Assignment 4: Water Quality in Rivers

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OVERVIEW

This exercise accompanies the lessons in Hydrologic Data Analysis on water quality in rivers.

Directions

1. Change "Student Name" on line 3 (above) with your name.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single HTML file.
5. After Knitting, submit the completed exercise (HTML file) to the dropbox in Sakai. Add your last name into the file name (e.g., "A04_Chamberlin.html") prior to submission.

The completed exercise is due on 25 September 2019 at 9:00 am.

Setup

1. Verify your working directory is set to the R project file,
2. Load the tidyverse, dataRetrieval, cowplot, xts and dygraphs packages.
3. Set your ggplot theme (can be theme_classic or something else)

```
setwd("/Users/gabrielagarcia/Desktop/Hydrologic Data Analysis/Hydrologic_Data_Analysis/Assignments")
packages <- c("dataRetrieval", "tidyverse", "ggplot2")

invisible(lapply(packages, library, character.only = TRUE))



library(ggplot2)
gabytheme <- theme_bw(base_size = 20) +
  theme(plot.title=element_text(face="bold", size=27, color="chocolate", hjust=0.5),
        axis.title=element_text(size=24, color="black"),
axis.text = element_text(size=20, color = "black"),
panel.background=element_rect(fill="#F5F5F5", color="darkblue"),
panel.border = element_rect(color = "black", size = 2),
legend.position = "top", legend.background = element_rect(fill="white", color="black"),
            legend.key = element_rect(fill="transparent", color="NA"))
theme_set(gabytheme)
```

Hypoxia

This assignment will look at another measure of water quality - oxygen concentration. Though not directly important for human health, oxygen in the water column is very important for aquatic life, and so is considered a measure of water quality. Hypoxia (low oxygen) has many different definitions. For this assignment, we will use 2 mg/L O_2 as our cut-off.

4. Import the oxygen water quality data from New Hope Creek at Blands (using `readNWISqw()`, site code `02097314`, parameter code `00300`). Make a data frame called `O2.dat` that includes only the Date and O_2 concentration values. Give your data frame understandable column names.

Import Oxygen Water Quality Data

```
library(dataRetrieval)
parameters <- parameterCdFile

OxyDatRaw <- readNWISqw(siteNumbers = "02097314",
                     parameterCd = c("00300"), ###Dissolved Oxygen
                     startDate = "",
                     endDate = "")
```

Filter Data Frame

```
library(dplyr)
O2.dat<-OxyDatRaw %>%
  select(SampleDate = sample_dt, OxyConc=result_va)
```

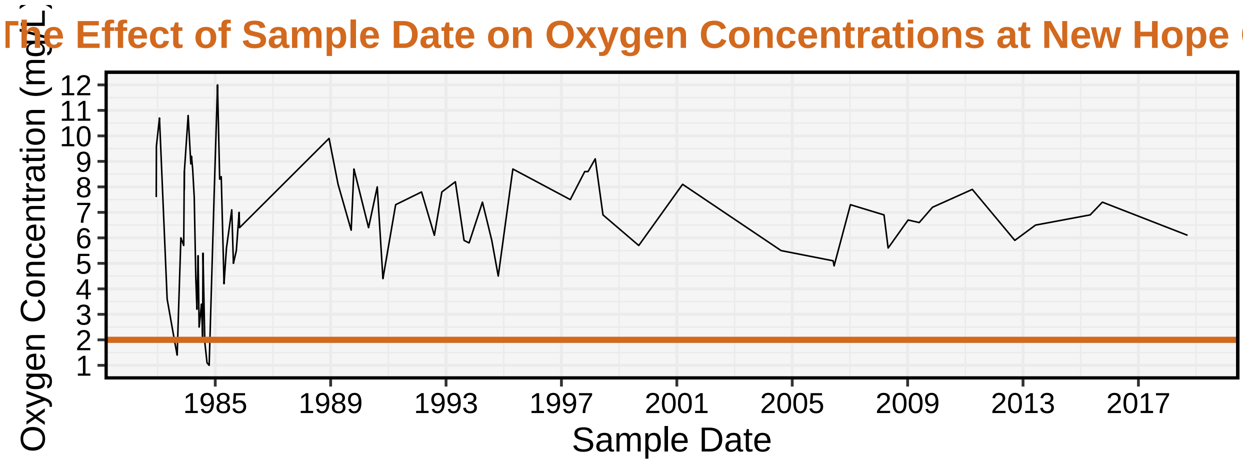
5. Create a ggplot of oxygen concentrations over time. Include a horizonal line at 2 mg/l to show the hypoxia cutoff.

GGPlot of Oxygen Concentrations over Time

```
library(ggplot2)
library(scales)
```

```
##
## Attaching package: 'scales'

## The following object is masked from 'package:purrr':
##
##     discard

## The following object is masked from 'package:readr':
##
##     col_factor
```

```
OxygenConcPlot<-
  ggplot(O2.dat, aes(x = SampleDate, y =OxyConc)) +
  geom_line(data=O2.dat, aes(x = SampleDate, y =OxyConc)) +
  gabytheme+
  labs(title="The Effect of Sample Date on Oxygen Concentrations at New Hope Creek", x="Sample Date", y=
   geom_hline(yintercept=2,color="#D2691E", lty=1, lwd=2)+
  scale_y_continuous(breaks=seq(0,12.5, by = 1))+
  scale_x_date(labels = date_format("%Y"), breaks = date_breaks("4 years"))

print(OxygenConcPlot)
```



6. What do you notice about the frequency of hypoxia overtime?

Nutrients

7. Often times hypoxia is associated with high nutrient concentrations, because abundant nutrients promote biomass growth which increases respiration and depletes oxygen concentrations in the water (remember how oxygen concentrations were very low in the hypolimnion from the Physical Properties of Lakes week). Create a new data frame, called `nutrients.dat` with total nitrogen (parameter code `00600`) and total phosphorus (parameter code `00665`) data from the USGS. Your data frame should have 3 columns, `Date`, `TotalNitrogen_mgl-N`, and `TotalPhosphorus_mgl-P`.

```
nutrients.dat<-readNWISqw(siteNumbers = "02097314",
                      parameterCd = c("00600", "00665"), ###Total Nitrogen and Total Phosphorus
                      startDate = "",
                      endDate = "")
```

Wrangle Nutrients Data Frame

```
library(tidyr)
nutrients.dat<-spread(nutrients.dat, parm_cd, result_va)%>%
 select(Date=sample_dt, 'TotalNitrogen_mgl-N'='00600','TotalPhosphorus_mgl-P' = '00665')
```

Check Nutrients Data Frame Structure

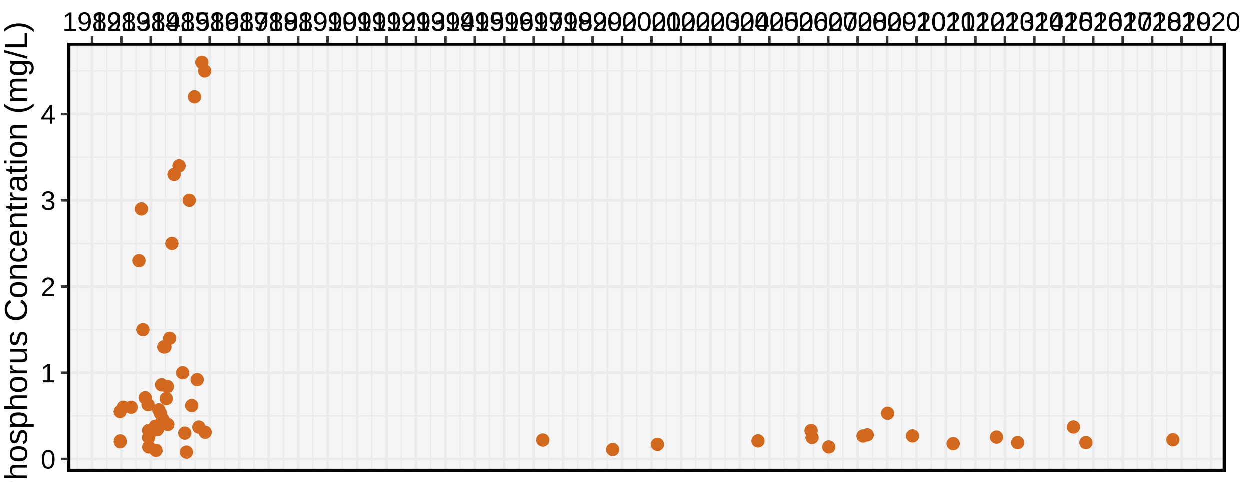
```
str(nutrients.dat)
```

```
## 'data.frame':    111 obs. of  3 variables:
##  $ Date                 : Date, format: "1982-12-16" "1982-12-17" ...
##  $ TotalNitrogen_mgl-N  : num  3.7 2.3 1.2 1.9 2.8 NA 27 NA 9.6 NA ...
##  $ TotalPhosphorus_mgl-P: num  0.55 0.2 0.21 0.6 NA 0.6 NA 2.3 NA 2.9 ...
```

8. Create two ggplots stacked with cowplot that show nutrient concentrations over time. (cowplot=plot_grid)

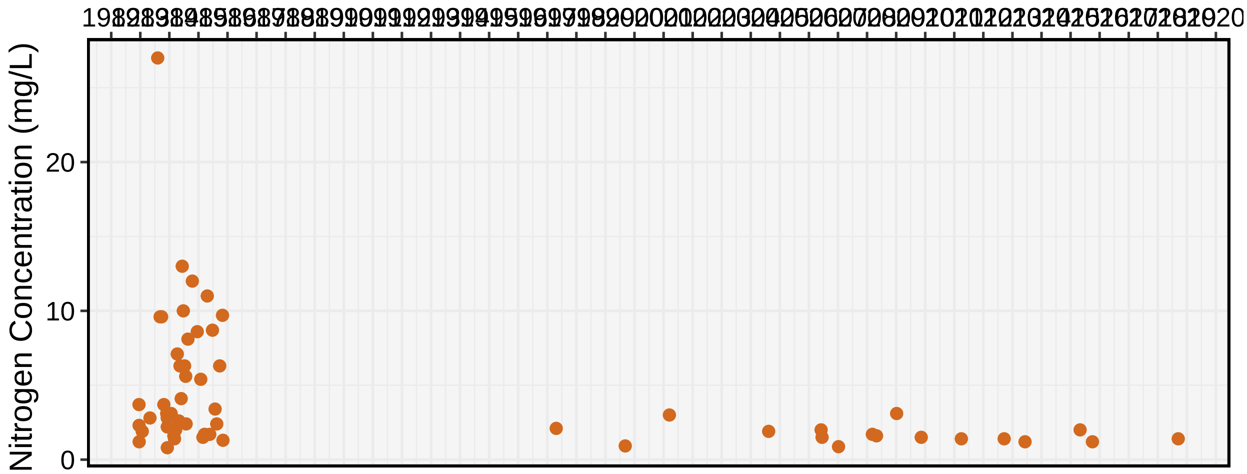
Phosphorus Plot

```
PhosphorusPlot<-ggplot(nutrients.dat, aes(x =Date, y =`TotalPhosphorus_mgl-P`)) +
  geom_point(data=nutrients.dat, aes(x =Date, y =`TotalPhosphorus_mgl-P`), color="chocolate", size=4, al
  scale_x_date(labels = date_format("%Y"),
               breaks = date_breaks("1 year"), position = "top")+
  labs(title="", x ="", y = "Phosphorus Concentration (mg/L) ") +
  theme(legend.position = "none",  axis.title.x = element_blank())+
  gabytheme

print(PhosphorusPlot)
```



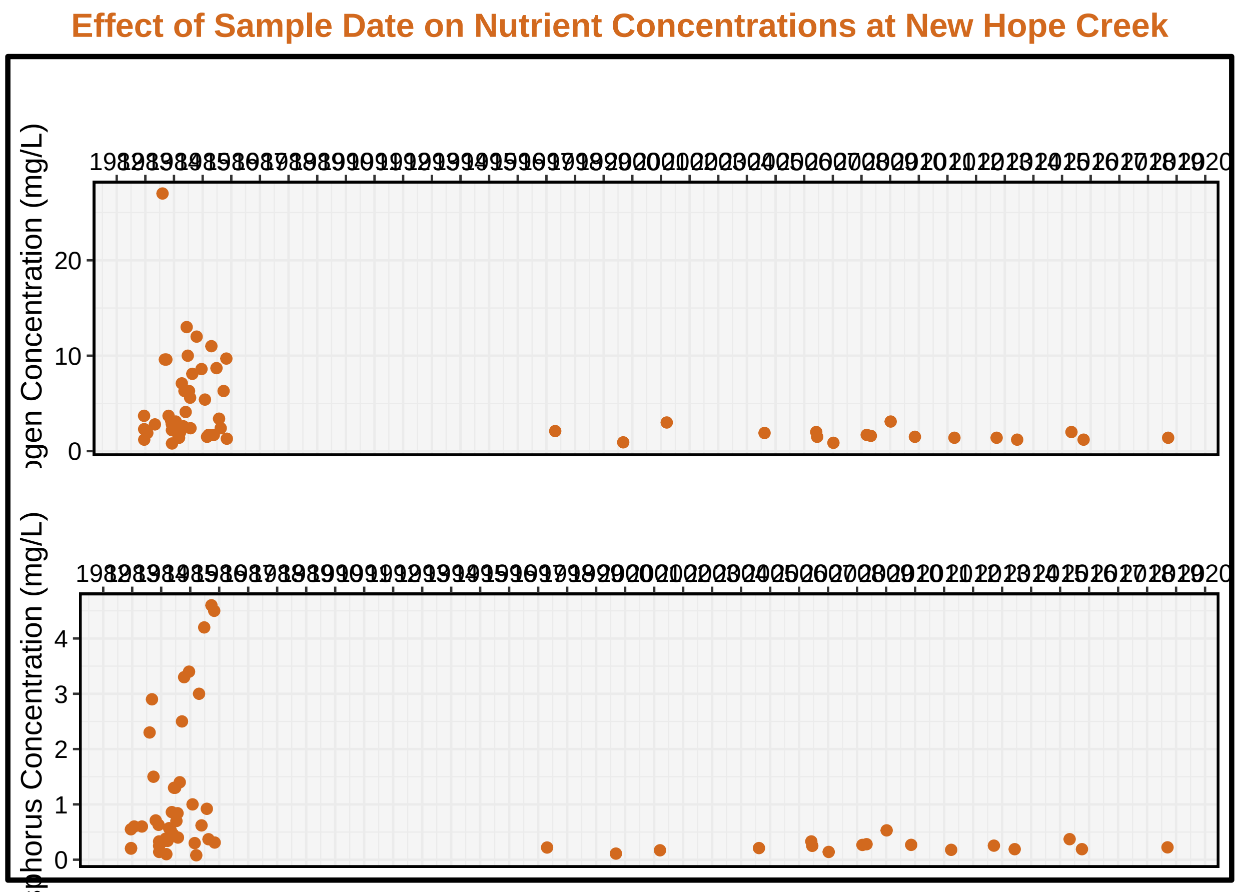
Nitrogen Plot

```
NitrogenPlot<-ggplot(nutrients.dat, aes(x =Date, y =`TotalNitrogen_mgl-N`)) +
  geom_point(data=nutrients.dat, aes(x =Date, y =`TotalNitrogen_mgl-N`), size=4, alpha=1, color="chocola
scale_x_date(labels = date_format("%Y"),
               breaks = date_breaks("1 year"), position = "top")+
  labs(title="",
       x ="", y = "Nitrogen Concentration (mg/L) ") +
  theme(axis.title.x = element_blank())+
  gabytheme

print(NitrogenPlot)
```



Combined Plot

```
library(cowplot)
CombinedNutrientPlot<-plot_grid(NitrogenPlot, PhosphorusPlot,
nrow= 2, rel_heights = c(1, 1)) +
  labs(title="Effect of Sample Date on Nutrient Concentrations at New Hope Creek")+
  gabytheme
print(CombinedNutrientPlot)
```



9. What do these plots tell you about nutrient concentrations over time? How might this relate to your previous plot of hypoxia events?

Discharge and Temperature

10. Turbulent flow in rivers mixes oxygen into the water column. As discharge decreases, water moves slower, and oxygen diffuses slower into the water from the atmosphere. Download and reformat the daily discharge data for New Hope Creek (function `readNWISdv()`, site `02097314`, parameter `00060`).
11. Create a dygraph of discharge and oxygen concentrations. You should have discharge on the y axis and oxygen concentration on the y2 axis. Set your y-axes limits so that they don't change as you zoom in and out. (hint: use `dyAxis(..., valueRange = c(0, 6500))` for discharge & `dyAxis(..., valueRange = c(0, 13))` for oxygen).
12. Do hypoxic events happen in the wet or the dry season? How many days after storm events (of at least 100 cfs) do they occur?
13. Temperature also impacts the solubility of oxygen in water. More oxygen can dissolve when temperatures are *lower*. How would you analyze the effects of temperature on dissolved oxygen concentrations? What data would you need? How would you separate the effects of temperature from the effects of flow?
14. What do you think is the biggest driver of hypoxia in New Hope Creek? What data do you use to support your conclusion?

Reflection

15. What are 2-3 conclusions or summary points about river water quality you learned through your analysis?

16. What data, visualizations, and/or models supported your conclusions from 15?

17. Did hands-on data analysis impact your learning about water quality relative to a theory-based lesson? If so, how?

18. How did the real-world data compare with your expectations from theory?