MUDAC 2019 Problem 2

Background

Problem 1 is about the relationships between land-based watershed characteristics and water quality. But there are also weather and climate also influence water quality. In particular, the amount, timing, and intensity of precipitation impacts water quality in Minnesota's rivers. Of these, the significance of precipitation intensity is not well understood. With climate scientists indicating that the intensity of rain storms is increasing in Minnesota, it is important to understand if and how precipitation intensity affects year-to-year variability in water quality. Your task is to help advance this understanding.

In problem 2 we are essentially "zooming in" to a few of the watersheds you saw in the previous problem, looking at hourly precipitation data for each watershed, and trying to come up with better models to predict water quality. These better models will be based on your previous predictors, plus a new concept of precipitation intensity. A significant part of this problem will be developing your own models of precipitation intensity.

Definitions

Precipitation intensity – The amount of precipitation that occurs over a period of time, often expressed as inches/day or inches/hour. Very intense thunderstorms may produce more than an inch of precipitation in an hour, or several inches in a day. For this problem, we are interested in the intensity over a period of a day or less.

Index – A number such as a sum, average, or ratio derived from a series of observations and used as an indicator or measure

Annual precipitation intensity index (APII) – An annual number (single number for each year) derived from a series of precipitation observations and used as an indicator or measure; in this case to help explain the year to year variability in two water quality variables.

Examples of possible APIIs:

1. Total number of days March-November where at least half of the precipitation zones in a watershed had more than 1 inch of precipitation.
2. Total number of days March-November where at least half of the precipitation zones in a watershed had more than 2 inches of precipitation.
3. Identify all days March-November where at one-third of the precipitation zones in a watershed had more than 1 inch of precipitation. Then look at the hourly precipitation for those days. If at one-third of the precipitation zones had more than 0.25 inches in a

given hour, identify that hour as an "intense hour." The PII value would be the total number of intense hours during the March-November time period.

These are just examples. You may vary the time step between hourly and daily. You may vary the precipitation amounts. You may also vary thresholds for numbers of precipitation zones, although it is important to understand that intense rainfall that is limited to one small area of a watershed may have little effect on river water quality.

Problem 2 Part A

Use the methods listed below or develop your own method(s) to create an annual precipitation intensity index (APII). Based on the multiple years of hourly precipitation data for four river watersheds (Figure 1), compute appropriate APII values for each watershed.

Data

The hourly precipitation data (contained in 4 Excel spreadsheets) was developed for use in watershed modeling. The effects of precipitation intensity has not been an explicit part of this modeling to date. The first column of each spreadsheet contains a time stamp in the form: 1/1/10 7:00 AM. Each of the subsequent columns contains hourly precipitation in inches for a precipitation zone in the watershed. Those zones are shown in figures 2-5. The precipitation values are for the hour starting at the time listed. In the example data row below, the precipitation that occurred in three different zone happened in the hour between 11:00 a.m. and 12:00 p.m.

1/6/10 11:00 AM	0.017	0.033	0.001

There are slight differences in the datasets for each watershed, which are described below.

Otter Tail precip hourly.xlsx – years 2010-2014; 8 precipitation zones
LeSueur precip hourly.xlsx – year 2007-2012; 19 precipitation zones
StLouis precip hourly.xlsx – years 2009–2014; 17 precipitation zones
Root precip hourly.xlsx – years 2009–2014; 12 precipitation zones

Analysis Considerations

- Each major watershed has multiple precipitation zones, but you will be combining the data from all of these zones to come up with one index value per year per major watershed. The total precipitation that occurs over an entire watershed for a given time period would be the average of all of the zones, not the sum.
- You should exclude data from the months of December, January, and February as precipitation in these month is likely to be in the form of snow. Snowfall intensity has no impact on water quality.

- Intense precipitation that occurs in spring and early summer (April-June) may have the greatest impact on water quality because vegetative cover on the landscape has not fully developed. You might try developing an index that focuses on those months or weights them more heavily.

Problem 2 Part B

Evaluate the relationship between the index values you have developed in Part A and annual water quality values for each of the four river watersheds. Two key water quality variables are provided: average annual concentrations of 1) total suspended solids, and 2) nitrate.

Data

The format of the water quality data in the spreadsheet Water_quality_data_Problem2.xlsx is in the format shown in the first table below. The river names match the four watersheds for which precipitation data is provided. The parameters (water quality variables) are described in the second table below. The years match the years for which precipitation data is provided.

Name	Parameter	Year	Avg. Concentration (mg/L)
Le Sueur River nr Rapidan, MN66	Nitrate	2007	8.6

TOTAL SUSPENDED SOLIDS (TSS)	The amount of suspended solids in the river expressed as an annual average concentration. Units are millgrams/liter. Sometimes referred to as suspended sediment.
NITRATE	The amount of nitrate in the river expressed as an annual average concentration. Units are millgrams/liter. Nitrate is a dissolved form of nitrogen.

Analysis Considerations

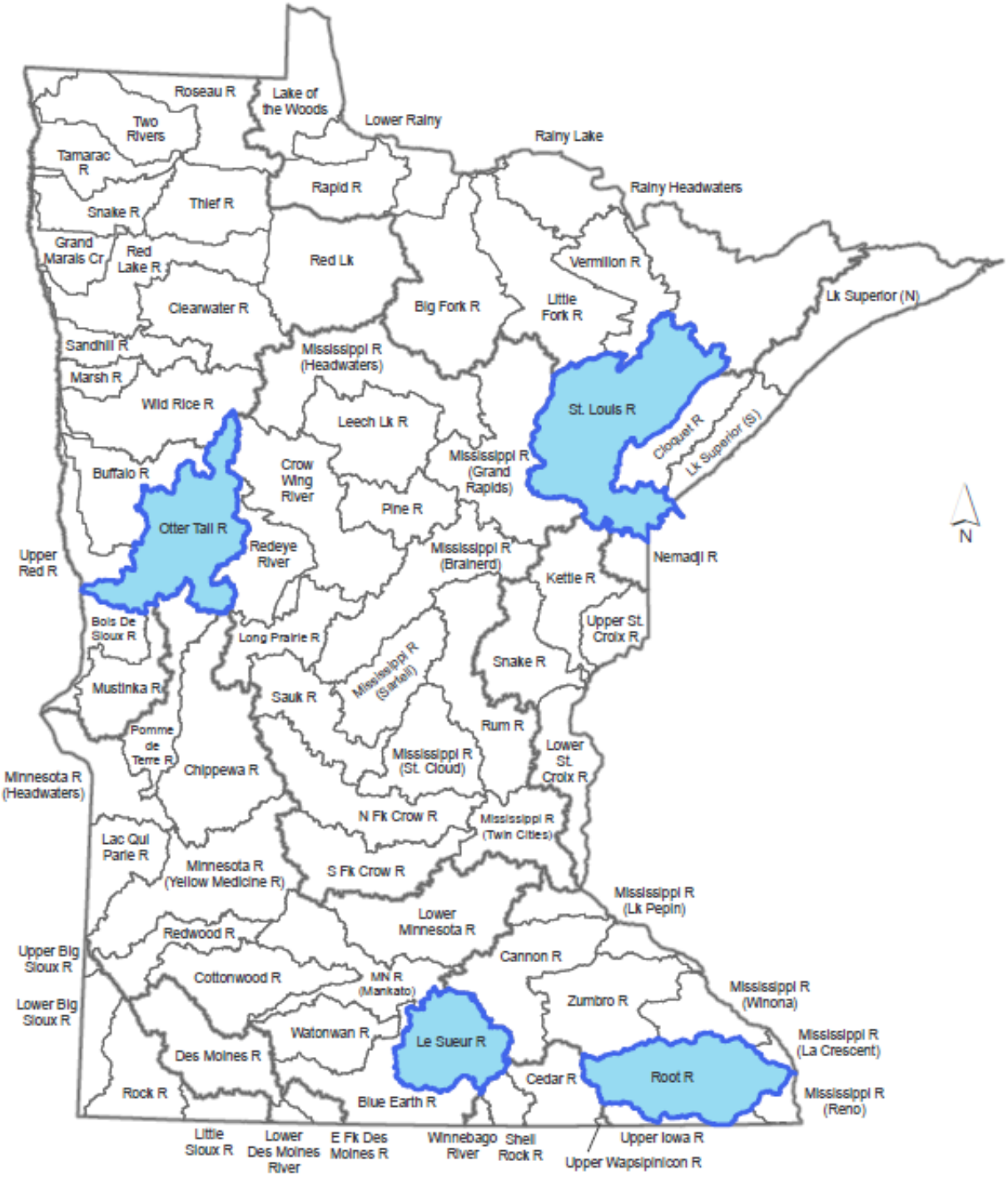
- Each watershed should be evaluated separately.
- Experiment with different index values to see which provides the best relationship with each of the two water quality variables.

Problem 2 Part C

Show how you might apply your API-based model to the statewide watershed-based water quality model developed in Problem #1.

Figure 1

Watershed Location



MINNESOTA POLLUTION CONTROL AGENCY

Figure 2

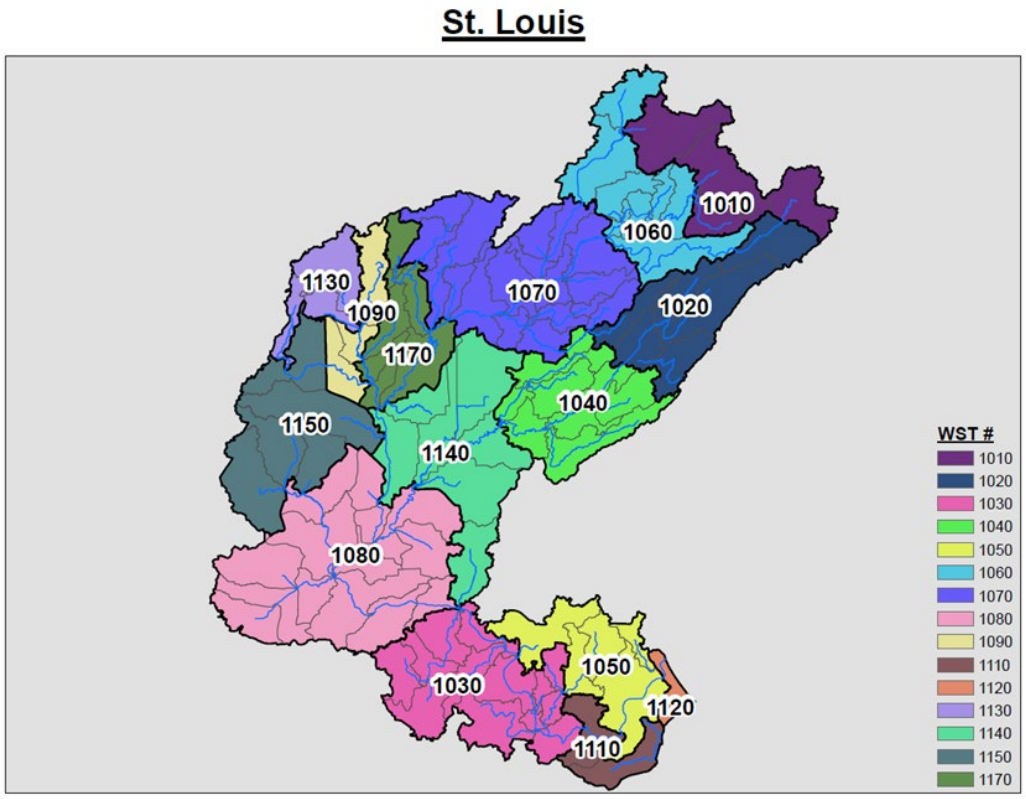


Figure 3 - Otter Tail

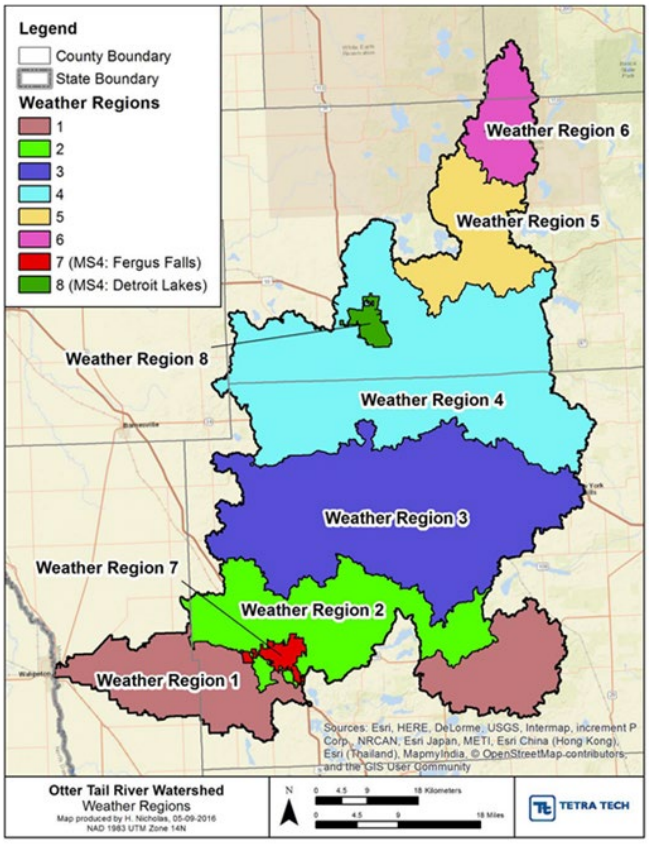


Figure 4

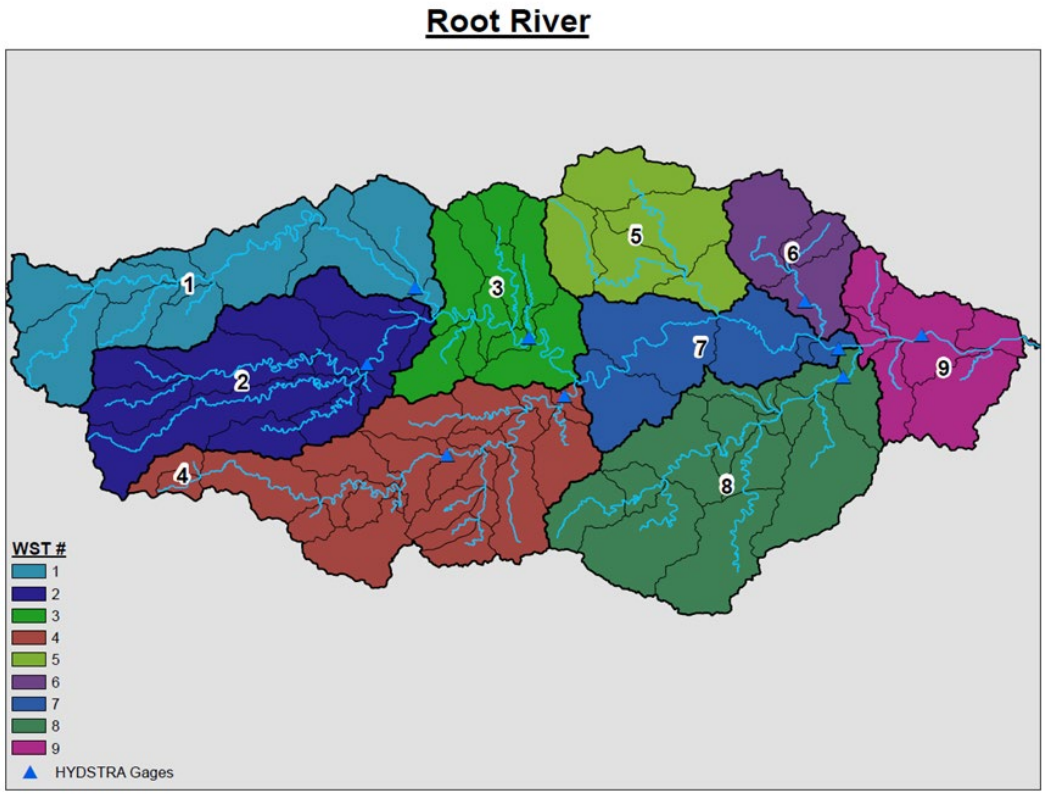


Figure 5