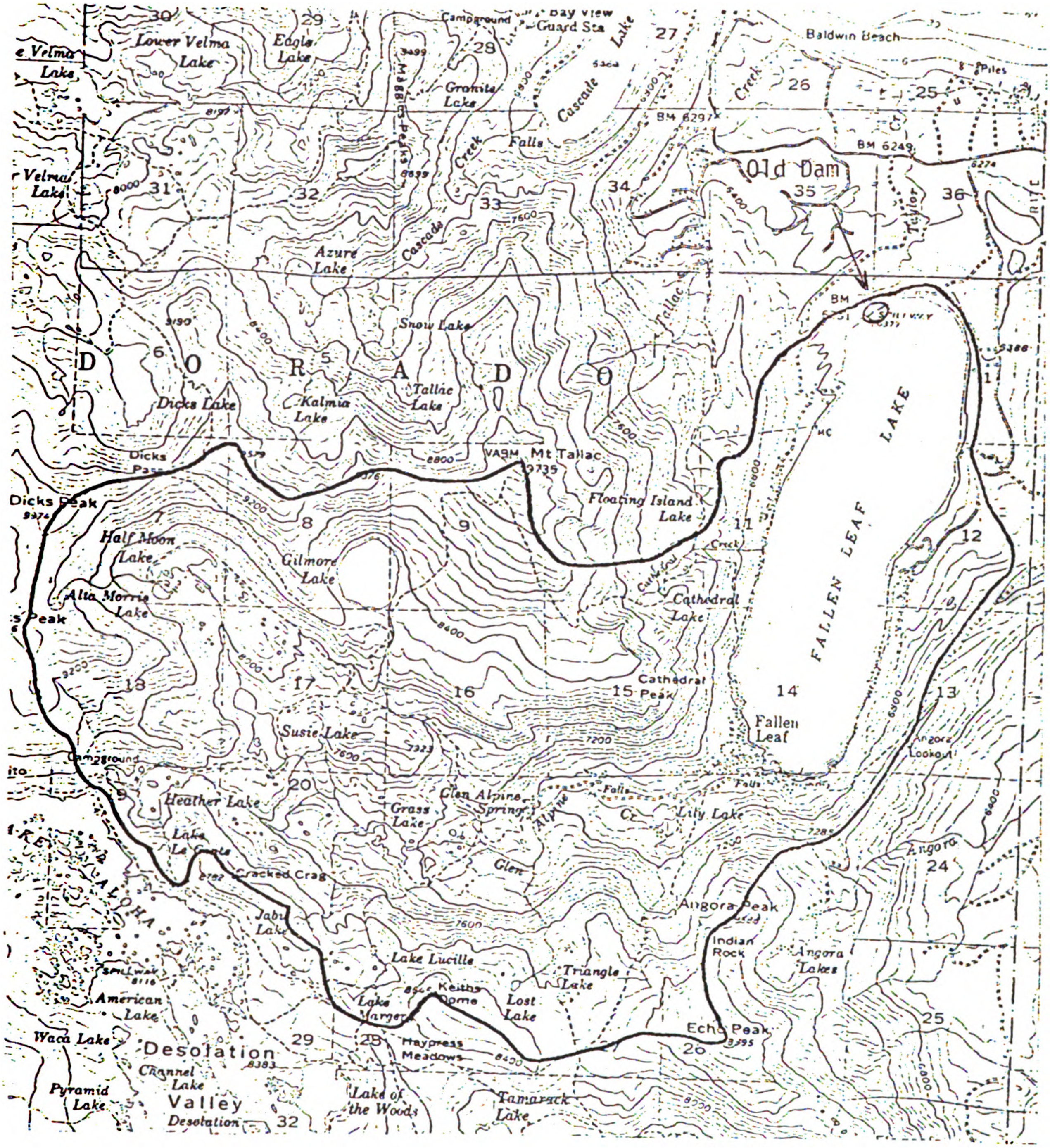

Figure 1. Fallen Leaf Lake watershed.

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baseflow component exists, which supplies 10-25 cfs inflow to the reservoir. An extensive runoff analysis is presented in the "Reservoir Water Budget" section of this report.

The lake is of glacial origin, with the area near the outlet being an end morraine. The lake is quite deep. For the most part the lake banks are steep and the change in storage capacity with stage is insignificant. Storage capacity is assumed to be 1400 acre feet per foot of stage. Due to an elevation difference of only 100 feet between Fallen Leaf Lake and Lake Tahoe, the local geology, and the presence of large meadows near the lake, seepage losses are assumed to be insignificant.

The dam is a lowhead concrete structure with a 30 inch outlet controlled by a gate. In addition there are three 8 foot wide spillway bays. The bays are 3 feet deep and are fitted with flashboards. Installation and removal of the flashboards are the primary means by which the water level is controlled. The Memorandum of Understanding defines the legal high water level as the top of the spillway bays (G.H. = 4.50 feet) and during normal years the legal low water level as the bottom (G.H. = 1.5 ft). The top of the dam is shaped like a broadcrested weir with 4 feet high cutoff walls and functions as the flood level spillway. The reservoir has a theoretical live storage capacity of 4200 acre feet. During drought years the Memorandum provides that the lake can be drawn down an additional 0.5 feet giving a live storage capacity of 4900 acre feet. An older dam built around 1908 exists 600 feet upstream from the present structure. It is a low concrete wall, about 2-4 feet high with ture has undergone significant deterioration, it still functions effectively as an hydraulic barrier. The old dam begins to exert control on outflow from the lake at gage heights of around 2.9 feet. This is evidenced by gage height discrepancies between the staff gage at the dam and the one on the lake. It assumes complete hydraulic control at gage height near 2.4 feet (flows passing over the old spillway are supercritical). The bottom of the old spillway is at approximately 1.9 feet and, for all practical purposes, the lake cannot be drawn below this level by gravity flow. In addition, in order to maintain a minimal outflow of 10 cfs an additional 0.3 feet of head is required giving an effective low water level of 2.2 feet.

Stored water is used in the fall for the Kokanee spawning run. Given the normal domestic and evaporative losses from the lake during the summer, and a minimum release into Taylor Creek to maintain aquatic ecosystems in this same period, it is difficult to keep the reservoir above a gage height of 3.0 feet before the start of the run. The presence of the old dam allows use of only 53% of the water the Forest Service has rights to during a normal year and only 40% during a drought year. It is obvious that the old dam is a major obstacle to meeting the highest priority instream need and this, in turn, limits Forest Service efforts at providing for other instream flow needs and lake levels desired by the homeowners.

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DEMANDS FOR WATER

Various demands are made for the runoff from the Fallen Leaf watershed. They are described as follows.

Domestic

Water is withdrawn from the lake to serve domestic uses, both private and public. This includes the residences around the lake and the Fallen Leaf Lake Lodge. A 28 inch pipeline serves the various U.S. Forest Service recreational facilities located on the south shore. These uses occur primarily from mid May through mid October. All the residences are essentially summer homes. The main roads into the area are not plowed during the winter but there are, however, some people who stay yearlong. Off-season domestic use in insignificant. Summer season use is a significant quantity, but not in terms of substantially affecting lake levels. However, total net losses from the system (evaporation, domestic use, and seepage) are accounted for in the annual water budget (to be presented in the next section).

Instream Flows

On the average, all the water that enters the lake, via either tributary inflow, subsurface runoff, or direct precipitation, minus losses such as domestic consumption, evaporation or seepage, exits the lake and flows down Taylor Creek. Unfortunately, the season of greatest demand and greatest inflow are not concurrent and the limited storage capacity of the reservoir does not alleviate the situation to any great extent.

The primary instream flow uses were described earlier in the report. A more detailed explaination of these uses and the flow required to support them can be found in "Minimum Flow Needs for Taylor Creek, With Special Reference to the Taylor Creek Kokanee Fishery", (USFS, 1980). The following tables list, by release period and use, that minimum flow needed to sustain the uses at their present levels, (Table 1) and that flow needed to insure only the survival of the aquatic populations the creek supports (Table 2). They are taken from the above cited source. The summary figures on Table 1 show those flows necessary to fullfill the minimum requirements of all the listed uses. The equivalent figure in Table 2 shows that flow needed to insure the survival of the population(s) associated with the highest priority use for each release period.

In terms of the aforementioned operating policy, it is the flow levels listed in the summary in Table 1 that the Forest Service will attempt to provide, within the framework of the Memorandum of Understanding. The summary values listed in Table 2 indicate the level to which the flow can be safely reduced when water is unavailable. Flows below these values incur the risk of damage to the health, vigor, and stability of the population in question.

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Table 1. Minimum flows by use and release period.

USE	Release Period Flows (cfs)								
	1	2	3	4	5	6	7	8	9
Kokanee	25	15	10	10	15	-	-	-	-
Bald Eagle	25	15	10	10	-	-	-	-	-
Aquatic Eco systems	7	7	7	7	7	10	10	10	7
Stream Profile Chamber	4	4	4	4	4	4	4	4	4
Brown Trout	25	15	10	10	10	-	-	-	-
Rainbow Trout	10	10	10	10	10	25	20	10	7
Recreation & Esthetics	10	10	10	10	10	10	10	10	10
Summary	23	15	10	10	15	25	20	10	10

Explaination

Release Period
1. Oct 8-31
2. Nov 1-15
3. Nov 16-30
4. Dec 1-Feb 28
5. Mar 1-31
6. Apr 1-June 30
7. July 1-15
8. July 16-31
9. Aug 1-Oct 7

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Table 2. Minimum flows necessary to insure survival of populations and other absolute minimum flow levels

	Release Period Flows (cfs)								
USE	1	2	3	4	5	6	7	8	9
Kokanee	10	10	5	7	7	-	-	-	-
Bald Eagle	10	10	5	7	-	-	-	-	-
Aquatic Eco-system	3	3	3	3	3	10	10	7	3-4
Stream Profile Chamber	2	2	2	2	2	2	2	2	2
Brown Trout	10	10	5	7	7	-	-	-	-
Rainbow Trout	5	5	5	7	7	10	10	7	3-4
Summary	10	10	5	7	7	10	10	7	3-4

Explaination

Release Period
1. Oct 8-31
2. Nov 1-15
3. Nov 16-30
4. Dec 1-Feb 28
5. Mar 1-31
6. Apr 1-June 30
7. July 1-15
8. July 16-31
9. Aug 1-Oct 7

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Lake Levels

The Fallen Leaf Lake Protection Association seeks the attainment of certain water levels. These levels vary, depending on the season of the year. Attainment of these levels will help maximize the benefits associated with the uses cited previously. Figure 2 depicts the lake levels they seek to attain.

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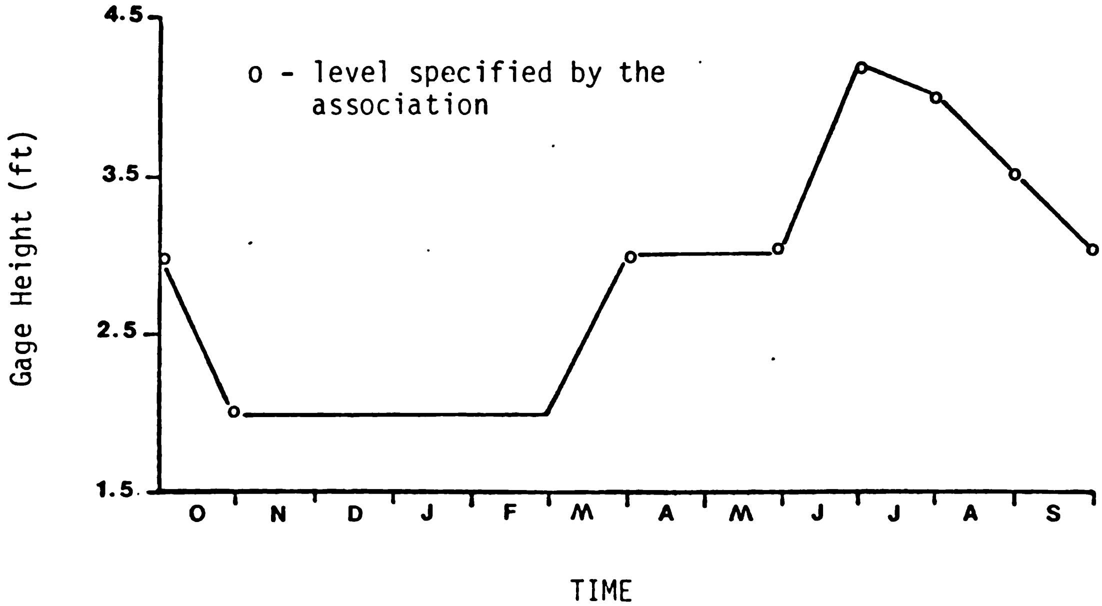

Figure 2. Lake levels desired by the Fallen Leaf Lake Protection Association.

1. Source: Correspondence from H.D. Pischel to Administrator, Lake Tahoe Basin Management Unit, August 29, 1974.

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WATER BUDGET

In order to manage the reservoir to provide for instream flows and water levels, it is necessary to know how much water enters the lake and when. Previous to October of 1968, there was no recording gage on Taylor Creek. Without such a gage it was impossible to determine the water budget of the lake and operations were based on speculation and experience. Reservoir levels, however, were monitored by the Association and this data was made available to the Forest Service. Since the start of the 1969 water year the Forest Service has contracted with the U.S. Geological Survey to provide continious monitoring of both the flow in Taylor Creek and the reservoir level. There are now eleven years of data available (U.S. Geological Survey). This report is apparently the first such use of this data.

The water budget was calculated on a monthly basis using the standard reservoir equation:

$$I = O + \Delta S$$

where O = Outflow
I = Inflow
ΔS = Change in storage over the time period

Since O was available from the flow data for Taylor Creek and S was determined from reservoir level data, the equation was solved for I. It is important to note that I represents the <u>net</u> monthly inflow. "I" can either be a positive or negative value. This is explained by not having precise data on outflows, other than streamflow releases. Therefore, if water entering the lake by tributary flow, precipitation interception, or subsurface flow exceeds the amount leaving the lake by any means, with storage accounted for, I is positive. If, however, the reservoir level drops and this value in acre feet exceeds the total flow in Taylor Creek for the period the net I is negative. A negative value connotates that other sources of outflow, primarily evaporation and domestic use, exceed the algebraic sum of streamflow releases and water entering the lake, if any.

Table 3 shows the net monthly inflow data for the period of record, along with the mean, median, standard deviation and coefficient of variations. Using this data, relative frequency distributions of net inflow for each month were constructed. Upon these were imposed the assumed actual frequency density functions (PDF's) (Benjamin and Cornell, 1970). These graphs are shown in Figures 3-5. It should be noted that the integeral of each function may not equal 1.0.

Inspection of Figures 3-5 shows that the distributions are frequently skewed. For planning purposes using mean values where a distribution is skewed is inappropriate. For instance, a water company bases its budget and profit margin using the average inflow into its system. The

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Table 3. Monthly net inflows, in acre feet, and descriptive statistics

Year	Oct	Nov	Dec	Jan	Feb	Mar	Month Apr	May	Jun	July	Aug	Sep
1969	118	3000	1630	4750	3070	1540	5210	15380	11370	4670	280	-390
1970	431	632	4970	11360	1906	2000	2550	9240	8600	2070	-504	-570
1971	-188	3140	2280	2460	1580	2120	3240	8830	11670	3070	-240	-493
1972	-355	916	1620	700	1110	3800	2980	8150	5620	76	-547	-209
1973	297	939	3760	2730	1260	1130	3530	12640	5440	321	-605	-474
1974	221	9020	2600	5010	1260	2590	3240	10800	9590	3530	-67	-430
1975	-211	46	440	932	1340	1930	1210	9490	10700	2650	161	-3
1976	2330	1680	624	513	882	930	1840	4460	403	-217	416	-151
1977	-236	-14	-183	86	583	515	2400	2620	1940	-497	-675	-609
1978	-459	322	2340	1930	1220	2640	3510	9190	10730	2990	-443	14
1979	-250	72	372	2860	1390	1540	3390	9910	4070	713	-567	-500

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Month Apr	May	Jun	July	Aug	Sep
Mean	145	1790	1860	3030	1420	1890	3010	9160	7280	1760	-253	-347
Median	-188	916	1630	2460	1260	1930	3240	9240	8600	2070	-443	-430
Std. Dev.	749	2640	1560	3200	645	916	1040	3470	3990	1753	390	222
Coef. of Var.	5.16	1.47	0.83	1.06	0.45	0.49	0.34	0.37	0.55	0.99	1.54	0.64

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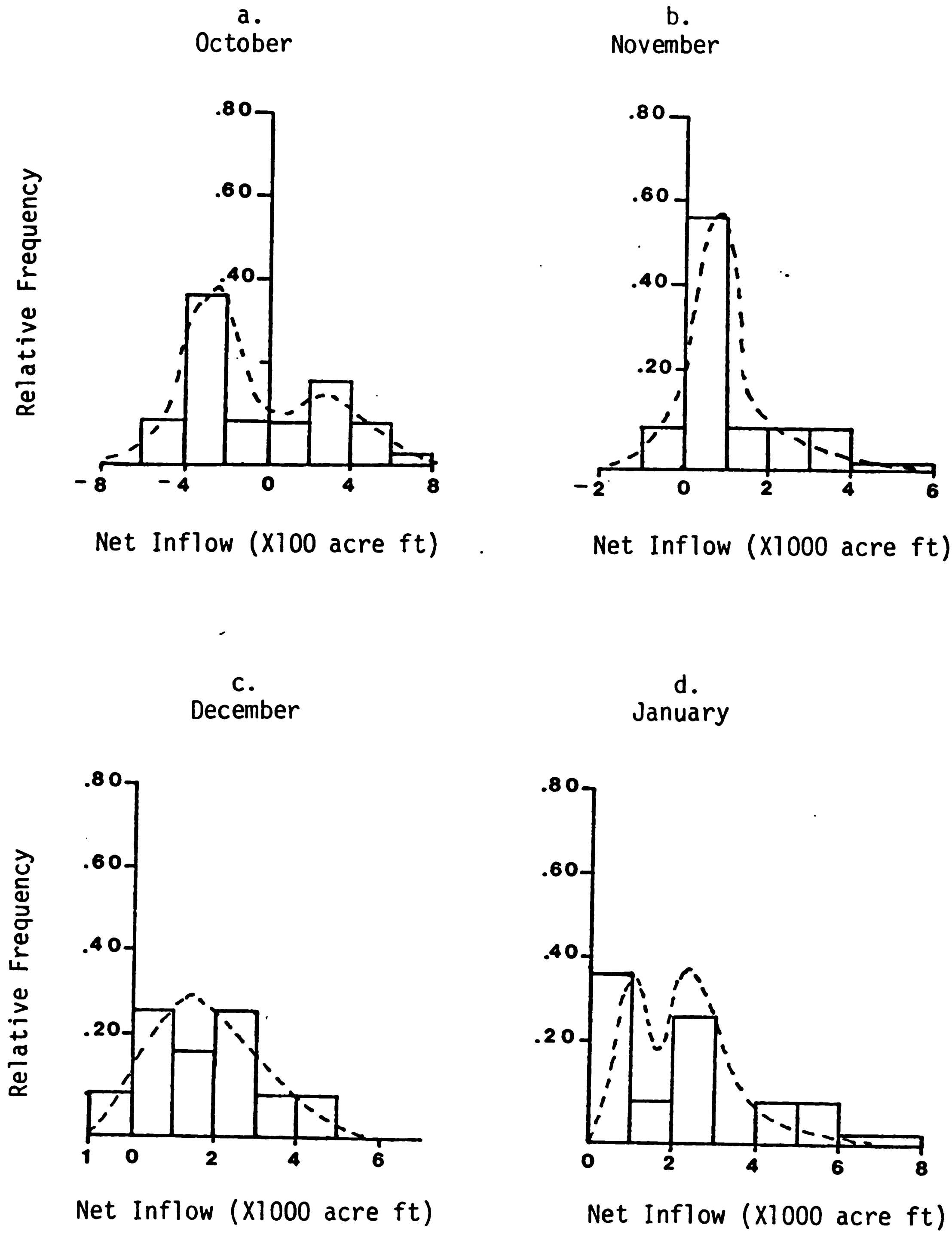

Figure 3. Relative frequency distribution of net monthly inflows and assumed PDF's for the months of (a) October, (b) November, (c) December, and (d) January.

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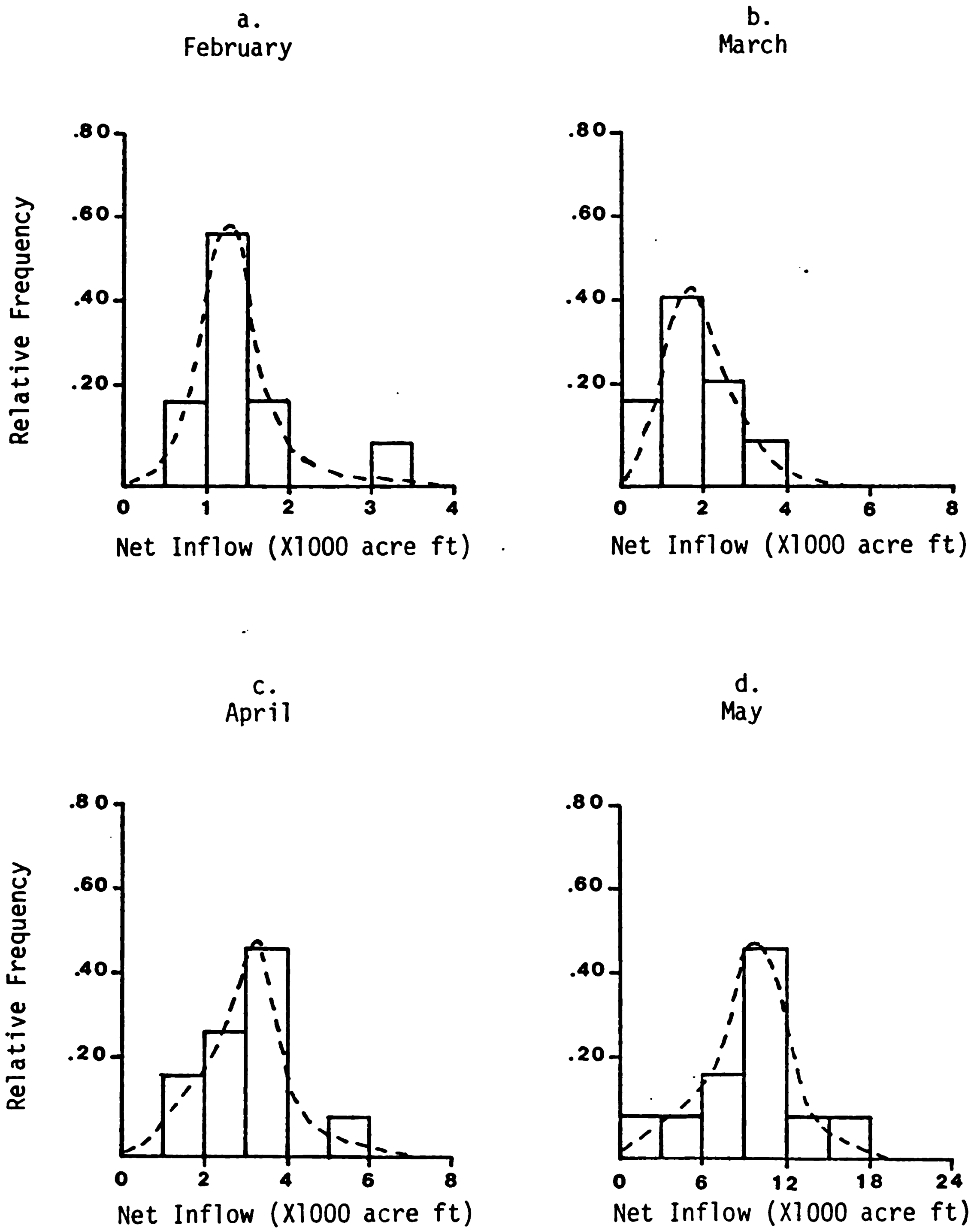

Figure 4. Relative frequency distributions of net monthly inflows and assumed PDF's for the months of (a) February, (b) March (c) April, and (d) May.

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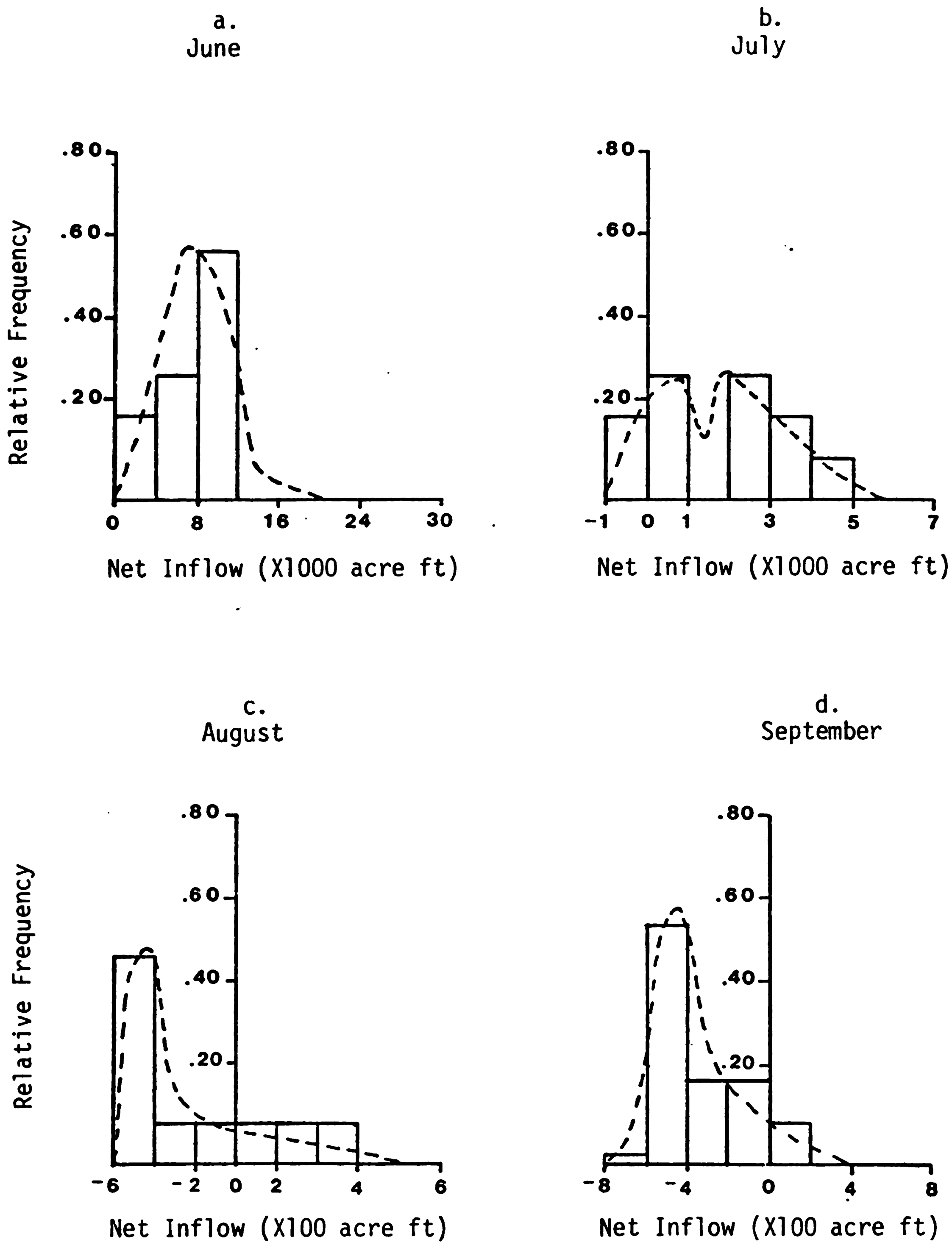

Figure 5. Relative frequency distribution of net monthly inflows and assumed PDF's for the months of (a) June, (b) July, (c) August, and (d) September.

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individual observations for inflow for each year are 10, 12, 15, 228, 7, and 11 thousand acre feet. The mean inflow is 47, however, for 5 of the 6 years, inflow is about 11. It is obvious that this company that has expenditures bases a receiving income from 47 thousand acre feet when the majority of the time only 11 thousand acre feet available will not be in business much longer.

In cases such as these, the most valid measure of central tendency is the median. The median value is that which is most likely to occur. It is defined as that value in which 50% of the observations are higher and 50% are lower. Predictions based on the median receive the best chance of success.

Table 4 gives the most likely net inflows and the sustained flow rates for each month. Slight adjustments were made from the raw data in order to fit them to the assummed PDF's.

The median net annual runoff (accounting for lake evaporation and domestic use) is 28,100 acre feet, or 34 area inches. This volume would support a constant yearlong flow of 39 cfs. However, the actual distribution of this runoff is far from uniform, nor is it reliable. Inspection of the previous figures and analysis of the coefficient of variation figures depict this variablility.

In general, the higher variability, the less likely that the inflow planned for will be received. This generates the need for storing excess water when it is available to lower the risk, and consequences of a future shortfall (indeed, then is the reason most reservoirs are built).

Runoff totals during the months of February through June have the least variability and a good degree of confidence can be placed in receiving the most likely (median) inflows. Runoff during these months is caused primarily by snowmelt. The amount of melt is determined by the energy available, which is fairly constant from year to year as far as the total amount received within any given month. The month of April has the lowest variability of all because of the lack of heavy precipitation and predominate sunny skies shining on an extensive snowpack that has more snow than there is energy with which to melt it.

The months of July and August are quite variable. July has a frequency distribution that is distinctly bimodal. This probably is, in fact, a bimodal distribution and not a reflection of the pacuity of data. During July it appears that the two modes can be a reflection of the weather pattern the previous spring (i.e., either the spring is wet and cloudy or, to some extent, it isn't). Thus, either a significant portion of the residual snowpack in left at the start of July, or there is none. Also, during July and August thunderstorms can contribute runoff. While individual convective type events are random and independent, the general weather pattern that creats a favorable environment for their occurance is not, and it appears that either this type of persistant system is present or it is not.

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Table 4. Median (most likely) net inflows and the associated sustained release to Taylor Creek, if any.

Month	Net Inflow (acre feet)	Sustained Release (cfs)
October	-250	-
November	800	13
December	1400	23
January	2400	39
February	1300	23
March	1700	28
April	3300	55
May	9100	148
June	7000	118
July	1800	29
August	-450	-
September	-450	-

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The month of September is moderately variable which seems to be the result of an absence of major thunderstorm activity.

Net inflows for October are extremely variable. This, for the most part is unexplained, but may be a function of the arrival of cooler fall weather.

The months of November through January are also quite variable which is mostly a function of the number and intensity of storms received during these months.

The majority of the large floods in the basin occur from November 10 through January. These floods cause high reservoir levels which can damage lakefront properties and high flow levels in Taylor Creek which can wash out Brown trout and Kokanee eggs. Figure 6 shows, for the 11 year period of record, the peak flow and maximum rise in reservoir level associated with each flood. Analysis reveals that antecedent levels under 2.5 feet will keep 80% of the floods from exceeding a gage height of 4.5 feet (top of the dam - bottom of overflow spillway), and attenuate flood peaks to keep eggs from being washed out. The remaining floods (return periods exceeding 5 years) will likely top the dam regardless of antecedent levels and peak flows in the creek may be expected to wash out eggs.

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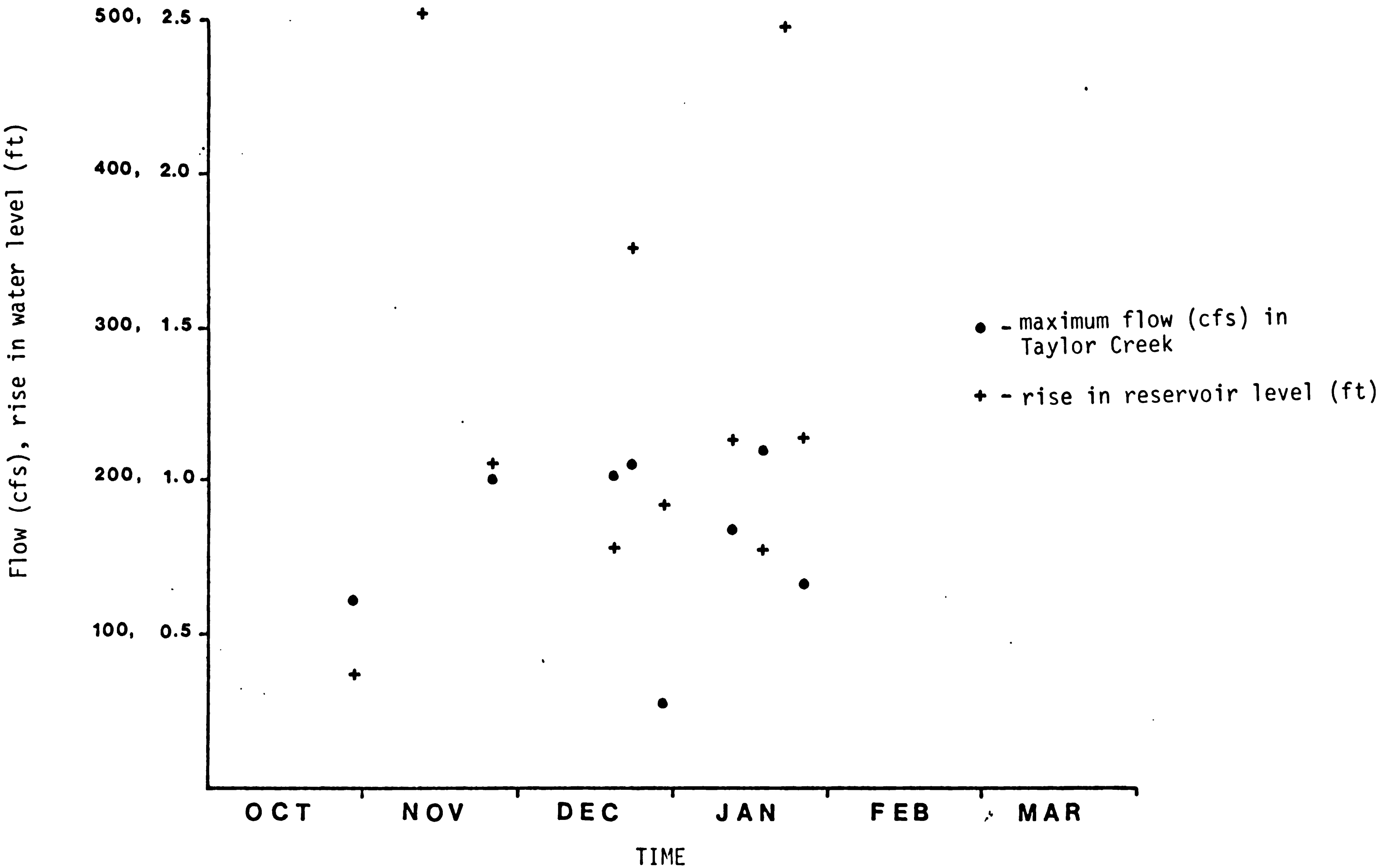

Figure 6. Occurance and magnitude of fall-winter storms.

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DAM OPERATIONS PLAN

The following section combines the data on the runoff with water demand. The old dam is a major constraint in achieving the stated goals and it has been recommended that a portion of the spillway be removed to provide hydraulic continuity between the reservoir and the new dam. Until this is accomplished, operations will differ significantly from what they will be without the old dam. For this reason it is necessary to present two operating plans, one to be used with the old dam in place, the other to be used in its absence.

Available Inflow vs Demand

Median net annual runoff from the basin is 28,100 acre feet (evaporation losses and domestic use accounted for). This volume would support a steady yearlong release of 39 cfs. Substansive instream flow needs represent 41% of this volume, while flows designed to maintain survival of aquatic populations represent 19% of the total. The available live storage capacity (from gage height 4.5 feet to 2.2 feet) is 11% of the total volume with the old dam in place and 15% (from gage height 4.5 feet to 1.5 feet) if the reservoir could be drawn down to the level set in the Memorandum of Understanding.

Table 5 lists the most likely net inflows by release period followed by the instream flow requirements in each catagory. These are followed by designation of whether this outflow can be supported by the inflow or if stored water release is needed to fullfill the requirement. If the latter occurs, the decrease in water level associated with it is shown. It is important to bear in mind that the figures shown are probably not what will actually occur. It is quite probable that stored water would be needed for all but the February-June release periods. For this reason it is prudent to carry additional water if it is available, or to release less water during lower priority release periods to protect higher priority instream uses.

Operating Rules

The reservoir will be operated via the policy stated earlier. In more specific terms, the operating rules are:

1) The lake level will not be raised over 4.5 feet.

2) The lake will not be drawn down below 1.5 feet in a normal year nor below 1.0 feet in a drought year.

3) The lake will not be drawn down below 3.0 feet before September 30 by Forest Service acts. Domestic use and evaporation losses can nearly exceed this level without any release to Taylor Creek.

4) A minimum flow of 3 cfs will be released into Taylor Creek at all times.

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Table 5. Comparison of median net inflows with instream flow requirements. Instream Flows 1 are derived from Table 1, Instream Flows 2 are taken from Table 2.

Release Period	Ave Net I (cfs)	Min. Instream Flows 1 (cfs)	Change In Res. Level Level (ft)	Min. Instream Flows 2 (cfs)	Change In Res. Level Level (ft)
1	-4.1	23	-0.99	10	-0.48
2	12.8	15	-0.05	10	+
3	14.1	10	+	5	+
4	25.2	10	+	7	+
5.	25.0	15	+	7	+
6	104.0	25	+	10	+
7	44.4	20	+	10	+
8	15.1	10	+	7	+
9	-7.1	10	-1.64	3	-0.97

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5) The lake will be drawn down starting October 8 to provide flow for the Kokanee spawning run and to provide for flood control.

6) During a normal year the reservoir will be maintained below a gage height of 3.0 feet in the spring through May as requested by the Fallen Leaf Lake Protection Association. During this period the lake will be uncontrolled by flashboards.

7) The lake will be filled to near capacity by July 6, unless inflows exceed the release capacity of the gate, in which case at least one of the top set of flashboards will be kept out. This will insure that the reservoir does not exceed the 4.5 feet level.

Within the above guidelines, and as runoff and climatic conditions dictate, as many of the objectives as possible, in terms of instream flows and desirable lake levels, will be met.

Target Levels and Release Plans

The plans as described in terms of target antecedent and ending levels and release volumes. The critical targets are filling the reservoir to capacity on approximately July 6, and having the maximum amount of water available for the Kokanee spawning run in October. Continuious monitoring during these periods will be necessary. Six release plans for the Kokanee run and egg incubation period have been established based on various October antecedent water levels. The plans provide for success levels slightly greater than 50% of the time (with the old dam in place) based on the median expected inflows (a full discussion of success probabilities is presented in the Evaluation section). Given the natural variability in the net inflows it can be expected that about 40% of the time there will be more than the expected inflow and releases and storage should be adjusted accordingly. Likewise about 40% of the time there will be less than the expected inflow and flows during the summer should be adjusted down to the minimum acceptable in order to conserve water for the Kokanee run.

Table 6 shows the release plans to be used during the Kokanee spawning and egg incubation period. These plans are geared to provide the maximum spawning habitat and egg protection within the amount of water available. Plans A and B can be viewed as drought year plans, plans C and D as normal year plans and plan E as a wet year plans. Once a plan is selected it should be followed if target levels are being achieved. If not, adjustments should be made. Such adjustments may be needed within a release period. It is not effective, for instance, to release an abundance of water during the spawning run and because of a shortfall have insufficient water to keep eggs well aerated and free from desiccation.

Too often in the past operation, the gate to attain a target level has been a matter of trial and error, this need not be the case. Appendix A presents formulas specific to the operations of Fallen Leaf Lake reservoir and example problems.

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Table 6. Kokanee fishery Release Plans

Antecedent level[1]			Release Period[3]				
Plan	WD[2]	WOD[2]	1	2	3	4	5
A	2.70	2.70	10	10	5	10	10
B	2.95	2.80	15	10	7	10	15
C	3.20	3.00	20	15	10	10	15
D	3.40	3.20	25	15	10	10	15
E	3.60	3.20	30	15	10	10	15

1. Actual antecedent should equal or exceed the level stated for a given plan.

2. WD - with old dam, WOD - without old dam. The additional capacity available without the dam enables lower release period 9 ending target levels for release period No. 9.

3. Release Period 1. Oct 8-31
   Release Period 2. Nov 1-15
   Release Period 3. Nov 16-31
   Release Period 4. Dec 1 - Feb 28
   Release Period 5. Mar 1-31

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Plan 1 - As Constrained by Old Dam

Target Level

Start	End	
		Release Period July 6-15 (No. 7)
4.45	4.45	During years of normal snowpack, release water as necessary to prevent exceeding the 4.5 level. During years of above normal snowpack, keep flashboards out as necessary to prevent exceeding 4.5 level. During drought years target release is 9-10 cfs.
4.45	4.30	Release Period July 16-31 (No. 8)
		Release water as necessary to meet target. During all but extreme drought years release at least 5 cfs whether or not target is met.
4.3	3.2-3.6	Release Period August 1 - October 7 (No. 9)
		Release a minimum of approximately 3 cfs regardless of antecendent level or target, except in years of extreme drought. During wet years release water as necessary to achieve 3.6 target level. As soon as top set of flashboards are "dry" remove them for flood control.
		Release Period October 8-31 (No 1)
		Follow one of the spawning flow release plans based on the antecedent level. Choose a plan where the acutal water level equals or exceeds the antecedent level on which the plan is based. Refer to the evaluation section for a discussion on success probability. Consult with California Department of Fish and Game. If additional inflow occurs increase release and store water to a maximum level of 2.7 feet at end of period. If it appears that there will be a large shortfall it may be necessary to adopt a plan with lower releases. Remove flashboards as they become "dry" or preferably obtain desired flow by pulling boards and letting water spill in conjunction with use of the gate. If antecedent level is below 2.7 feet consult with concerned parties to develop a release plan.

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Plan A

2.70 2.27 Release 10 cfs

Plan B

2.95 2.30 Release 15 cfs

Plan C

3.20 2.40 Release 20 cfs

Plan D

3.40 2.40 Release 25 cfs

Plan E

3.60 2.45 Release 30 cfs

Release Period November 1-15 (No. 2)

Release flows as specified. If additional inflow becomes available, increase outflow and storage as needed. Maximum reservoir level at the end of period is 2.6 feet.

Plan A

2.27 2.33 Release 10 cfs

Plan B

2.30 2.35 Release 10 cfs

Plan C & D

2.40 2.35 Release 15 cfs

Plan E

2.45 2.40 Release 15 cfs

Release Period to November 16-31 (No. 3)

Release flows as specified. If additional water becomes available increase release and store water to a maximum of 2.5 feet. Remove any remaining flashboards at start of period.

Plan A

2.33 2.50 Release 5 cfs

Plan B

2.35 2.47 Release 7 cfs

Plan C & D

2.35 2.45 Release 10 cfs

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Plan E

2.40 2.50 Release 10 cfs

Release Period Dec 1 - Feb 28 (No. 4)

Varies 2.50 Set gate to release desired water using the table in Appendix B under the 1.5 feet gage height setting. Under Plans A-E, the minimum release is 10 cfs. Under Plan D, it is 15 cfs. Under this scheme, the reservoir is unconstrained as to release at higher levels but does not allow for rapid over release if levels are low. Monitor levels as necessary if they are low.

Release Period March 1-31 (No. 5)

Varies 3.0 Make at least the required minimum release of 10 cfs for Plan A, 15 cfs for plans B-E. A shortfall during this month is rare.

Release Period April 1 - July 5 (No. 6)

3.0 4.45 Install first set of boards at start of period. Keep level around 3.0 feet until after May 20 which should cause no problems except in extreme drought years when the level should be brought up earlier. It is advisable to install the first three set of flashboards and open the gate valve all the way before water begins to spill over the bays. This should be accomplished just before April 15. After June 10 begin installing additional boards one set at a time. During dry and normal years the lake should be at capacity and all boards in place by July 5. During wet years keep boards out as needed to prevent the water level from exceeding 4.50 feet.

Plan II

Operate under this plan when there is hydraulic continuity between the lake and the dam (i.e., a portion of the old dam has been removed). Target levels during the summer and fall are quite different from those under Plan I.

Target Levels

Start End Release Period July 6-15 (No. 7)

4.45 4.40 During years of normal snowpack, release water as necessary to prevent exceeding the 4.5 level. During years of above normal snowpack, keep flashboards out as necessary to prevent exceeding 4.5 level. During drought years target release is 9-10 cfs.

Release Period July 16-31 (No. 8)

4.40 4.20 Release Water as necessary to meet target. During all but extreme drought years release 5 cfs whether or not target is met.

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Release Period August 1 - October 7 (No. 9)

4.2 3.2 Release a minimum of approximately 3 cfs regardless of antecedent level or target except in years of extreme drought. During normal or wet years release water as necessary to meet target or be slightly higher. As soon as the top set of flash boards are "dry" remove them for flood control.

Release Period October 8-31 (No. 1)

Follow one of the spawning flow release plans based on the antecedent level. Choose a plan where the acutal water level equals or exceeds the antecedent level on which the plan is based. Refer to the evaluation section for a discussion on success probability. Consult with California Department of Fish and Game. If additional inflow occurs increase release and store water to a maximum level of 2.2 feet at end of period. If it appears that there will be a large shortfall it may be necessary to adopt a plan with lower releases. Remove flashboards as they become "dry" or preferably obtain desired flow by pulling boards and letting water spill in conjunction with use of the gate. If antecendent level is below 2.7 feet consult with concerned parties to develop a release plan.

Plan A

2.70 2.20 Release water as necessary to meet target but not less than 10 cfs.

Plan B

2.80 2.15 Release water as necessary to meet target but not less than 15 cfs

Plan C

3.00 2.20 Release water as necessary to meet target but not less than 20 cfs

Plans D-E

3.20 2.05-2.20 Release water as necessary to meet target (2.20 for D, 2.05 for E) but not less than 25 cfs under Plan D and 30 cfs under Plan E.

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Release Period Nov 1-15 (No. 2)

Varies 2.05-2.10 Release water as necessary to meet the target (2.1 feet under plans A-E). but not less than:

10 cfs under Plans A and B
15 cfs under Plans C - E

In the event of a large shortfall it may be necessary to adopt a release plan that requires less water. However, in no case should the release be less than 10 cfs.

Release Period Nov 16-30 (No. 3)

Varies 2.0 Release water as necessary to meet the target but not less than:

5 cfs under Plan A
7 cfs under Plan B
10 cfs under Plans C-E

In the event of a large shortfall during the period it may be necessary to switch to a release plan requiring less water, but in no case should flow drop below 5 cfs.

Release Period December 1 - February 28 (No. 4)

2.0 2.0 Set gate to release desired water using the table in Appendix A under the 1.5 feet gage height setting. Under Plans A-E, the minimum release is 10 cfs. Under Plan D, it is 15 cfs. Under this scheme the reservoir is unconstrained as to release at higher levels but does not allow for rapid over release if levels are low. Monitor levels as necessary if they are low. During drought years keep the bottom set of flashboards in to prevent over-releases.

Release Period March 1-31 (No. 5)

2.0 3.0 Make at least the required minimum release of 10 cfs for Plan A, 15 cfs for Plans B-E, a shortfall this month is rare.

Release Period April 1 - JULY 06 (No. 6)

3.0 4.5 Keep level around 3.0 feet until after May 20 which should cause no problems except in extreme drought years when the level should be brought up earlier. It is advisable to install the next 2 sets of flashboards (if the first was left in during the winter) on the first 3 sets before the water level spilling over the bays exceeds a few inches. This should be accomplished just before April 15. After June 10 begin installing additional boards one set at a time.

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During dry and normal years the lake should be at capacity and all boards in place by July 5. During wet years keep boards out as needed to prevent the water level from exceeding 4.50 feet.

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EVALUATION

Having defined the policy and operating rules under which the reservoir will be operated, and having developed these criteria into specific operating plans, the most important question remaining is how effective these plans will be in achieving the stated objectives. Again, since the presence of the old dam so vastly affects the amount of live storage capacity the following section will be based on two analyses taking into account the old dam and assuming its effect to be absent.

Domestic Uses

Operation of the reservoir will not, nor will it in the future, affect the use of water for domestic use.

Instream Flows

Within the constraints contained in the Memorandum of Understanding the primary objective of reservoir operation will be to provide for instream flows.

Except during years of extreme drought there will be no problem in meeting the desired minimum instream flows for the months of February through June (release periods No. 5, 6, and a portion of 4). Median total net inflow during this period is 22,400 acre feet, which is 80% of the median annual net inflow. The minimum instream flow requirement during this period (Table 1) is 5980 acre feet or only 27% of the total.

Satisfying this requirement would leave 16,420 acre feet of water which could raise the level of the lake (if the dam were high enough) by 11.7 feet. With proper management it will always be possible (with the exception of droughts of the magnitude of 1977) to fill the lake to capacity by July 6.

Operating success for the remainder of the year is affected by the old dam and the two plans are hereafter discussed separately. Each plans success is based on comparing the inflows and targets with the actual data available to date e.g. if all the target levels are met then the plan would have been successful for that particular year. If a plan were to be successful for all eleven years of data its success probability would be 1.0. This type of test technique is rather primitive. A more acceptable technique giving more representative results would be to simulate an extensive period of record using computer-based stochastic simulation procedures (Hanes, Fogel, and Duckstein, 1976) and then test the plans for each simulated year. However, 15-20 years of data are needed to use this method in order that representative descriptive statistics can be obtained from the actual data. It should be noted that the drought of 1977 was an occurrance of extreme magnitude and none of the plans under any circumstances would have successfully operated in that year.

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Plan I - As Constrained by the Old Dam

For release periods No. 7 - 9 it should nearly always be possible to meet the October 7 target level of 3.2 feet. To accomplish this, flows in Taylor Creek during August and September would range from 3 cfs to 13 cfs with the average release being 7 cfs which is below the recommended minimum of 10 cfs but much higher than the absolute minimum acceptable of 3 cfs. Target levels of 3.4-3.6 should be attainable about 60% of the time.

During the Kokanee spawning run and egg incubation period (release periods No. 1-4) one of 5 release plans is selected. The selection of the plan is based primarily on the October 7 antecedent water level. The success probability for each plan is shown in Column 0 of Table 7 (the individual release plans were presented in Table 6). As can be seen, the risk of failure is rather high. However, the operations staff in conjunction with the California State Department of Fish and Game has the option of operating under a plan which requires less water. This raises the probability of success but will lower the amount of spawning habitat available and thus effectively lower the number of progeny produced. The remaining columns of Table 7 indicate the success probability of operating under successively higher antecedent water levels but still releasing the water specified under each plan.

Plan II - Unconstrained by the Old Dam

For summer operations (July 1 - October 7, release periods 7, 8, and 9) the ending target level of 3.2 feet should nearly always be met. Operating under this plan August 1 - October 7 flows in Taylor Creek will average 7 cfs, which is below the minimum recommended level of 10 cfs but well above the absolute minimum of 3 cfs.

For the Kokanee run and egg incubation period, this plan differs markedly from Plan I in that under all the plans at the end of release period No. 1 (October 31) the water level will be brought down to 2.2 feet. Thus, whatever sustained flow level necessary to meet this target is released. Table 8 shows the success probabilities associated with the Kokanee release plans as unconstrained by the old dam. Again, the staff has the option of operating under a plan using less water with a higher antecedent water level. However Plans D and E do not, since they start with the maximum antecedent level. The success of these plans is entirely a function of the net inflow during October. Examination of the data shows that Plans A-E would always be successful through the end of the egg incubation period (again 1977WY being an exception). It should be noted that success is defined as providing the required release, without drawing the reservoir below the established legal low water level of 1.5 feet. The drought year provision of being able to lower the lake to 1.0 would not have been needed. Based on median expected inflows water levels should rise or remain static under all plans after November 15 if the specified releases are adhered to.

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Table 7. Plan I success probabilities associated with the release plans to be used during the Kokanee run.

Plan	Antecedent level	Incremental Increase in Antecedent Level					
		0	+1	+2	+3	+4	+5
A	2.70	.65	.75	.95	.98	.99	
B	2.95	.63	.75	.90	.95		
C	3.20	.60	.70	.80			
D	3.40	.63	.68				
E	3.60	.63					

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Table 8. Plan II success probabilities associated with the release plans to be used during the Kokanee run.

Plan	Antecedent level	Incremental Increase in Antecedent level			
		0	+1	+2	+3
A	2.70	.98	.99	.993	,996
B	2.80	.97	.98	.99	
C	3.00	.95	.97		
D	3.20	.90			
E	3.20	.85			

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Flood Protection and Water Levels Desired By The Fallen Leaf Lake Protection Association

The two plans differ markedly in providing for flood protection and summer and fall water levels desired by the Association. Figure 7 shows the water levels desired by the Association (from Figure 1) and those target levels to be met using the respective plans. It is obvious that Plan II, as unconstrained by the old dam is far superior in providing for the levels of flood protection during the fall and winter as requested by the Association, and in nearly matching the summer season levels they desire.

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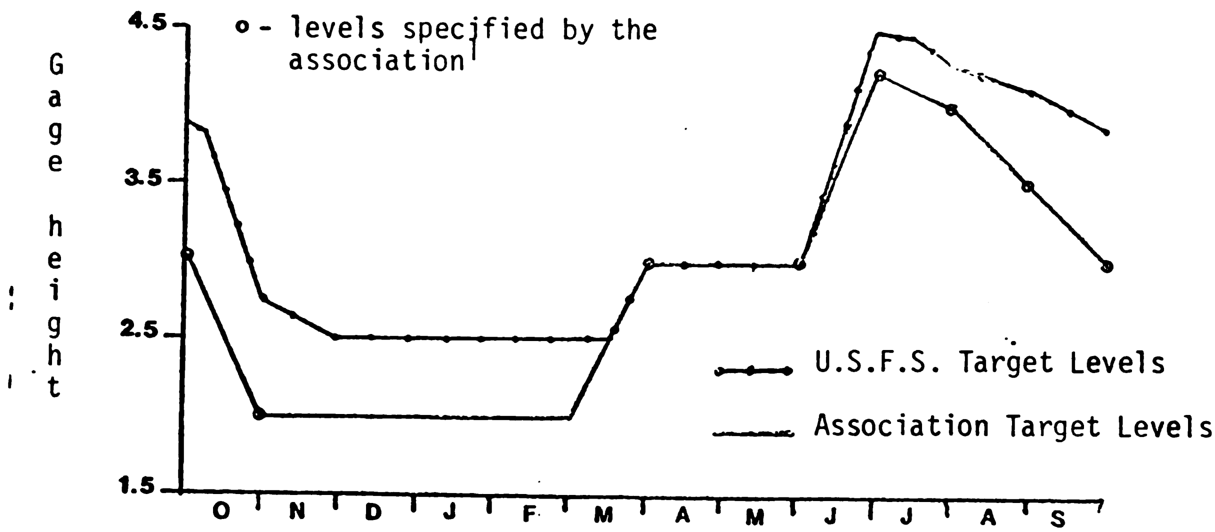
a. Constrained by the old dam.



b. Unconstrained by the old dam.

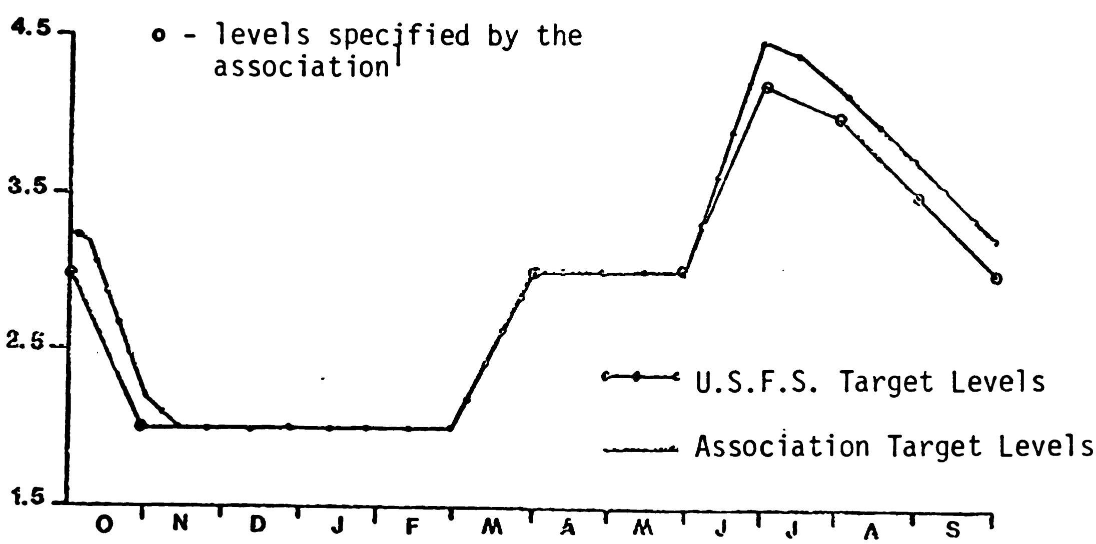


Figure 7. Comparison of reservoir levels desired by the Fallen Leaf Lake Protection Association with Forest Service target levels as (a) constrained by the old dam, and (b) unconstrained by the old dam.

1. Correspondence from H.D. Pischel to Administrator, Lake Tahoe Basin Management Unit, August 29, 1974, and other written and personal communication.

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CONCLUSIONS

Fallen Leaf Lake and its outlet, Taylor Creek, provide for a multitude of beneficial uses. Heretofore, many of these uses seemed incompatable Two operating plans were developed. Each was designed to best meet all the existing uses as defined earlier. It is clear that Plan II, as unconstrained by the old dam is far superior in providing both for the highest value instream flow use - the Kokanee fishery - and in providing for the level of flood protection and other water levels sought by the Association. A comparison of Tables 7 and 9 show that under Plan II the "average year" release plans, Plans C-D have a success probability of .90-.95 as compared to .60-.63 under Plan I, as constrained by the old dam. Under Plan II, invoking the legally agreed upon drought year provision of being able to lower the lake to 1.0 feet will essentially not be needed. For these reasons it is in the best interests of the Forest Service to provide hydraulic continuity between the present dam and the lake.

Success of any operating plan is contingent upon careful and consistant management. To provide for the uses at the levels identified, it is necessary to abide by the plan. Daily attention during the early summer and fall will be needed if an operating plan is to be successfully invoked. Operation of the dam need not be guesswork based on a trial and error approach. Using the formulas provided in Appendix B will give assurance that target levels will be met.

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Appendix A

To meet a target water level when there is either no inflow into the reservoir, or little outflow by evaporation, is a simple matter. The desired release is calculated as:

$$O_R = \frac{\Delta S}{tp(1.98)} \qquad (1)$$

where

O_R = Outflow required to meet target level in cfs

ΔS = The desired change in water level in acre feet

tp = Period of time, in days, between the present and the target date

For use on Fallen Leaf Lake this becomes:

$$O_R = \frac{GHp - GH_{TD}(1400)}{tp\ (1.98)} \text{ or } \frac{G.H.p - G.H._{TD}(707)(2)}{tp}$$

where

GHp = present gage height reading

$G.H_{TD}$ = desired gage height on target date

Since the net inflow will rarely be exactly zero it is necessary to calculate the existing inflow in order that the net desired outflow can be found. The net inflow can be found from:

$$\frac{O_{t1} + O_{t2}}{2} + \frac{(G.H._{t2} - G.H._{t1})707}{t_2 - t_1} \qquad (3)$$

where

O_{t1} = Observed release on t_1

O_{t2} = Observed release on t_2

t_1 = Julian day number of previous observations

t_2 = Julian day number of present observations

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Use of equations 2 and 3 will allow for accurate management of the dam. However they are based on the assumption that the net inflow in uniform throughout the period in question, which will rarely be the case. There fore frequent readjustments may be necessary. However, during the recession as the water level drops in the reservoir the release at any given gate setting will ocur because of the reduced static head. Also the net inflow will also decrease so that the two effects will tend to be self compensating. Use of this equation 3 without an observed change in gage height of at least 0.03 feet is not recommended since the resolution of the gaging equipment is not much beyond this level.

Example 1.

On July 8, G.H. - 4.42, on July 15 it is 4.47. On these same dates flow in Taylor Creek was 31 cfs and 36 cfs respectively. What release is needed to meet the July 31 target level of 4.20 feet as specified in Plan II?

$$0 = \frac{(4.47 - 4.20)(707)}{16} + \frac{31 + 36}{2} + \frac{(4.47 - 4.42)707}{7}$$

$$0 = 11.9 + 33.5 + 5.05$$

$$0 = 11.9 + 38.55$$

$$0 = 50.5 \text{ cfs}$$

Example 2.

On August 23 the G.H. was 3.96 and the release was 8 cfs. On August 27, the G.H. was 3.90 and the release is 7.7 cfs. What adjustment in the release is needed to meet the October 7 target level of 3.20 feet?

$$0 = \frac{3.90 - 3.20(707)}{41} + \frac{8.0 + 7.7}{2} + \frac{(3.90 - 3.96)707}{4}$$

$$0 = 12.0 + 7.8 - 10.6$$

$$0 = 12.0 - 2.8$$

$$0 = 9.2$$

Since the present release is 7.7 cfs it should be increased to 9.2 to meet the October 7 target level.

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APPENDIX B

DISCHARGE OF 30" No. 101 ARMCO GATE IN FALLEN LEAF LAKE DAM

for various gate openings in terms of fish-ladder gage reading

g , ...gate ...ore ...el	Fish-ladder gage reading in feet									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
	Discharge in cubic feet per second									
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7
	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3
	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1
	2.0	2.1	2.2	2.4	2.5	2.6	2.7	2.8	2.9	3.0
	2.7	2.8	3.0	3.2	3.4	3.5	3.6	3.8	3.9	4.0
	3.2	3.5	3.7	3.9	4.0	4.2	4.4	4.6	4.8	4.9
	3.8	4.1	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8
	4.4	4.8	5.1	5.4	5.6	5.8	6.0	6.3	6.5	6.7
	5.1	5.4	5.8	6.1	6.4	6.7	6.9	7.2	7.4	7.7
	5.7	6.1	6.4	6.8	7.2	7.5	7.8	8.1	8.4	8.7
	6.3	6.7	7.2	7.6	8.0	8.3	8.6	9.0	9.3	9.6
	6.9	7.4	7.8	8.3	8.7	9.1	9.4	9.8	10.2	10.6
	7.5	8.1	8.6	9.0	9.4	9.9	10.3	10.7	11.1	11.5
	8.1	8.7	9.2	9.8	10.2	10.7	11.2	11.6	12.0	12.4
	8.7	9.3	9.9	10.5	11.0	11.5	12.0	12.5	13.0	13.4
	9.3	9.9	10.6	11.2	11.7	12.2	12.8	13.3	13.8	14.2
	9.8	10.5	11.2	11.8	12.4	13.0	13.6	14.1	14.6	15.1
	11.9	12.8	13.6	14.4	15.1	15.8	16.5	17.1	17.8	18.4
	13.8	14.8	15.8	16.7	17.6	18.4	19.2	19.9	20.7	21.4
	15.6	16.8	17.9	18.9	19.9	20.8	21.7	22.6	23.5	24.3
	17.1	18.3	19.5	20.7	21.8	22.8	23.8	24.8	25.7	26.6
	18.5	19.9	21.2	22.5	23.7	24.8	25.9	26.9	27.9	28.9
	19.9	21.4	22.8	24.2	25.5	26.8	28.0	29.1	30.2	31.2
	21.2	22.9	24.4	25.9	27.3	28.6	29.9	31.1	32.3	33.4
	22.5	24.3	25.9	27.5	29.0	30.4	31.7	33.0	34.3	35.5
	23.7	25.6	27.3	29.0	30.6	32.1	33.5	34.9	36.2	37.5
	25.0	27.0	28.8	30.6	32.2	33.8	35.3	36.8	38.2	39.6
	26.2	28.3	30.2	32.1	33.8	35.5	37.1	38.7	40.2	41.9
	27.4	29.6	31.6	33.6	35.4	37.2	38.9	40.5	42.1	43.6
	29.6	32.0	34.2	36.4	38.4	40.3	42.1	43.9	45.6	47.3
	31.8	34.4	36.8	39.1	41.2	43.3	45.3	47.3	49.1	50.9
	33.9	36.7	39.2	41.7	44.1	46.4	48.5	50.5	52.5	54.5
	35.9	38.8	41.5	44.2	46.7	49.1	51.4	53.6	55.7	57.8
	37.6	40.7	43.6	46.5	49.1	51.7	54.1	56.4	58.6	60.8
	39.3	42.6	45.7	48.7	51.4	54.1	56.6	59.1	61.5	63.8
	40.4	43.8	47.0	50.1	52.9	55.7	58.3	60.9	63.3	65.7

...supercedes the one prepared on Jan. 27, 1956 and presented in the report ...Leaf Lake, 1954-1955 by Walter Ruppel, dated Mar. 31, 1956. It should ...ly when the entire discharge past the dam is taking place through the ... It was prepared from measurements made by Calif. Dept. of Fish and ... Biologists' Training Session, Oct. 4-7, 1960. For gate openings of ...hes, cognizance was taken of tests made by the Fresno Irrigation Dist., ... to tests by the Calif. Dept. of Fish and Game.

...el.

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ADDENDUM

DETAILED PLANS FOR FILLING THE LAKE

UNDER PLANS NO. 1 AND NO. 2 FOR RELEASE PERIOD 6

The following plans were developed to give more clear guidelines on filling the reservoir during the runoff season. The learge amount of variance, both in the volume and timing of runoff prompted the need for setting some general plans. Each plan is based upon the projected runoff for that year, by using the SCS April 1 Issue of Water Supply Outlook for Nevada. The percent of average for the Lake Lucille snow course, the projected Lake Tahoe rise (% of normal), and projected runoff for the Truckee River at Farad (% of normal). Do not depend too heavily on Lake Lucille snowcourse readings, since it appears that there may be a poor correlation between runoff from the watershed and the snowcourse, or at least the % of normal readings for the snowcourse may be biased on the high side. During 1981, Lake Lucille water content readings were 71% of normal yet net runoff into Fallen Leaf Lake was less than 50% of normal.

The real key in successfully filling the reservoir without having to wage a constant vigil of pulling and resetting boards is to calculate the net inflow every several days. By knowing what it is and how much you need to raise the water level you can calculate the rate of rise. Several things that are of critical importance.

1) The gate valve cannot release more water than approximately 50 cfs.

2) The minimum flow of 25 cfs during release period No. 6 <u>must</u> be net, unless the net inflow is less than this. If so, the outflow may be gradually dropped to a minimum of 2.5-3.0 cfs.

3) If an error is made, it is best to have the lake slightly lower than desirable, than to risk a violation of the Memorandum of Understanding.

4) During a wet year make certain that the seasonal peak has passed before installing additional flash boards or lowering the gate valve to raise the lake level. All of the spillway capacity in the bays will be needed during peak flows.

5) It is best to start plotting out the net inflow every several days starting in May to give yourself a clearer picture of what is happening.

6) During a dry year the net inflow can drop off <u>very rapidly</u> during the recession, from 80 cfs to 25 cfs in several days. Plan for a severe drop in net inflows when making calculations on filling the lake.

The plans presented are guidelines and were based upon a <u>normal</u> timing of runoff associated with the projected runoff volume. However, beware of a cold spring and a heavy snowpack, or a very warm spring or rains during a drought year, in each case, strictly operating under one of the plans would not be successful.

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The plans are intended to be guidelines. The key to success is to keep the objective in mind and a close watch on net inflows.

As soon as the road into the dam is clear of snow - usually around mid to late April, install -

the first 4 sets of boards - - - - - - - - - - - - - - - - - -	if projected runoff is less than 60% of normal.
the first 3 sets of boards - - - - - - - - - - - - - - - - - -	if projected runoff is greater than 60% but less than 110% of normal.
the first 2 - - - - - - - - - - - - - - - - - -	if projected runoff is greater than 110% of normal.

Depending on the projected runoff, the following interim target levels and board installation dates are recommended.

1. If projected runoff is 30% or less of normal, install an additional set of boards around May 1 and bring the water level up to 4.00 feet by May 15. Install remaining boards on this date and gradually raise water level to 4.3 feet by June 1. Once net inflow drops below 50 cfs, gradually raise water level to a maximum of 4.45 feet, while still providing for minimum flows. After this point as net inflow drops, reduce outflow to a minimum of 2.5-3.0 cfs.

2. If projected runoff is between 30% and 60% of normal, install an additional set of boards by May 10 and bring water level up to 4.00 feet by May 20. Install the next set of boards on this date and hold the water level steady until the net inflow drops below 100 cfs. Thereafter, install the remaining set of boards and raise the lake gradually to a maximum of 4.45 feet while still providing for or exceeding minimum flow levels. If net inflow drops below 25 cfs, reduce outflow commensurately to maintain the lake level to a minimum outflow of 2.5-3.0 cfs.

3. If projected runoff is between 60% and 90% of normal, calculate net inflow every several days during mid to late May. After seasonal peak flow has occurred, install the next set of boards. After the net inflow has fallen below 150 cfs, install the next set of boards (probably between May 25 and June 10). Bring the lake level up to 4.00 feet by June 15. After net inflow falls below 100 cfs gradually raise the water level to 4.45 feet while equaling or exceeding an outflow of 25 cfs. If net inflow falls below 25 cfs, reduce the outflow commensurately to maintain the lake level. Minimum outflow is 2.5-3.0 cfs. Special care is needed when operating under this regime. If projected inflow is near 60% of normal, consider operating under sub plan No. 2. The most critical element is keeping a close eye on the net inflow. If the projected runoff is close to 90% of normal it is possible to get a couple of seasonal peaks and

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installing the flashboards too soon can easily result in exceeding the 4.5 foot level. If the projected runoff is close to 90%, consider operating under sub plan No. 4 but keep a close watch on net inflows.

4. If projected runoff is between 90% and 120%, install the next set of boards after the seasonal peak has passed, probably around June 15. Try to keep the water level around 3.5 to 4.0 feet up to June 15. After the net inflow drops below 150 cfs, install boards and progressively raise the water level to between 4.30 and 4.45 feet.

5. If projected runoff is greater than 120% of normal, install the next set of boards after the seasonal peak has passed. This will usually occur by June 15. However, seasonal peak flows have occurred in late June (1971WY). Try to have the water level around 3.50 feet until the net inflow drops below 180 cfs. After this point, install all but the last set of flash boards and let water level rise to crest over the boards, but do not let the lake level rise beyond 4.30 feet. If it does, pull boards as necessary. Try to keep the lake level steady at 4.30 feet until the net inflow drops below 60 cfs. Thereafter, install the last set of boards and release water as necessary to maintain the lake level at 4.30 feet while still meeting or exceeding minimum flow releases. Under a projected runoff of exceeding 120%, do not be concerned with having the lake level rise to 4.45 feet by July 6, as shown in the general plan, nor be concerned with having it at 4.45 feet by July 16. However, try to meet the July 31 target level.

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