A PEAKFLOW FORECAST FOR PAYETTE LAKE USING SNOTEL DATA

by

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INTRODUCTION

Payette Lake, a natural lake on the North Fork of the Payette River near McCall, Idaho, is fed primarily by snowmelt runoff. The lake is regulated at its outflow by a small dam of tainter gates and flashboards. Once the boards are in place, regulation is limited to a maximum flow of approximately 42 m^3s through the open gates. The goal of reservoir operation is to capture as much runoff as possible without flooding businesses and residences on the lake shore. The placement of boards must be timed so that the reduced outflow will not engender flooding. Reservoir operations could be improved by incorporating forecasts of the time of peak flow and the total volume runoff into management procedures.

Snow water equivalent and snowmelt rates provide an index to runoff volumes and peak flows in the basin. Daily snow water equivalent readings are available from several Soil Conservation Service SNOTEL (SNOw TELemetry) sites located within the basin. This data can be used to forecast volume inflow and the date of peak inflow to the lake.

THE SITE

The headwaters of the North Fork of the Payette River drain an area of approximately 37000 ha above Payette Lake (Figure 1). The basin ranges in elevation from 1518 m at the outlet of Payette Lake to over 2400 m along the northern divide. Over a dozen perennial streams drain the surrounding hills and many small lakes dot the upper valley

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sides. Upper Payette Lake, approximately 14.5 km upstream of Payette Lake, drains the northeast quadrant of the basin; it is unregulated.

Although the total volume of the lake is unknown, operational storage is approximately 35,000 dam^3. The reservoir is managed for irrigation purposes, although the town of McCall benefits from its use as a recreational destination. Discharge is passed through Cascade Reservoir, 19 km downstream of the lake, for irrigation use around Emmett, Idaho, an additional 105 km downstream from the Cascade Reservoir outlet.

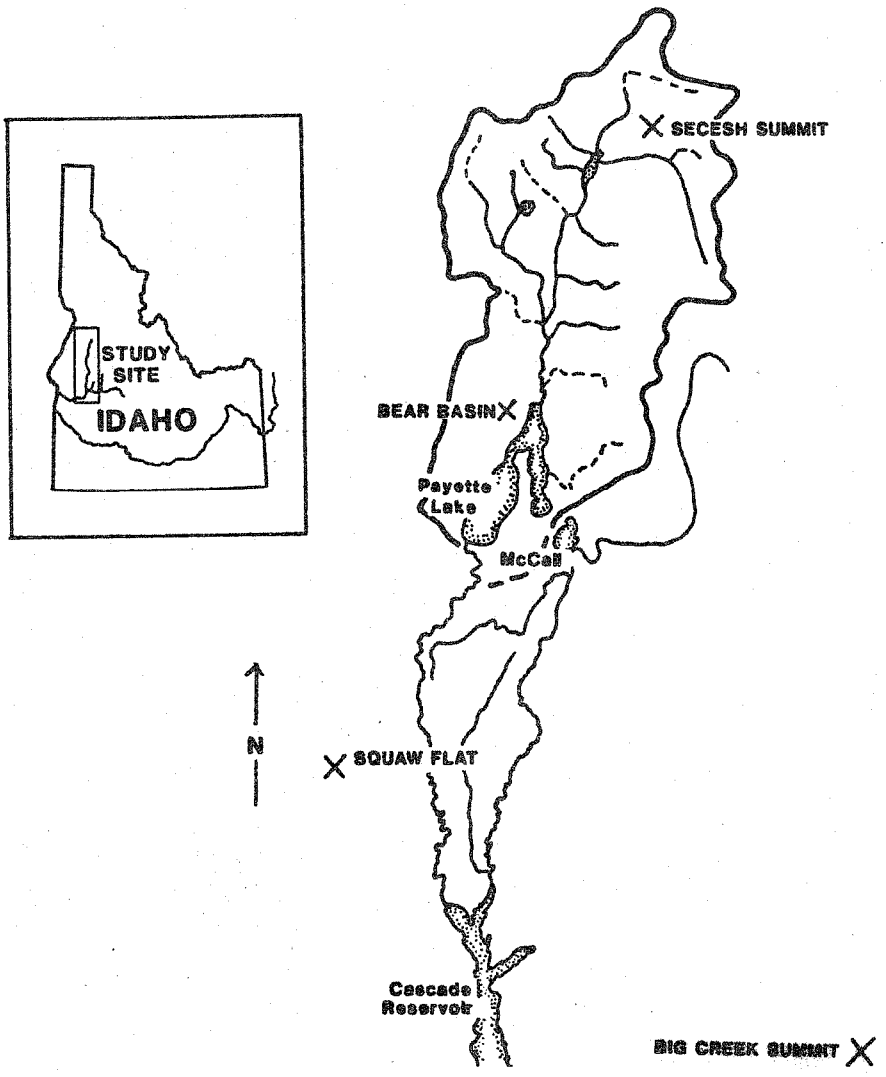

FIGURE 1 - STUDY SITE

DATA AND ANALYSIS

Streamflow data was acquired from the U.S. Bureau of Reclamation (USBR) Boise-Minidoka Hydromet System (Hydromet). The USBR regional office in Boise, Idaho, operates Hydromet, a hydrometeorologic data acquisition system that uses the NOAA GOES satellite to relay telemetered data from data collection platforms (DCPs) to the receiving station in Boise. Two DCPs are located near Payette Lake: the Payette Lake station records lake elevation on 15 minute intervals and telemeters the data every 4 hours; the stream gaging station, North Fork Payette River at McCall, transmits observed flows. The stream gaging DCP is located just downstream of the reservoir outlet gates and, therefore, transmits regulated outflows. Although there is no actual inflow gaging station above the reservoir, the USBR's Hydromet computer synthesizes natural inflow by adding the change in reservoir storage to the observed streamflow below the reservoir. This synthesized data set was used for the forecast analysis.

Four SNOTEL sites are located in the North Fork Payette River basin (Figure 1). Table 1 contains location information for these sites. Seven years of snow pillow data (1981-87) were available from three of the sites, Bear Basin, Big Creek Summit, and Squaw Flat, and six years of data (1982-87) were recorded from Secesh Summit. All four SNOTEL sites were analyzed to identify the best correlators to the date of peak inflow.

Precipitation data is available from the SNOTEL sites and several National Weather Service (NWS) climatological stations in the basin.

TABLE 1 - LOCATION INFORMATION FOR SNOTEL SITES

SITENAME	ELEVATION	LATITUDE	LONGITUDE	SECTION	TOWNSHIP	RANGE
Bear Basin	1632 m	44 57"	116 08"	30	19N	3E
Big Creek Summit	2007 m	44 38"	115 48"	24	15N	5E
Secesh Summit	1989 m	45 11"	115 58"	4	21N	4E
Squaw Flat	1903 m	44 46"	116 15"	32	17N	2E

The first step in the site analysis is to determine the yearly dates of "half-melt" and meltout for each site. Half-melt is the date on which the snow pillow has melted to one-half of its seasonal maximum water equivalent and meltout is the first day of the melt season that a site telemeters zero snow water equivalent on the pillow. These dates can be related to the timing of peak runoff (Farnes,

1984). Table 2 contains these dates, and their offset in days from peak inflow, for the two SNOTEL sites that correlate best with peak inflow: Bear Basin and Secesh Summit.

TABLE 2 - RELATIONSHIP OF SNOTEL HALF-MELT AND MELTOUT DATES TO PEAKFLOW AT PAYETTE LAKE

Year	Max SWE	Date	Half Melt	Date	Offset from Peak	Meltout Date	Offset from Peak	Peak Flow	Date
					BEAR BASIN				
1981	16.0	4/15	8.0	4/30	+25 +39	5/18	+ 7 +21	2839 1/ 3831 2/	5/25 6/08
82	26.2	4/21	13.1	5/15	+33 +11	5/31 3/	+17 - 5	3765 1/ 3819 2/	6/17 5/26
83	28.9	4/14	-	-	-	5/31	- 2	4146	5/29
84	25.0	4/15	12.5	5/23	+27	6/08	+11	4050	6/19
85	16.9	4/01	8.4	5/01	+24	5/16	+ 9	2878	5/25
86	18.2	3/27	9.1	5/03	+27	5/21	+ 9	4677	5/30
87	11.3	4/03	5.7	4/23	+14	4/29	+ 8	1648	5/07
					SECESH SUMMIT				
1981	-	-	-	-					
82	63.2	4/21	31.3	6/17	0 -22	7/10	-23 -45	3765 1/ 3819 2/	6/17 5/26
83	50.2	4/18	-	-	-	-	-	4146	5/29
84	42.6	5/10	20.7	6/15	+ 4	6/28	- 9	4050	6/19
85	36.7	4/01	18.3	5/13	+12	5/27	- 2	2878	5/25
86	35.8	3/26	17.7	5/26	+ 4	6/03	- 4	4677	5/30
87	20.6	4/05	10.3	4/28	+ 9	5/08	- 1	1648	5/07

1/ Snowmelt peak
2/ Rain induced peak
3/ Rain on May 26-27 1982, caused high melt to occur at Bear Basin. Precipitation as snow would have delayed meltout 4-5 days.

Reservoir operators also require an indication of total volume inflow for the runoff season. Although a volume forecast exists for the North Fork at Cascade, and further downstream at Banks, a procedure was developed to forecast the April-July volume inflow to Payette Lake. Forecast procedures are commonly developed using a 25-year period. In this case, an equation was developed based on the seven

year period for which SNOTEL data is available. Multiple linear regression was used to generate the equation.

Snow water equivalent at two different sites, Big Creek Summit and Secesh Summit, showed a strong correlation to the April-July volume inflow. Along with snow water equivalent, precipitation data from the NWS's Garden Valley Ranger Station Climatological Station was incorporated into the equation. In this case, fall precipitation (October-December) acts as an index to soil moisture.

RESULTS

Bear Basin proved to be the best predictor of the time of peak inflow to Payette Lake. Approximately 9 days after Bear Basin melts out, peak inflow occurs at the lake. Figure 2 illustrates the relationship between the Bear Basin snow pillow meltout date and the Payette Lake peak inflow date. Table 3 displays the forecasting errors, in days, that would have been realized if the 9-day relationship had been used for the period 1981-87. The average absolute error for the seven year period is 3.4 days, with a

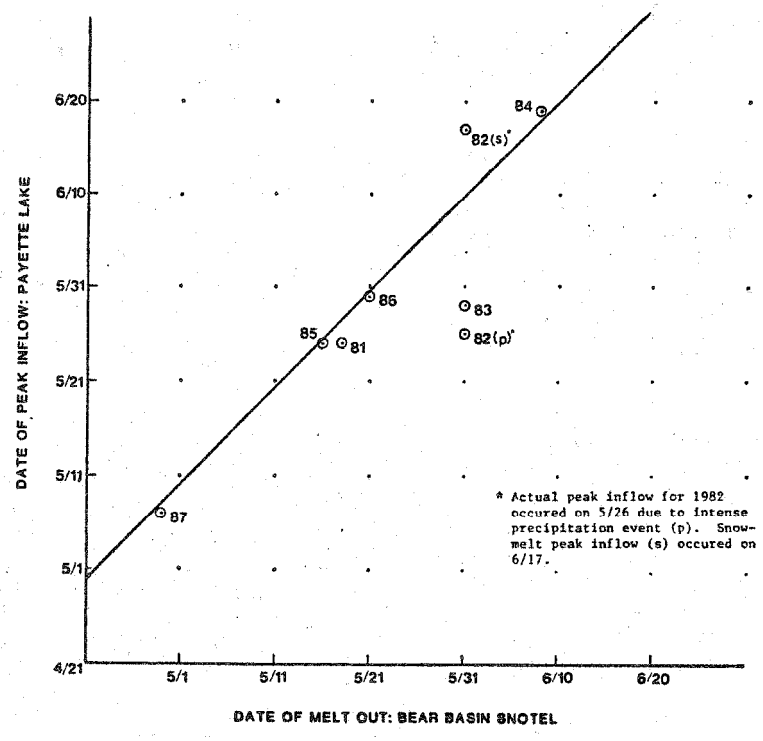

FIGURE 2 - RELATIONSHIP OF BEAR BASIN SNOTEL SNOW PILLOW MELTOUT DATE TO PEAK INFLOW FOR PAYETTE LAKE

TABLE 3 - PEAK INFLOW DATE FORECASTING ERRORS
USING BEAR BASIN SNOW PILLOW MELTOUT DATES

Year	Meltout Date	Meltout +9 Days	Actual Peak Flow Date	Error in Days
1981	5/18	5/27	5/25 1/ 6/08 2/	+ 2 1/ -12 2/
82	5/31	6/09	6/17 1/ 5/26 2/	- 8 1/ +14 2/
	(6/04) 3/	(6/13) 3/	6/17 1/	- 4 3/
83	5/31	6/09	5/29	+11
84	6/08	6/17	6/19	- 2
85	5/16	5/25	5/25	0
86	5/21	5/30	5/30	0
87	4/29	5/08	5/07	+ 1

1/ Snowmelt peak
2/ Rain induced peak
3/ Rain on May 26-27 1982, caused high melt to occur at Bear Basin. Precipitation as snow would have delayed meltout 4-5 days.

maximum error of 11 days. The maximum error occurred in 1983, when the snowpack at Bear Basin was almost 140 percent of normal. The next largest error occurred in 1982, when the snowpack was 125 percent of normal. Secesh Summit provided the second best correlation to the date of peak inflow. The Secesh Summit snow pillow reaches half-melt approximately 6 days before peak inflow occurs, and reports meltout about 8 days after peak inflow.

The elevation of the sites relative to basin area provides some insight to the strength of their correlation. Bear Basin, elevation 1632 m, is in the lower 16 percent of the watershed area and usually melts out before the middle and high elevation snowpacks have begun to melt at a rate sufficient to produce high flows. In contrast, Secesh Summit is located at 1989 m, about midway along the area-elevation curve for the basin. By the time this site melts out, the remaining contributing snow covered area is insufficient to produce high flows.

The forecast equation based on the SNOTEL data showed a very strong correlation ($R^2 = 0.91$). The F-ratio (10.27 with 3 and 3 degrees of freedom) indicates a statistically significant relationship. Additionally, the years 1981-87 are representative of the larger 25-year record and contains

values from the high and low ends (±15 percent), as well as the center of the distribution. Nonetheless, until a greater period of record develops, this equation should be used in conjunction with the equations for Cascade and Banks, both reliable forecast equations.

OPERATIONAL USE OF THE PEAK INFLOW DATA FORECAST PROCEDURE

By using the close relationship between average daily air temperature and local snowmelt rates (Gray and Male, 1981), melt rates can be extrapolated for a short time into the future based on current melt rates and the extended weather forecast. The dates of meltout at Bear Basin and half-melt at Secesh Summit can be predicted up to a week in advance given consistent weather patterns and available weather forecasts. This information can be used to bracket the probable dates of peak inflow to the lake. The forecasted meltout date at Bear Basin, along with the 9-day lag between meltout and peak inflow, provides a two week advance forecast for the date of peak inflow to the lake. A predicted date of half-melt and meltout at Secesh Summit provides the outside date of peak flow; it is extremely unlikely that peak flow will occur after Secesh Summit has melted out.

Heavy rain on snow events may cause a peak flow greater than the snowmelt peak. This type of event occurred in both 1981 and 1982 on the North Fork Payette drainage. The hydrographs, precipitation records, and snowmelt rates show that the actual snowmelt peak occurred 14 days before the rainfall peak in 1981, and 22 days after the rainfall peak in 1982. Although this type of event is difficult to forecast, the effect of rain on snow is usually to augment melt generated runoff and, depending on the temperature, to increase the rate of melt. If such an event occurs prior to the forecasted snowmelt peak flows, the flashboards are usually not in place and the resulting high flows can be passed without flooding the lakeshore. However, if a rain induced peak occurs after the snowmelt peak has occurred and the flashboards are in place, the possibility of flooding will depend on the volume of flow generated.

SUMMARY

Payette Lake does not require complicated procedures for planning and operation. Given a forecast of the date of peak flow, reservoir operators can plan their activities to maximize capture without flooding the lakeshore. SNOTEL is particularly suited to this project because the availability of daily data allows for fine-tuning the forecast if conditions change within the basin. The volume forecast provides another tool for planning purposes. The Idaho Data

Collection Office staff routinely attends user meetings and has provided training so that users can retrieve snowpack and forecast information from the SNOTEL system and the Centralized Forecast System (CFS).

Future developments in the SNOTEL system will make even more information available. The sites in the North Fork Payette basin are scheduled to receive upgraded radio transceivers in the summer of 1988. The new transceivers are equipped with microprocessors and can compute daily maximum, minimum, and average air temperatures. The air temperature data in particular will benefit the peak flow forecast because of the close relationship between air temperature and local snowmelt rates.

REFERENCES

Farnes, P.E., 1984. Predicting Time of Peak Snowmelt Runoff from Snow Pillow Data. Proceedings, 52nd Western Snow Conference, pp. 132-138.

Gray, D.M. and Male, 1981. Handbook of Snow: Principles, Processes, Management and Use. Pergamon Press, Willowdale, Ontario.