CE EN 431
Engineering Hydrology
Winter 1994
Section 1

Lab 10: Forecasting Volume of Stream Runoff Using Snow Measurements

Submitted to:
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by
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March 24, 1994

Contents

Introduction

In this report, I analyzed the snow pack and runoff data for the Snake River drainage basin at King Hill, Idaho. I then graphed the relationship between water content of the high-elevation mountain snow cover on April first versus the April to September runoff in the Snake River at King Hill. I graphed the water content-runoff relationship for three snow courses. These three courses included the Mascot Mine, the Copper Basin, and Teton Pass courses.

King Hill is located in south-west Idaho. There is not much there. I have obtained the following information about the gaging station and watershed at King Hill, Idaho:

- **Location: 43 degrees latitude, 115 degrees, 12 minutes longitude**
- **Area of watershed above gaging station: 35,800 square miles**
- **Type of water stage measurement instrument: Water-stage recorder**
- **Reliability of record: Records are excellent. Record from 1909 to present**
- **Shape of watershed: See contour map in appendix C**
- **Size of watershed: Huge watershed, covering much of eastern and central Idaho**
- **Topography and elevation of watershed: Rugged, mean elevation of 6040 ft**
- **Other factors:** Flow in the Snake River at King Hill is regulated by American Falls Reservoir 168.4 miles upstream. Occasional fluctuation in the river is caused by hydroelectric plants upstream. At times, practically the entire flow is diverted at Milner (upstream) during irrigation season. Lots of the flow at King Hill is derived from springs and seepage entering below Milner. Diversions above the station irrigate about 2.45 million acres.

After graphing the snow water content-runoff relationship for each of the snow courses, I determined the best-fit equation for each relationship. Then, I used some assumed runoff values to determine the predicted runoff for 3 years for each of the three best-fit equations. Finally, I averaged each of the three runoff values for each of the three years.

Objectives/Procedure

For the objectives and procedure, I have included the lab handout. You can find the lab handout in the appendix.

Results

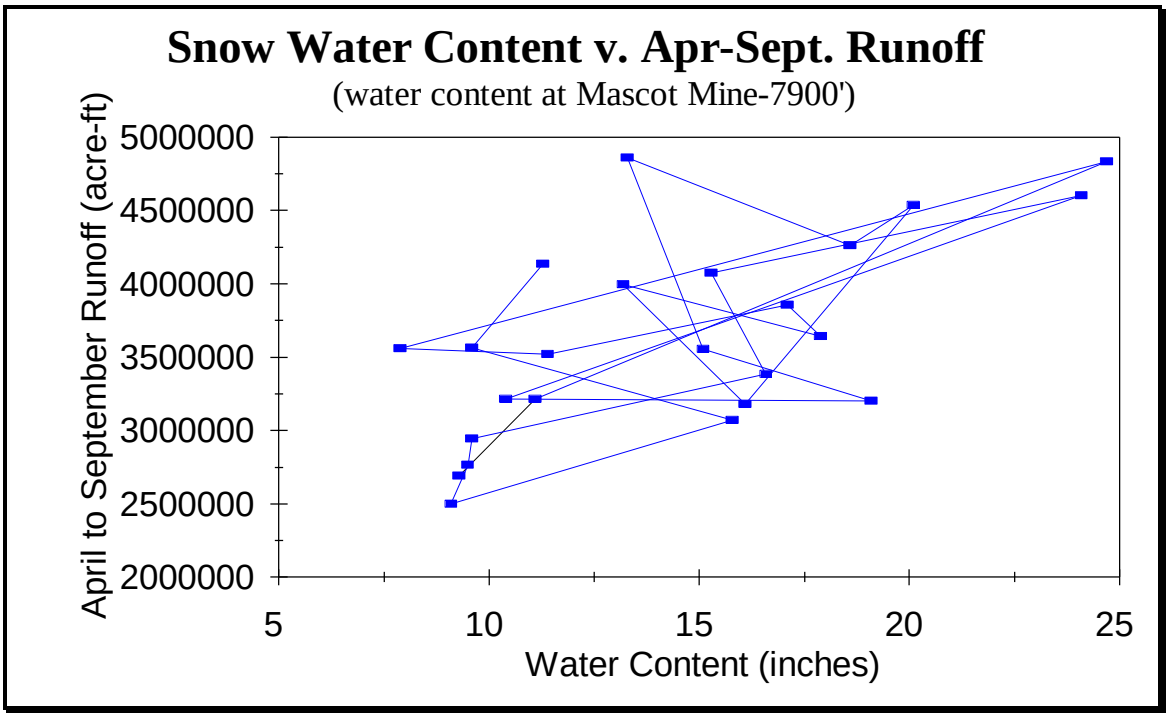

Figure 1: April 1 snow pack water content at Mascot Mine, Idaho versus growing season runoff on the Snake River at King Hill, Idaho. The data points cover a period of 24 years (1941-1964).

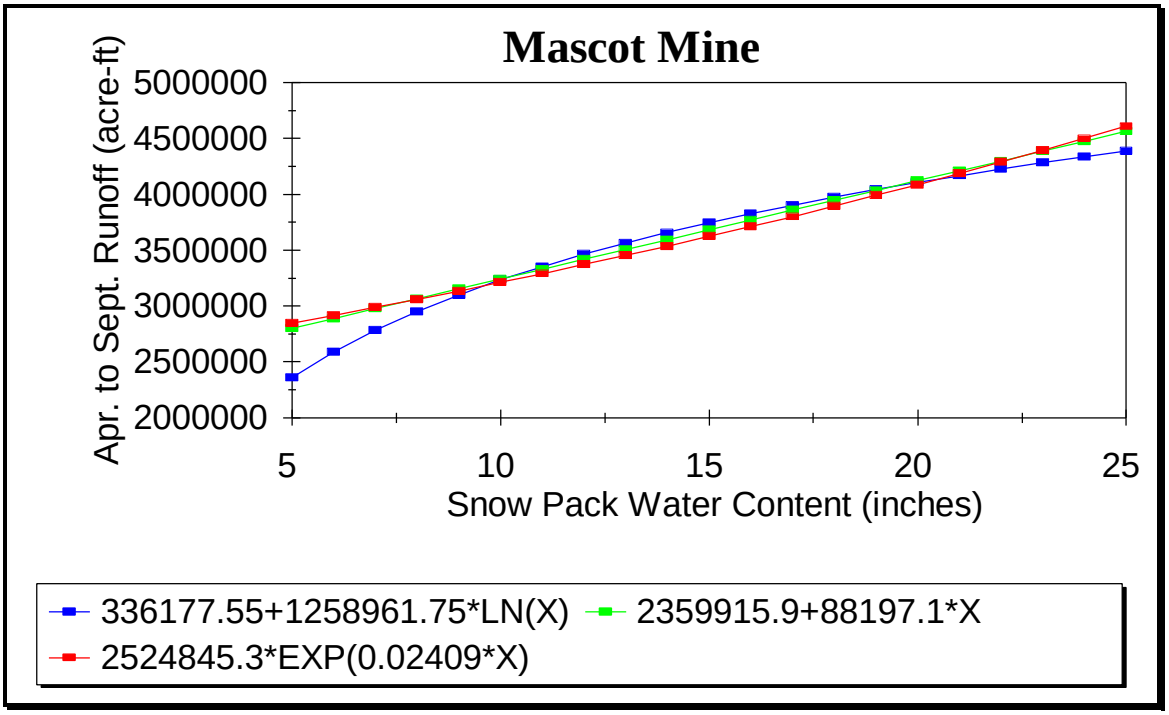

Figure 2: April 1 snow pack water content at Mascot Mine, Idaho versus growing season runoff on the Snake River at King Hill, Idaho. This graph shows logarithmic, exponential, and linear best-fit lines for the data in figure 1.

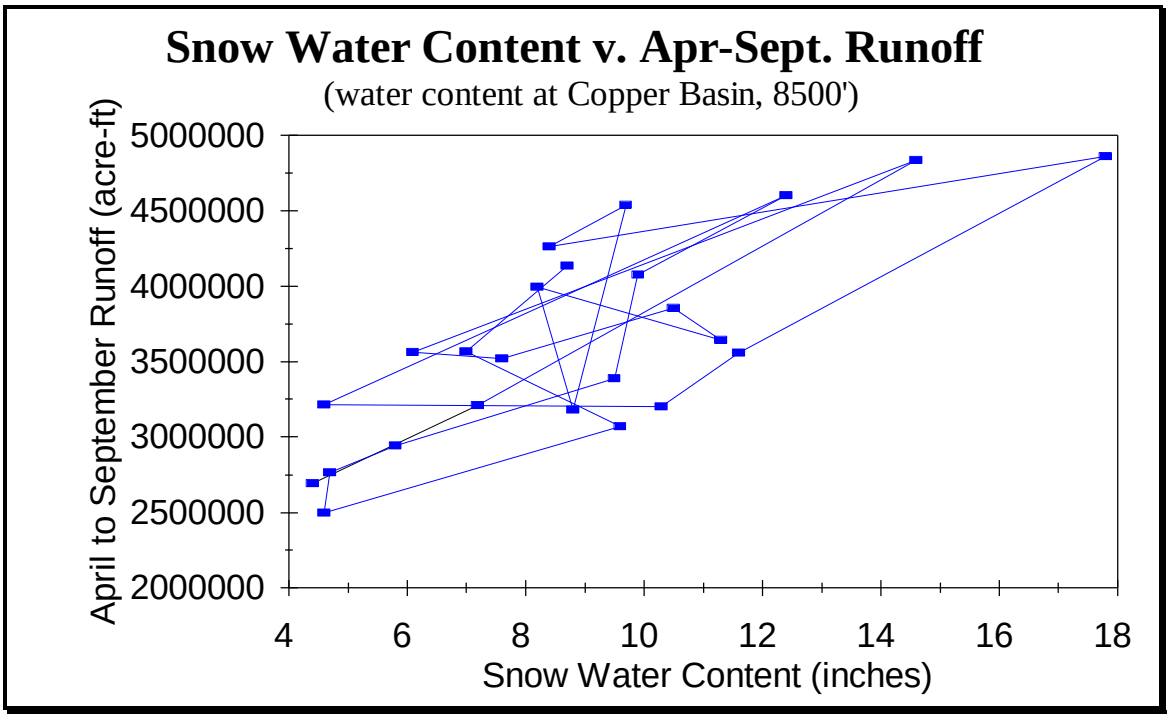

Figure 3: April 1 snow pack water content at Copper Basin, Idaho versus growing season runoff on the Snake River at King Hill, Idaho. The data points cover a period of 24 years (1941-1964).

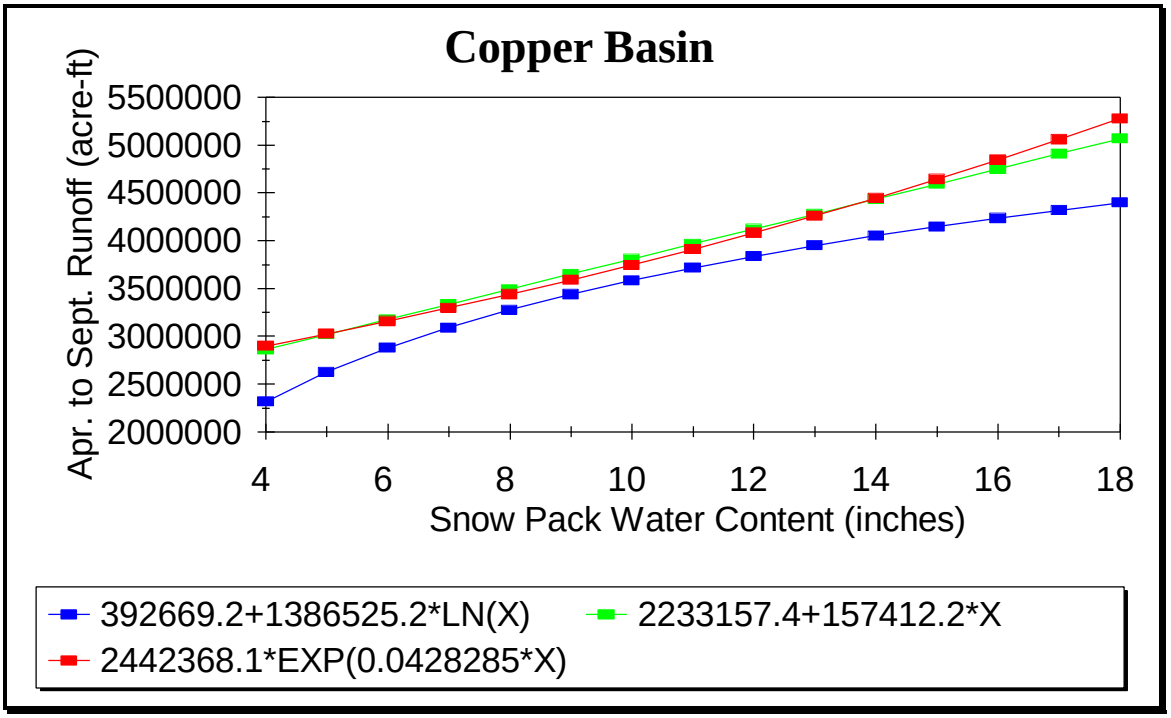

Figure 4: April 1 snow pack water content at Copper Basin, Idaho versus growing season runoff on the Snake River at King Hill, Idaho. This graph shows logarithmic, exponential, and linear best-fit lines for the data in figure 3.

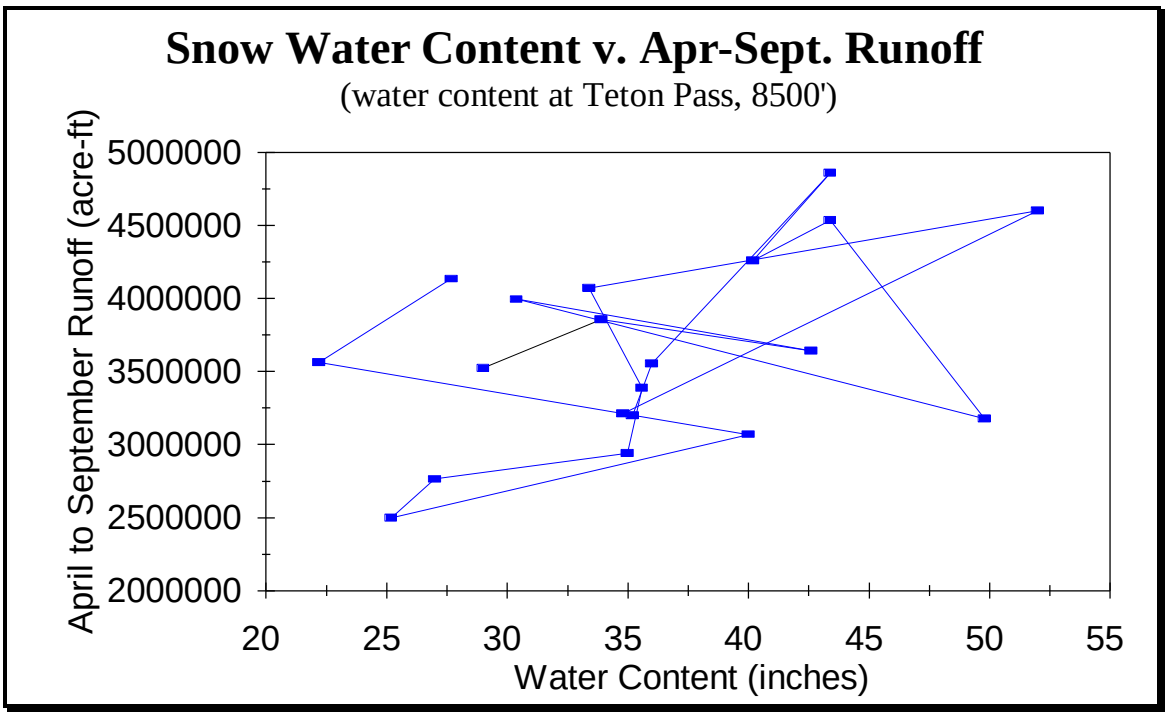

Figure 5: April 1 snow pack water content at Teton Pass, Wyoming versus growing season runoff on the Snake River at King Hill, Idaho. The data points cover a period of 20 years (1945-1964).

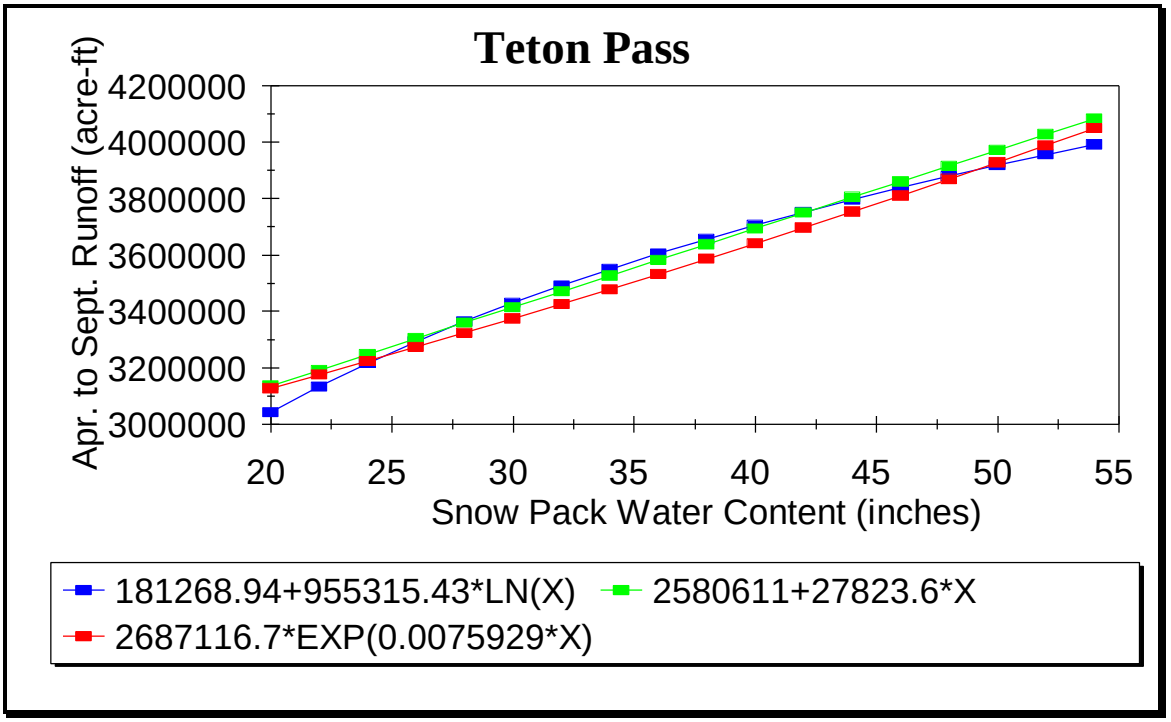

Figure 6: April 1 snow pack water content at Teton Pass, Wyoming versus growing season runoff on the Snake River at King Hill, Idaho. This graph shows logarithmic, exponential, and linear best-fit lines for the data in figure 5.

Table 1: Predicted individual and average runoff values at King Hill, Idaho for 1972, 1980, and 1985. Runoff volume is from April to September.

Year	Mascot Mine Water Content (inches)	Predicted Runoff (acre-ft)	Copper Basin Water Content (inches)	Predicted Runoff (acre-ft)	Teton Pass Water Content (inches)	Predicted Runoff (acre-ft)	Average Predicted Runoff (acre-ft)
1972	20	4107700	10	3585000	42	3751900	3815000
1980	9.5	3170500	6	2877000	34	3550100	3199200
1985	24	4337200	12	3838100	52	3956000	4043700

Discussion

You can see the results in figures 1-6 and table 1.

Predicted runoff. I predicted the runoff using the logarithmic equations and curves located in figures 2, 4, and 6. The predicted runoff values at King Hill are located in table 1. Since no data was available for any of the snow courses after 1964, I had to make up some snow pack water content values for 1972, 1980, and 1985. Wood Miller said we could.

Actually, my values of snow pack water content are much like three of the years which I had data for. After calculating the average predicted runoff of each of the three snow courses, I compared my data with the actual data for the three years. The average predicted runoff values turned out to be very close to the actual runoff values for the three years. (3900 thousand ac-ft versus 3600 thousand ac-ft, 3200 thousand ac-ft versus 3000 thousand ac-ft, and 4000 thousand ac-ft versus 4600 thousand ac-ft).

There was fairly good correlation for the data points in graphs 1, 3, and 5. I used my HP calculator to find the best-fit lines to match these data points. The calculator also calculated the correlation coefficients for the data points. For the Mascot Mine and Copper Basin graphs, the correlation coefficient was about 0.70. But for Teton Pass, the correlation coefficient was only about 0.40.

Some reasons the snow pack water content may not be directly correlated to the runoff values are:

- Other forms of precipitation besides snow may have occurred in the basin
- Infiltration may have occurred and may have varied between years
- More evaporation may have occurred

Calculations

The calculations were fairly straightforward and involved tabulating the data, determining the best-fit lines for the snow pack water content-growing season runoff curves, and predicting the growing season runoff for three years. *My calculations and data are located in Appendix C.*

I found the logarithmic, exponential, and linear best-fit lines using my HP calculator statistical solver. Then, I used the logarithmic equations in figures 2, 4, and 6 to predict the runoff, given the snow pack water content. I then averaged the three runoff values for the three years and put the results in table 1.

Conclusions/Applications

Forecasting volume of stream runoff using snow measurements is very useful. Farmers and engineers need to know how much runoff will occur for the year so they can distribute the water evenly, prevent flooding, and have a prosperous harvest. Using the snow pack water content values from the USGS snow course survey, hydrologists can predict runoff at various gaging stations along a stream.

All a hydrologist has to do is to find the best-fit equation to match a set of data. Then, the hydrologist can plug this equation into the snow pack water content value for the year the runoff is desired.

Appendix

Appendix A: References

- Wanielista, Martin. **Hydrology and Water Quantity Control**. John Wiley and Sons, Inc. 1990.
- United States Department of Interior, Geological Survey. **Water Supply Papers-Basin 13, 1940-1970 data (3 volumes)**.
- Nelson, Morlan W. and J. Alden Wilson. **Summary of Snow Survey Measurements for Idaho**. Soil Conservation Service, 1968.

The lab handout and my calculations are located on the following pages.

Appendix B: Lab Handout

Appendix C: Calculations and Data