CE EN 431
Engineering Hydrology
Winter 1994
Section 1

Lab 6: Estimating Seasonal Consumptive Use and Water Requirements--Great Falls, Montana

Submitted to:
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by
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Contents

Introduction

The purpose of this report is to estimate the consumptive use of water and the water requirements of crops in Great Falls, Montana using Blaney and Criddle's equation. The basic form of Blaney and Criddle's equation is:

$$U = KF$$

where $\boldsymbol{U}$ = the seasonal consumptive use (or evapotranspiration) of a crop in inches,
$\boldsymbol{K}$ = the empirical consumptive use crop coefficient,
and $\boldsymbol{F}$ = the sum of the monthly consumptive use factors for the period you are considering.

In this report, I will show how much water each of the four main crops in Great Falls, Montana use. The four main crops used in Great Falls are wheat, barley, alfalfa(hay), and oats. I will compare the seasonal consumptive use of wheat, barley, alfalfa, and oats with the seasonal precipitation. The difference between the seasonal consumptive use for a crop and the precipitation during its growing season is the irrigation water required for that crop.

Objectives/Procedure

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

Results

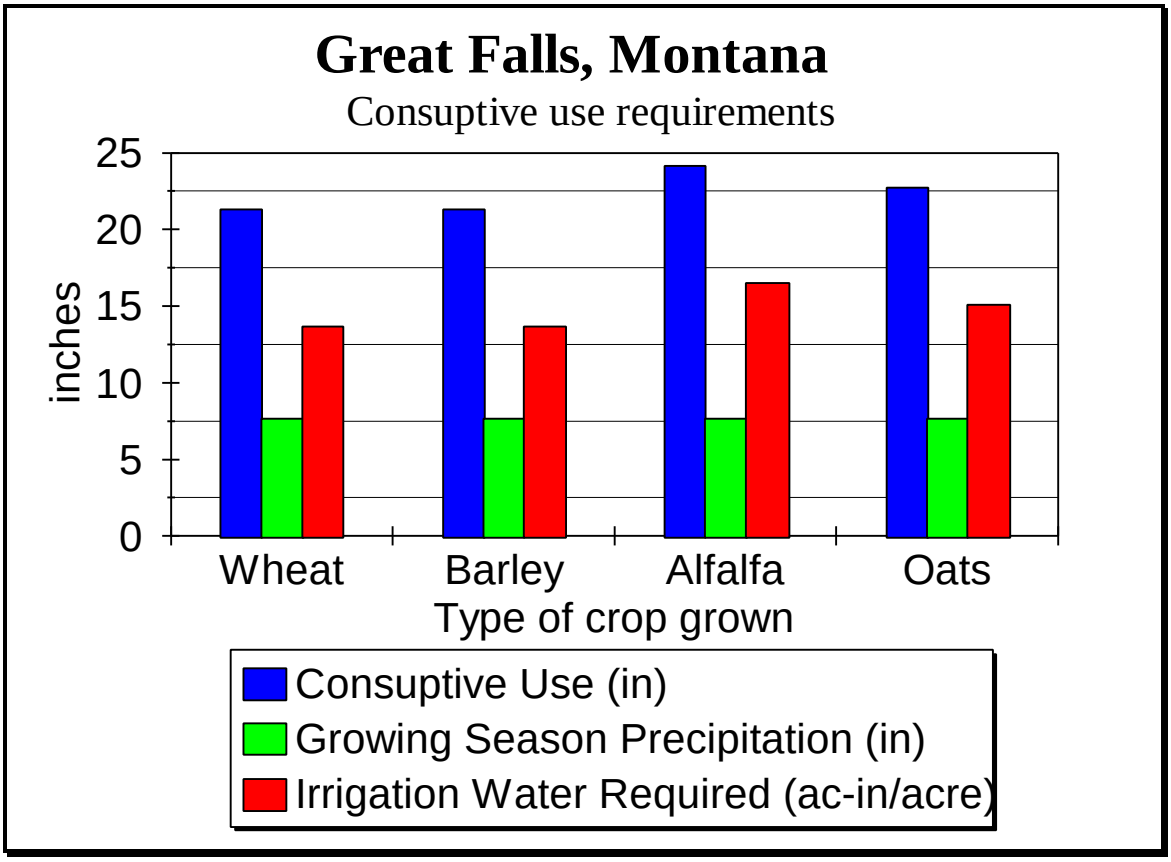

Figure 1: The consumptive use, total precipitation for the growing season, and irrigation water required for wheat, barley, alfalfa, and oats in Great Falls, Montana. Precipitation data is from the 1985 Climatological data, annual summary.

Table 1: Data and calculations for the consumptive use and irrigation water requirements for wheat, barley, alfalfa, and oats in Great Falls, Montana. GROWING SEASON: from May 11 to September 25.

Crops Grown	Consumptive use Coefficient, K	Growing season	Sum of consumptive use factors, F
Wheat	0.75	4 months	28.41
Barley	0.75	4 months	28.41
Alfalfa	0.85	Between frosts	28.41
Oats	0.80	4 months	28.41

Crops Grown	Seasonal Consumptive use, U=KF, inches	Growing Season Precip (in.)
Wheat	21.30	7.64
Barley	21.30	7.64
Alfalfa	24.15	7.64
Oats	22.73	7.64

Crops Grown	Precipitation Deficiency (inches)	Irrigation Water Required (ac-ft/acre)
Wheat	13.66	1.14
Barley	13.66	1.14
Alfalfa	16.50	1.38
Oats	15.08	1.26

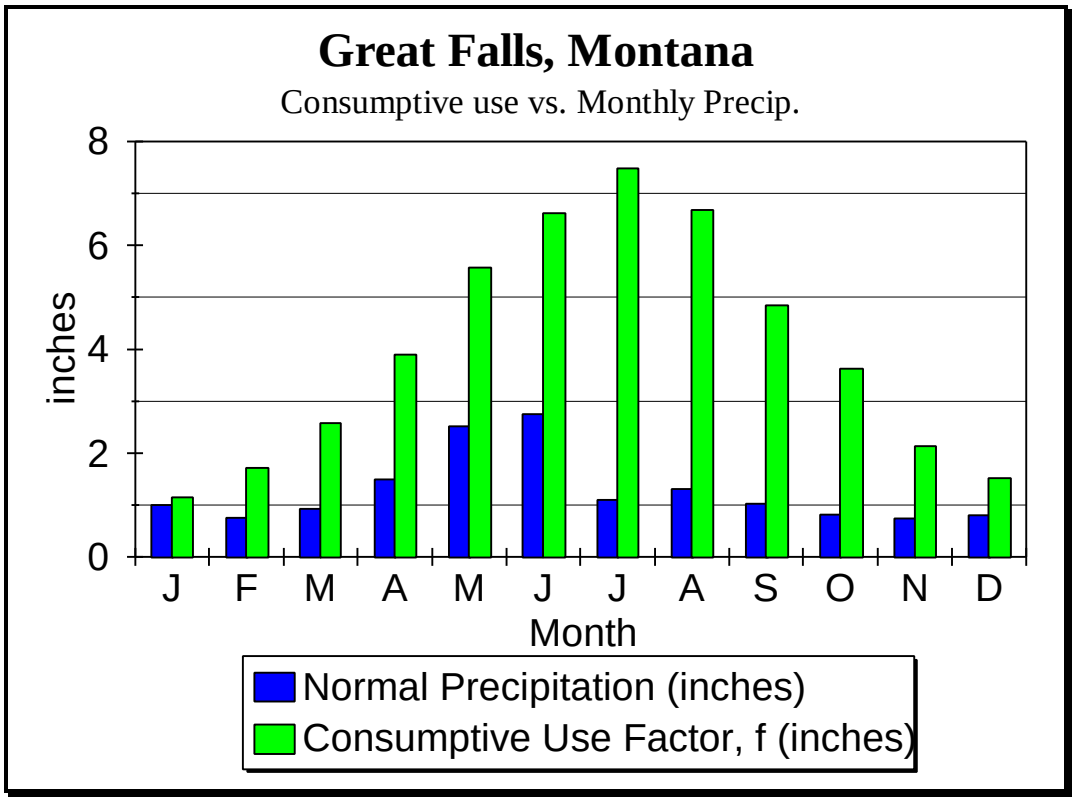

Figure 2: Consumptive use factor versus the normal monthly precipitation for Great Falls, Montana. Since the actual consumptive use for a crop is usually about the same as the consumptive use factor, the consumptive use will usually exceed the normal precipitation in Great Falls. Irrigation will be required unless the precipitation is above normal. The growing season is from May 11 to September 25.

Discussion

The results are located above in figures 1, 2, and in table 1. A table showing the normal monthly temperature, precipitation, and average spring and fall frost dates is located in appendix C.

Consumptive use crop requirements. In this lab, I calculated the consumptive use requirements for wheat, barley, alfalfa, and oats in Great Falls, Montana. Since I did not have the consumptive use coefficient for wheat or barley available, I had to estimate these coefficients. I obtained the growing season for wheat and oats from an encyclopedia. For most crops, the actual consumptive use for the crop is usually between half the consumptive use factor and the full consumptive use factor.

Alfalfa requires the greatest amount of water over the growing season. This makes sense, since alfalfa is a "greener" crop. Wheat and barley do not require as much water.

Growing season precipitation and irrigation water required. Since Great Falls has a relatively dry climate (15.24 inches of precipitation per year), irrigation is required for every month of the growing season; however, irrigation may not be required during a month having excessive precipitation. I have graphed the consumptive use factors for each month of the year versus the mean monthly precipitation in figure 2.

Since the actual consumptive use for a crop is usually about the same as the consumptive use factor, the consumptive use will usually exceed the normal precipitation in Great Falls. Irrigation will be required unless the precipitation is above normal.

Temperature and consumptive use. Since temperature and consumptive use are directly related, as the temperature goes up, the consumptive use will go up. During the summer, when the crops are grown, the consumptive use remains high while the precipitation is relatively constant. Temperature and consumptive use data are located in appendix C.

The spreadsheet calculations for the consumptive use and irrigation water requirements in Great Falls are located in appendix C: calculations.

Calculations

The calculations were fairly straightforward and involved calculating the consumptive use factor for each crop, determining the consumptive use coefficients for each of the crops, and performing unit conversions. I followed the following steps to perform my calculations:

- First, I determined the growing season. I averaged the values of the last spring killing frost (28 F) and the first fall killing frost for 20 years before 1985 to determine the average growing season. Using this method, I determined the growing season to be between May 11 and September 25.
- Second, I determined the monthly percent of daytime hours of the year for each month at 47 degrees, 29 minutes (about 47.5) degrees north. I determined these values from table 16 on the lab handout.
- Third, I determined the consumptive use factors (*K*'s) and growing seasons for each of the crops I considered. Since the consumptive use factors for wheat and barley were not available, I had to estimate their factors.
- Fourth, I calculated the consumptive use factor, *f*, for each month of the year according to the following equation:

$$f = \frac{t \times p}{100}$$

where *t* is the mean monthly temperature, in degrees F, and *p* is the monthly percentage of daytime hours of the year.

- Then, I added the consumptive use factors for the entire growing season ($F = \sum f$ for the season). Since the growing season was about 4 months, I assumed that each of the crops were grown throughout the entire growing season.

- I calculated the total consumptive use for each crop for the growing season according to the equation:

$$U = KF$$

where U is the seasonal consumptive use, K is the consumptive use crop coefficient, and F is the sum of the monthly consumptive use factors explained in the introduction.

- Finally, I determined the precipitation deficiencies caused by the crop growth and the irrigation water required due to these deficiencies. Deficiency = *P-U*, where *P* is the precipitation over the period considered.

Conclusions/Applications

In conclusion, determining the consumptive use of water for crops grown in an area is very useful. The consumptive use of water for a crop is determined using the Blaney-Criddle equation, *U=KF*. After hydrologists determine the consumptive use of water for a crop over a time period, they can determine the irrigation water required to supply that consumptive use. Then, engineers can design channels and water control structures to store and deliver the irrigation water required.

In this study of the consumptive use and irrigation water requirements for Great Falls, Montana, I determined that over 1 acre-ft per acre would be required for each of the crops grown. This means that if a farmer had 20,000 acres of wheat to irrigate in Great Falls, he would need over 20,000 acre-ft of water to irrigate his fields over the growing season. This water could be stored in reservoirs near his farm and transported by canals.

Appendix

Appendix A: References

- Wanielista, Martin. **Hydrology and Water Quantity Control**. John Wiley and Sons, Inc. 1990.
- United States Department of Commerce, Weather Bureau. **Climatological Data, Montana, 1965-1985**. Printed by the United States Government Printing Office.

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

Appendix B: Lab Handout

Appendix C: Calculations and Data