Assignment 4: Physical Properties of Rivers

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OVERVIEW

This exercise accompanies the lessons in Water Data Analytics on the physical properties of 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 PDF file.
5. After Knitting, check your PDF against the key and then submit your assignment completion survey at https://forms.gle/futQwtCsyYsZG9nCA

Having trouble? See the assignment's an in swer key if you need a hint. Please try to complete the assignment without the key as much as possible - this is where the learning happens!

Target due date: 2022-02-15

Setup and Data Processing

1. Verify your working directory is set to the R project file. Load the tidyverse, cowplot, dataRetrieval, lubridate, lfstat, and EcoHydRology packages. Set your ggplot theme (can be theme_classic or something else).
2. Acquire daily mean discharge data for the Bitterroot River in Montana (USGS gage 12344000) and the Nehalem River in Oregon (USGS gage 14299800). Collect the 10 most recent complete water years.
3. Add columns in the dataset for water year, baseflow, and stormflow. Feel free to use either baseflow separation function we used in class.
4. Calculate annual total discharge, annual baseflow, and annual proportion baseflow for the two sites.

```
 # 1. Verify directory, load packages, set theme
getwd()
```

```
## [1] "/Users/lydiecostes/Documents/Duke/WaterDataAnalytics/Water_Data_Analytics_2022/Assignments"
```

```
library(EcoHydRology)
library(tidyverse)
library(cowplot)
library(dataRetrieval)
library(lubridate)
library(lfstat)
```

```
theme_set(theme_bw())

# 2. Import data and update column names
Bitter <- readNWISdv(siteNumbers = "12344000",
                     parameterCd = "00060", # discharge (ft3/s)
                     startDate = "2012-10-01",
                     endDate = "2021-09-30")
names(Bitter)[4:5] <- c("Discharge", "Approval.Code")

Nehalem <- readNWISdv(siteNumbers = "14299800",
                      parameterCd = "00060", # discharge (ft3/s)
                      startDate = "2012-10-01",
                      endDate = "2021-09-30")
names(Nehalem)[4:5] <- c("Discharge", "Approval.Code")

# 3. Add columns for water year, baseflow, and stormflow
Bitter <- Bitter %>%
  mutate(WaterYear = water_year(Date),
         Baseflow = baseflow(Discharge),
         Stormflow = Discharge - Baseflow)

Nehalem <- Nehalem %>%
  mutate(WaterYear = water_year(Date),
         Baseflow = baseflow(Discharge),
         Stormflow = Discharge - Baseflow)

# 4. Calculate annual total discharge, annual baseflow, annual proportion baseflow

BitterAnnual <- Bitter %>%
  group_by(WaterYear) %>%
  summarise(AnnualDischarge = sum(Discharge, na.rm = TRUE)*723.968,
            AnnualBaseflow = sum(Baseflow, na.rm = TRUE)*723.968,
            PropBaseflow = AnnualBaseflow/AnnualDischarge) %>%
  mutate_if(is.numeric, round, 2)

NehalemAnnual <- Nehalem %>%
  group_by(WaterYear) %>%
  summarise(AnnualDischarge = sum(Discharge, na.rm = TRUE)*723.968,
            AnnualBaseflow = sum(Baseflow, na.rm = TRUE)*723.968,
            PropBaseflow = AnnualBaseflow/AnnualDischarge) %>%
  mutate_if(is.numeric, round, 2)
```

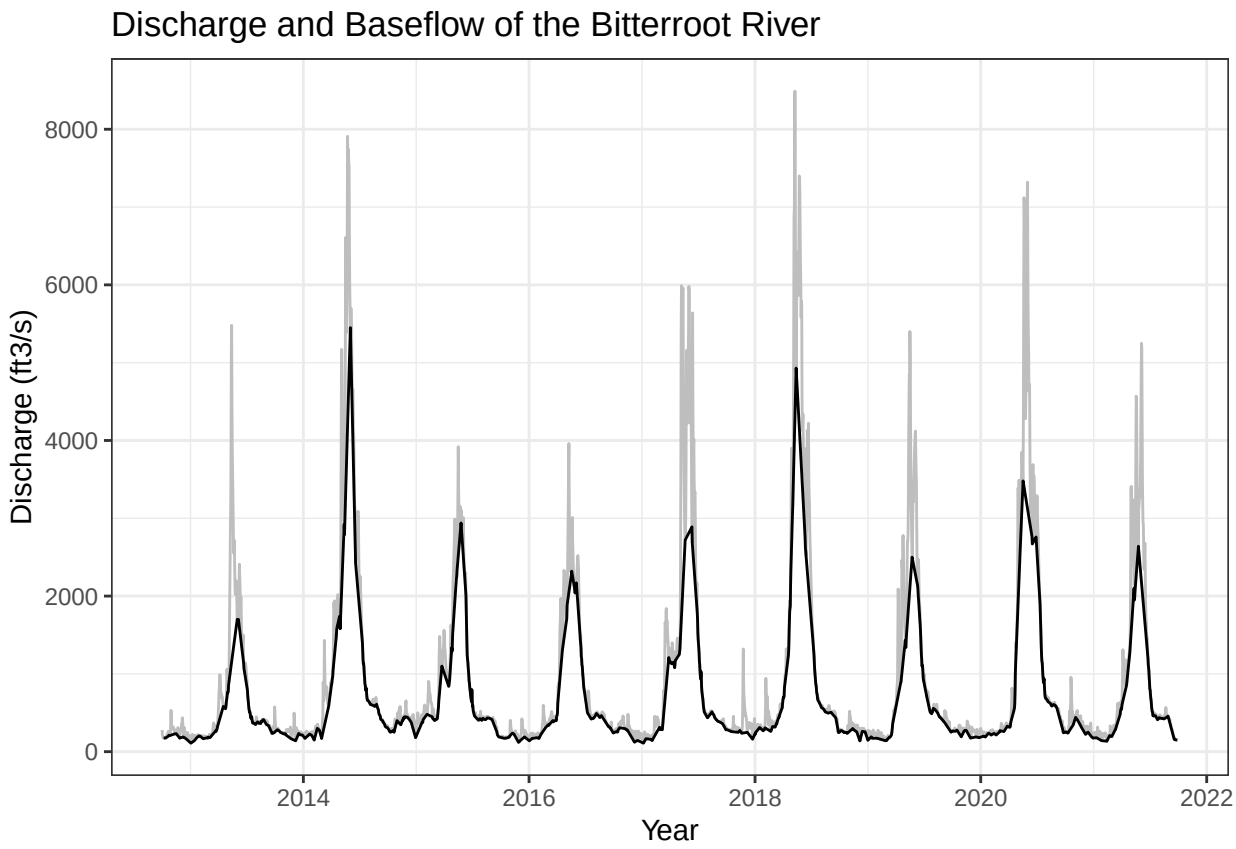
Analyze seasonal patterns in discharge

5. For both sites, create a graph displaying discharge and baseflow by date. Adjust axis labels accordingly.
6. For both sites, create a graph displaying annual total discharge and annual baseflow across years, and a second graph displaying the proportion baseflow across years (adjust axis labels accordingly). Plot these graphs on top of one another using `plot_grid`. Remember to align the axes!

```
# 5. Graph of discharge and baseflow by date
ggplot(Bitter, aes(x = Date)) +
  geom_line(aes(y = Discharge), color = "grey") +
```

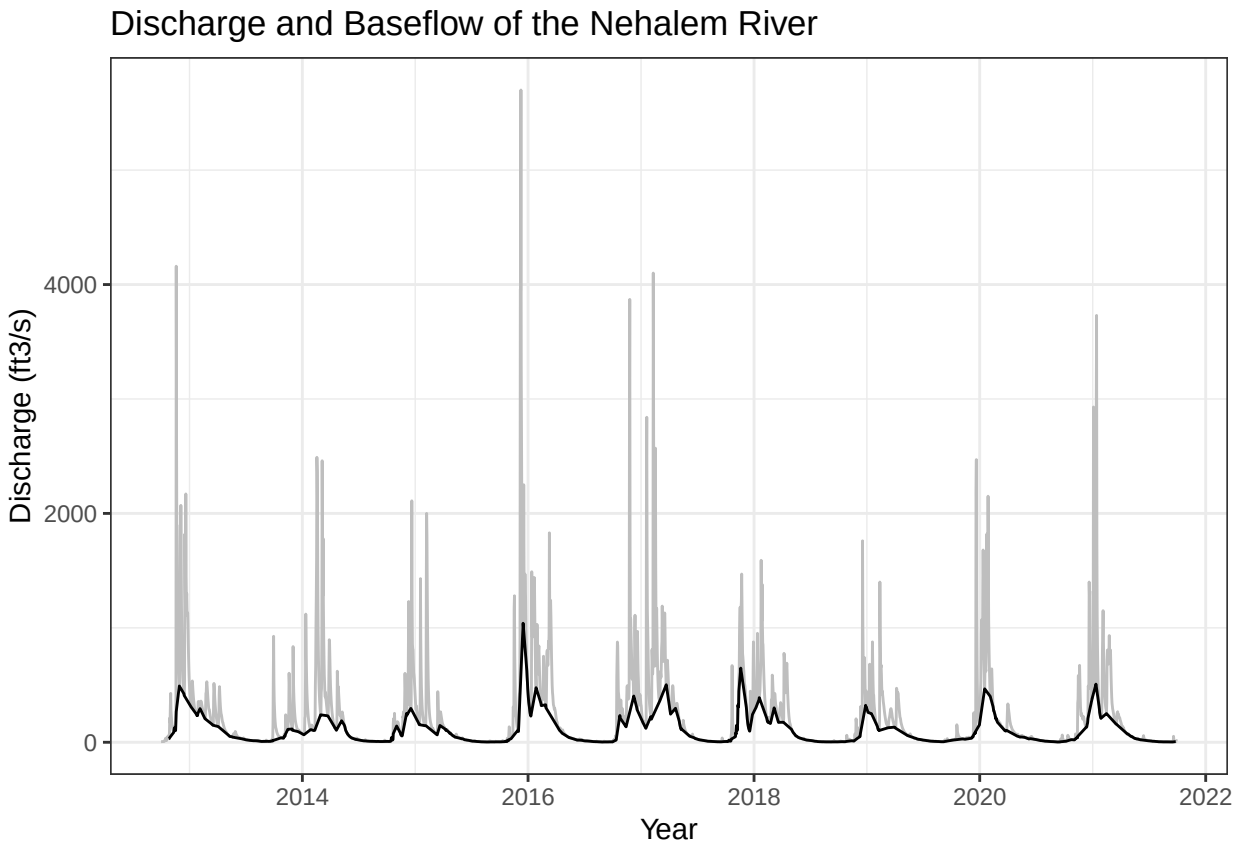
```
  geom_line(aes(y = Baseflow)) +
  labs(y = "Discharge (ft3/s)", x = "Year",
       title = "Discharge and Baseflow of the Bitterroot River")
```

```
## Warning: Removed 8 row(s) containing missing values (geom_path).
```

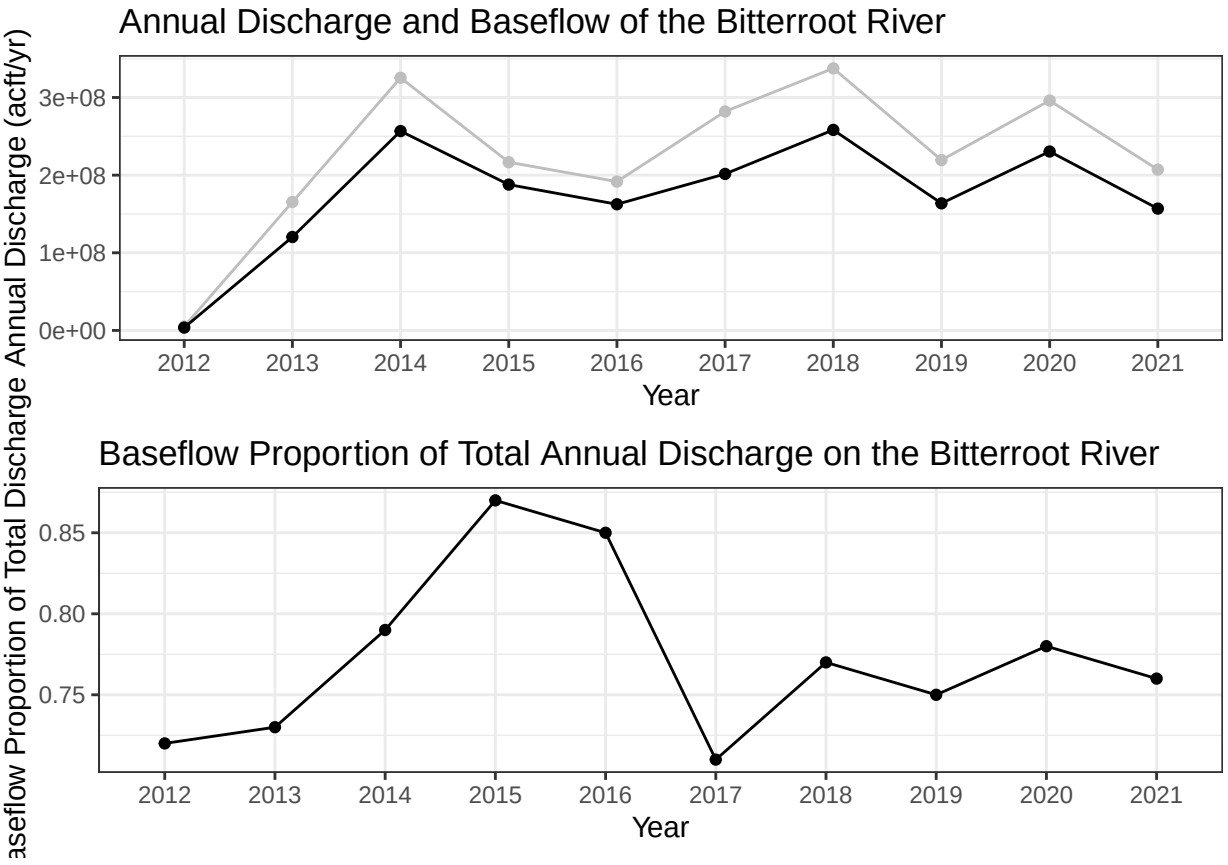



```
ggplot(Nehalem, aes(x = Date)) +
  geom_line(aes(y = Discharge), color = "grey") +
  geom_line(aes(y = Baseflow)) +
  labs(x = "Year",
       y = "Discharge (ft3/s)",
       title = "Discharge and Baseflow of the Nehalem River")
```

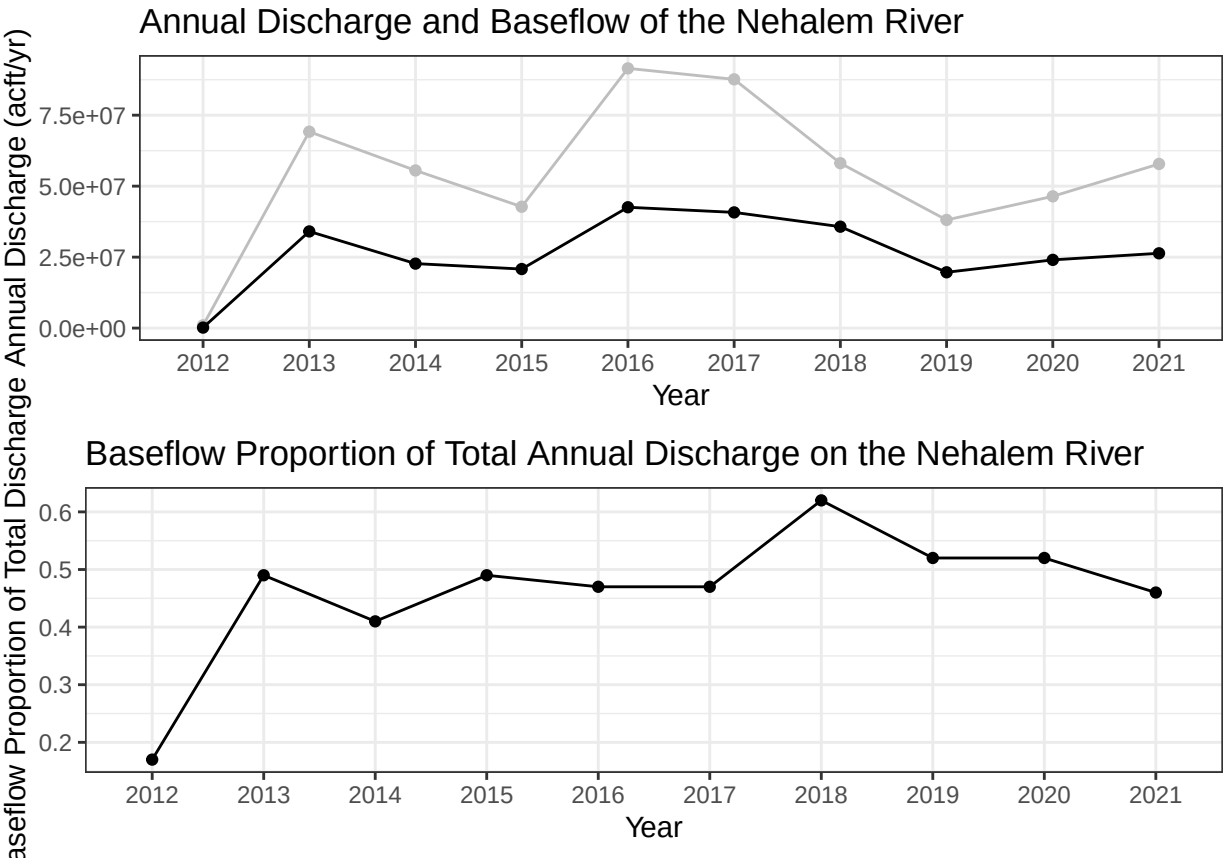
```
## Warning: Removed 29 row(s) containing missing values (geom_path).
```




```
# 6. Graph of annual total discharge, annual total baseflow, proportion
BitPlotFlow <- ggplot(BitterAnnual, aes(x = WaterYear)) +
  geom_point(aes(y = AnnualDischarge), color = "grey")  +
  geom_line(aes(y = AnnualDischarge, group = 1), color = "grey") +
  geom_point(aes(y = AnnualBaseflow)) +
  geom_line(aes(y = AnnualBaseflow, group = 1)) +
  labs(x = "Year",
       y = "Annual Discharge (acft/yr)",
       title = "Annual Discharge and Baseflow of the Bitterroot River")

BitPlotProp <- ggplot(BitterAnnual, aes(x = WaterYear,
                                        y = PropBaseflow)) +
  geom_point() +
  geom_line(aes(group=1)) +
  labs(x = "Year",
       y = "Baseflow Proportion of Total Discharge",
       title = "Baseflow Proportion of Total Annual Discharge on the Bitterroot River")

plot_grid(BitPlotFlow, BitPlotProp, ncol = 1)
```




```
NehPlotFlow <- ggplot(NehalemAnnual, aes(x = WaterYear)) +
  geom_point(aes(y = AnnualDischarge), color = "grey")  +
  geom_line(aes(y = AnnualDischarge, group = 1), color = "grey") +
  geom_point(aes(y = AnnualBaseflow)) +
  geom_line(aes(y = AnnualBaseflow, group = 1)) +
  labs(x = "Year",
       y = "Annual Discharge (acft/yr)",
       title = "Annual Discharge and Baseflow of the Nehalem River")

NehPlotProp <- ggplot(NehalemAnnual, aes(x = WaterYear,
                                         y = PropBaseflow)) +
  geom_point() +
  geom_line(aes(group=1)) +
  labs(x = "Year",
       y = "Baseflow Proportion of Total Discharge",
       title = "Baseflow Proportion of Total Annual Discharge on the Nehalem River")

plot_grid(NehPlotFlow, NehPlotProp, ncol = 1)
```



7. How do these rivers differ in their discharge and baseflow, both within and across years? How would you attribute these patterns to the climatic conditions in these locations?

Bitterroot's discharge and baseflow are closer to each other, averaging baseflow above 70% of total discharge for all years. Much of the high peaks in discharge for Bitterroot River are considered to be baseflow and are somewhat smoothed over the course of the season, suggesting some continuity with snowpack melt. Meanwhile, Nehalem River has discharge peaks that depart substantially from the baseflow, and baseflow averages under 55% of total discharge for all years except one. Nehalem's peaks are much steeper, suggesting that they are linked to specific precipitation events rather than snowmelt and are therefore not part of baseflow.