Miller Creek and Vogel Lake Water Quality

Benjamin Meyer (ben@kenaiwatershed.org)

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Contents


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library(bookdown)
library(tinytex)
library(packrat)
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options(knitr.duplicate.label = "allow")
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Chapter 1

Introduction

This draft document contains preliminary data explorations of 2021-2023 water quality data from the Vogel Lakes complex and Miller Creek in the Northern Kenai peninsula. These data are being collected as part of potential plans to eradicate invasive pike from the area, which were identified in 2018-2019 by the Alaska Dept. of Fish and Game.

The draft environmental assessment for potential eradication of invasive Northern Pike from this system is available from the US Fish and Wildlife Service.

Water quality and watershed characterization fieldwork for this project is conducted by Kenai Watershed Forum.

An ArcGIS Online map of sites included in water quality monitoring efforts is found here: https://arcg.is/0fqvb0.

A GitHub repository with the code generating this report is also available.

Chapter 2

Lake Water Quality Profiles

Lake water quality profiles were collected at 1-2 month intervals at five sites at 1 meter depth intervals. Hydrolab MS5 sondes were descended from an anchored boat centered over the deepest point of each lake.

Raw water quality field data is stored in a Google Sheet that can be viewed at https://tinyurl.com/kwf-vogel-wqx-data.

Data visualizations are provided for each site visit here.

2.1 Data by Month

2.1.1 January 2021

Jan 22, 2021

2.1.2 March 2021

March 23, 2021

2.1.3 May 2021

May 25, 2021

2.1.4 June 2021

June 29, 2021

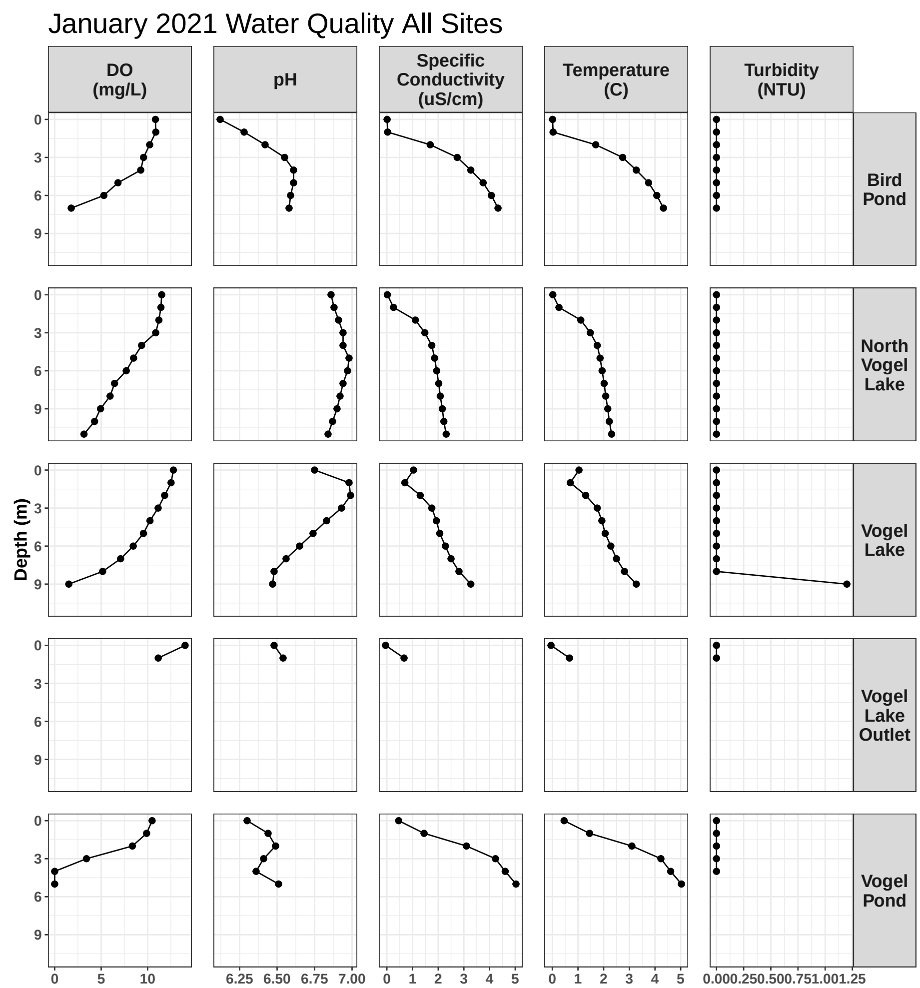

Figure 2.1: January 2021

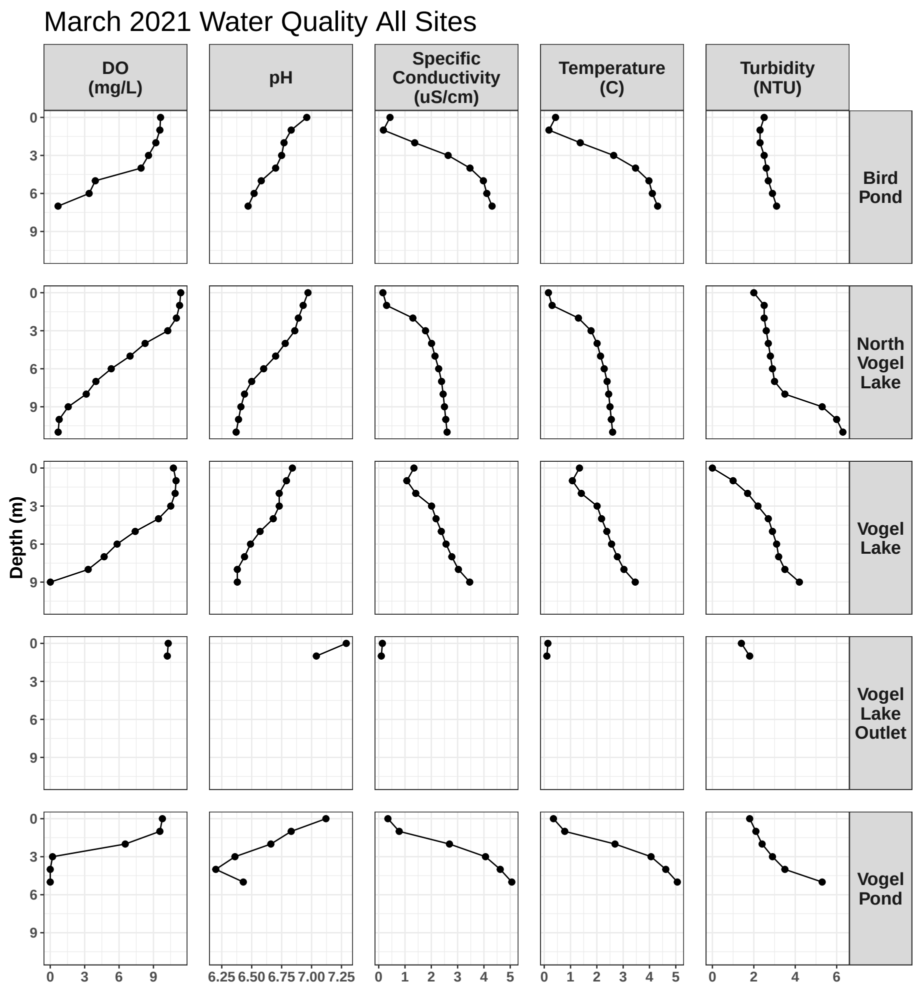

Figure 2.2: March 2021

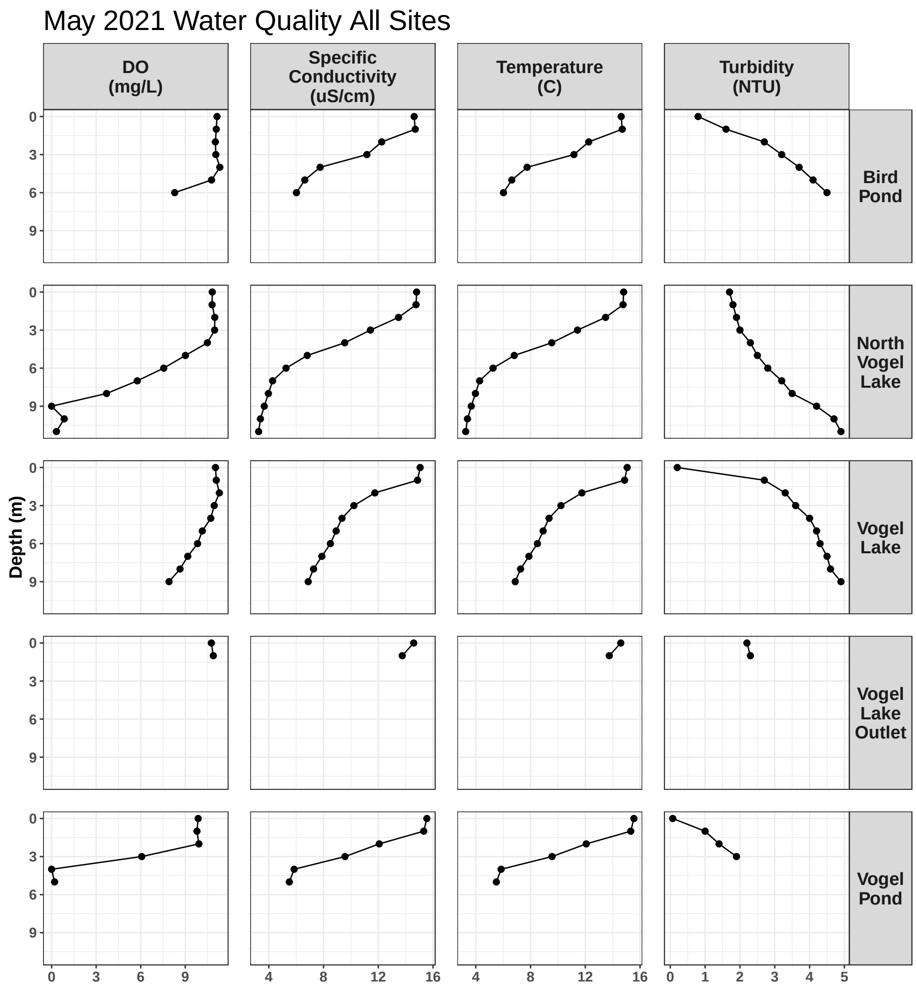

Figure 2.3: May 2021

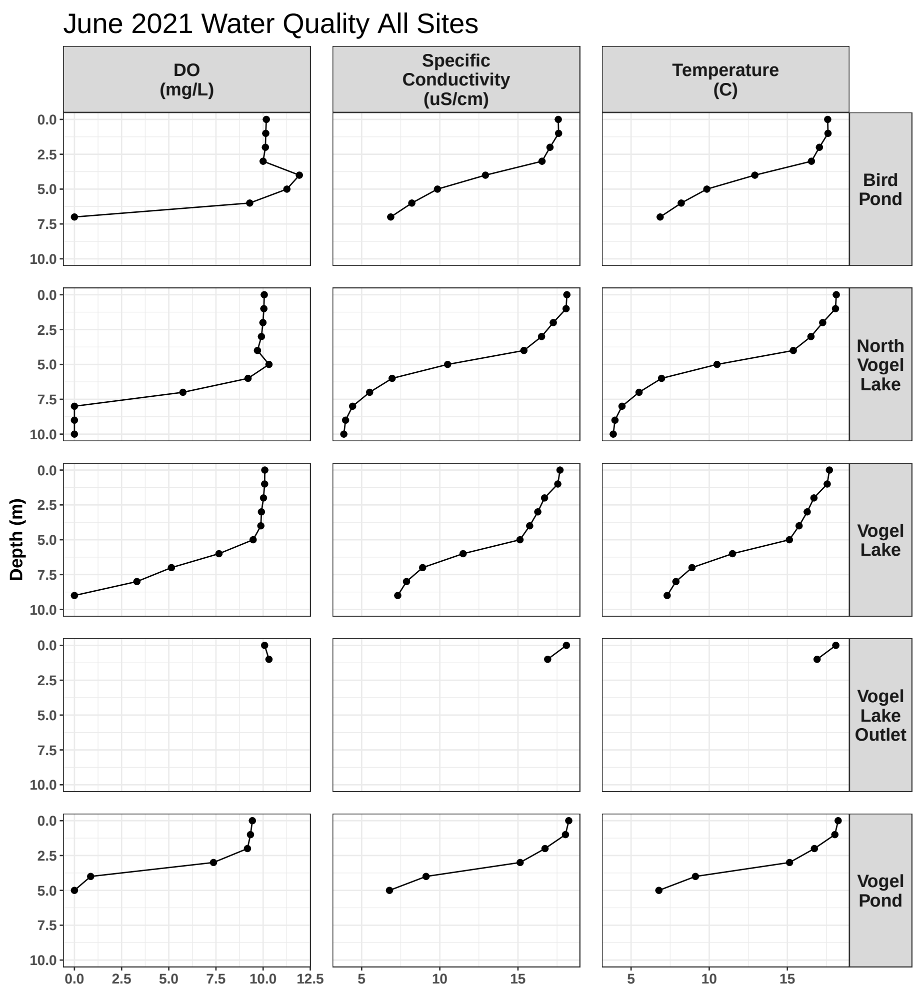

Figure 2.4: June 2021

Note: turbidity data is absent from June 2021 sampling due to an equipment issue.

2.1.5 August 2021

August 3, 2021

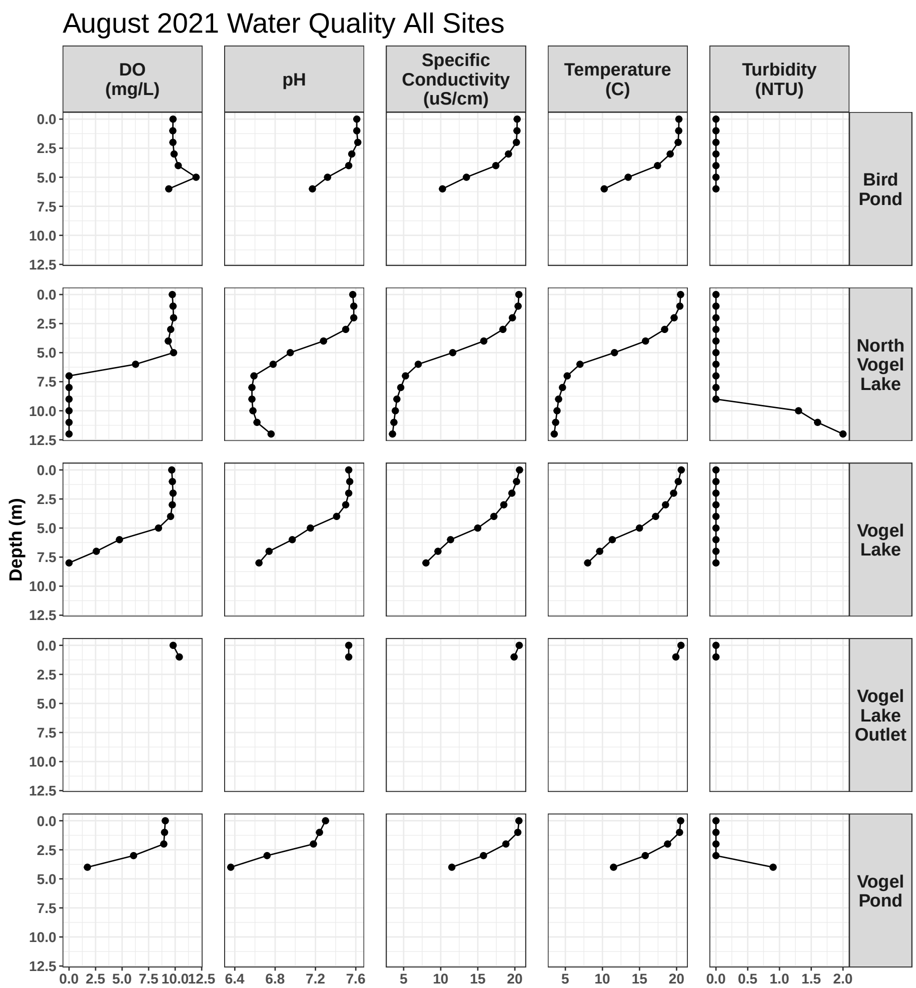

Figure 2.5: August 2021

2.1.6 September 2021

September 15, 2021

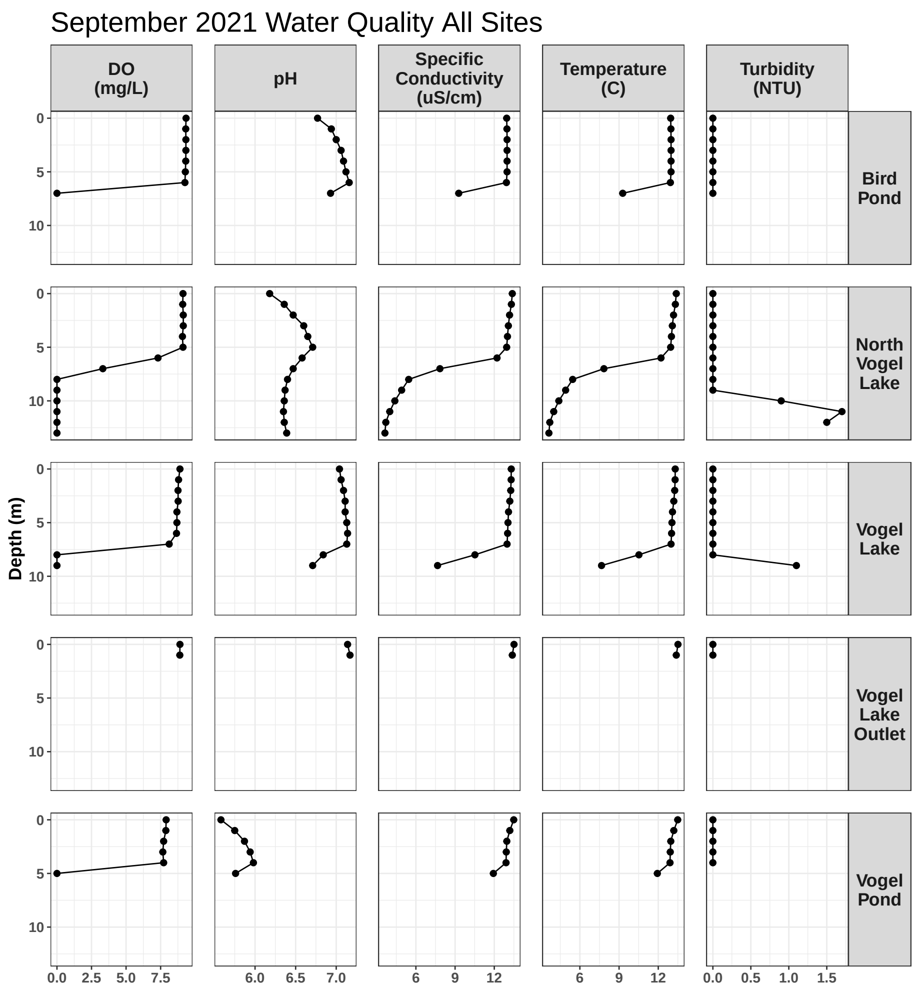

Figure 2.6: September 2021

2.2 Overall Data

2.2.0.1 Dissolved Oxygen

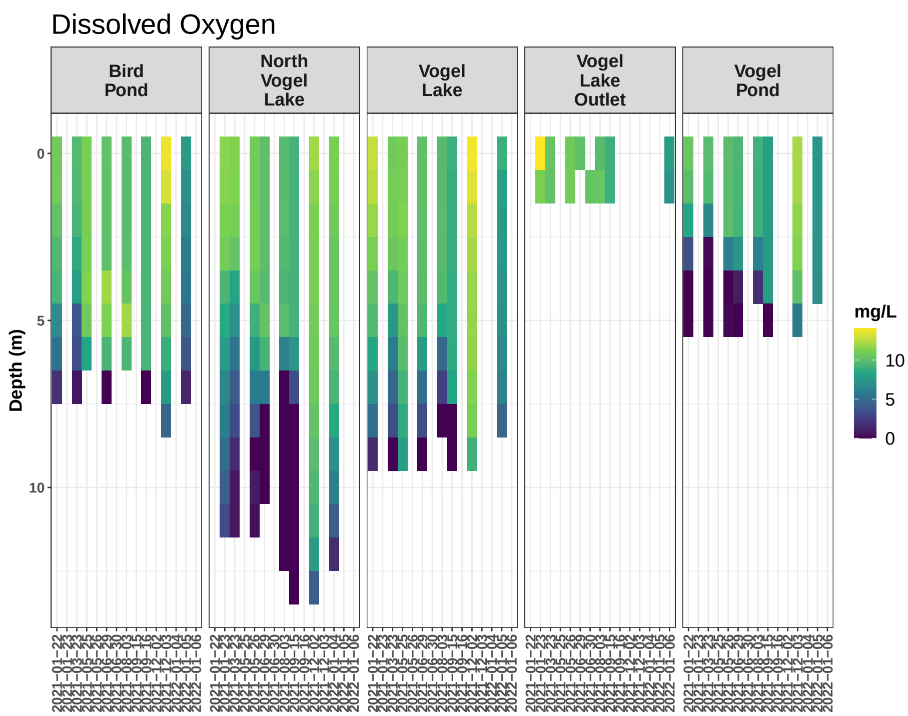

Figure 2.7: Dissolved Oxygen (mg/L)

2.2.0.2 pH

Note: pH values are excluded from the May and June 2021 site visits due to an instrument error.

2.2.0.3 Turbidity

Note: some turbidity values near the benthic surface of each site visit are not displayed in the above plot in order to improve visualization.

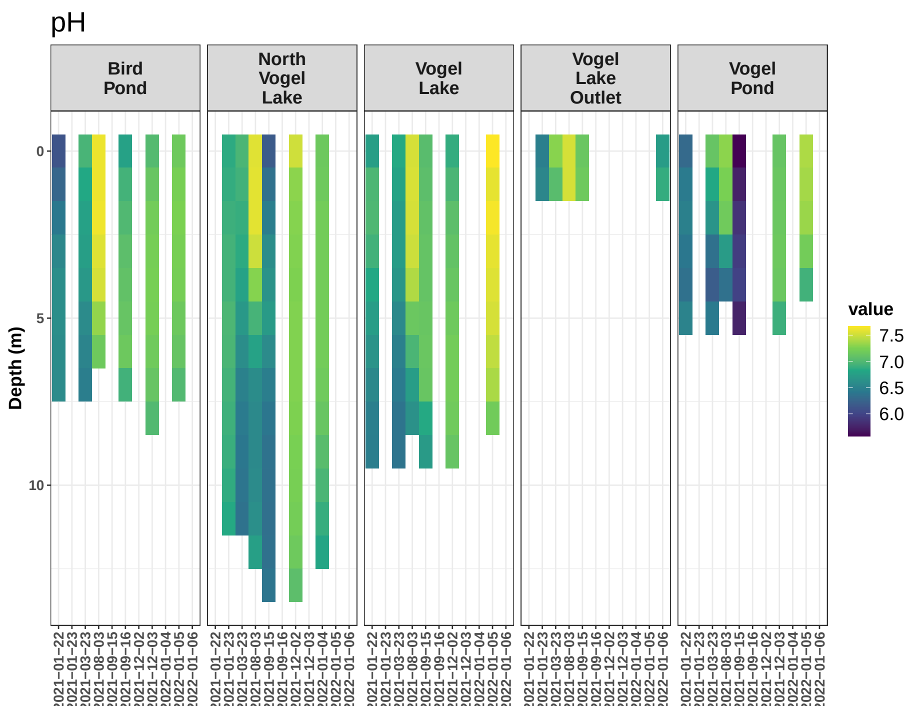
pH
Bird Pond
North Vogel Lake
Vogel Lake
Vogel Lake Outlet
Vogel Pond
Depth (m)
0
5
10
value
7.5
7.0
6.5
6.0
2021-01-22
2021-01-23
2021-03-23
2021-08-03
2021-09-15
2021-09-16
2021-12-02
2021-12-03
2022-01-04
2022-01-05
2022-01-06

Figure 2.8: pH

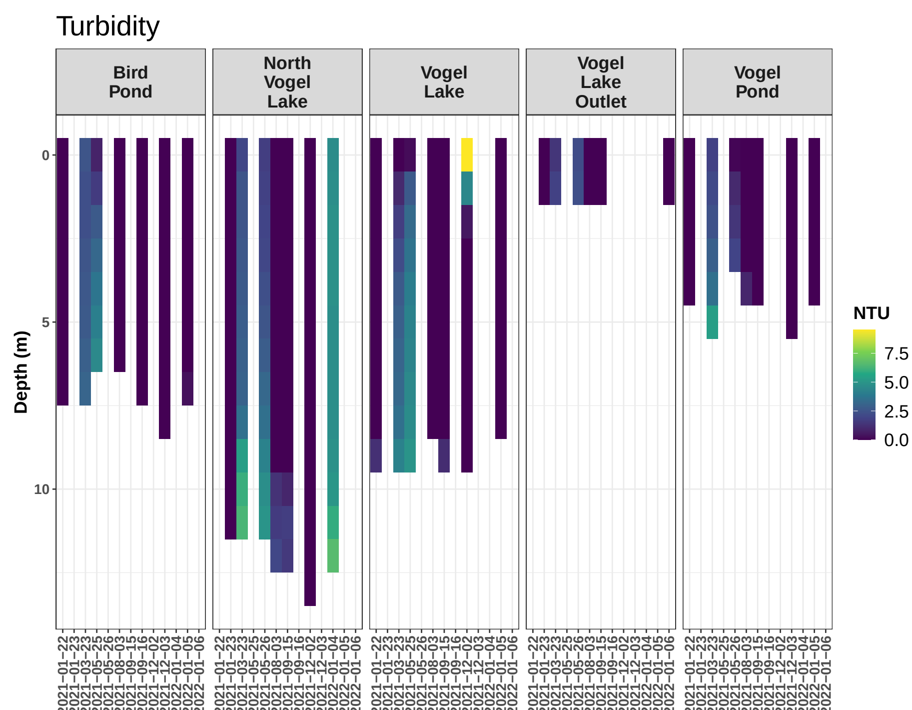

Figure 2.9: Turbidity (NTU)

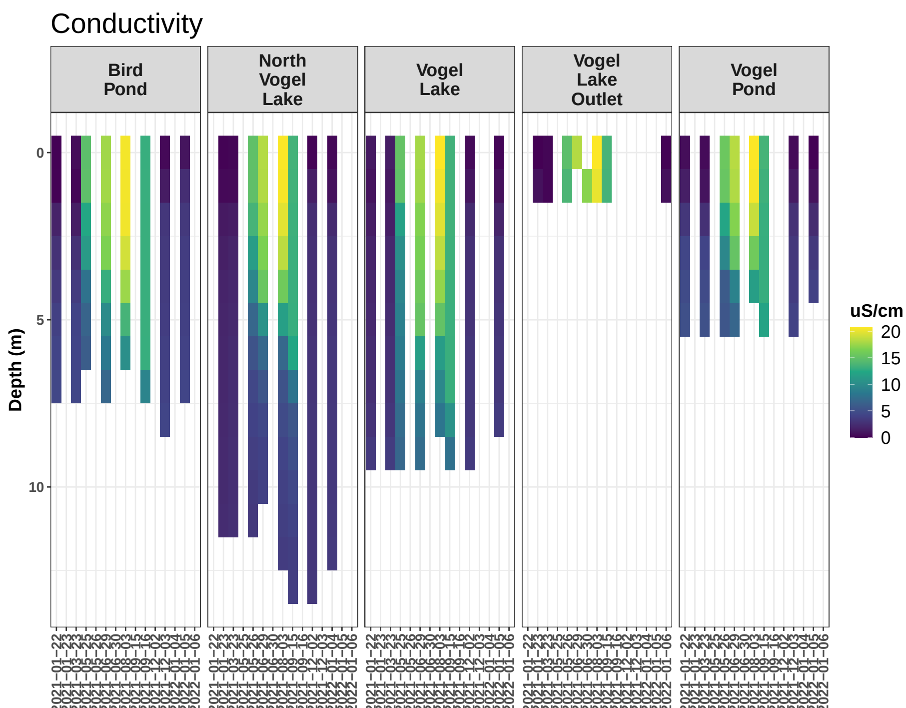

Figure 2.10: Conductivity (uS/cm)

2.2.0.4 Conductivity

2.2.0.5 Water Temperature

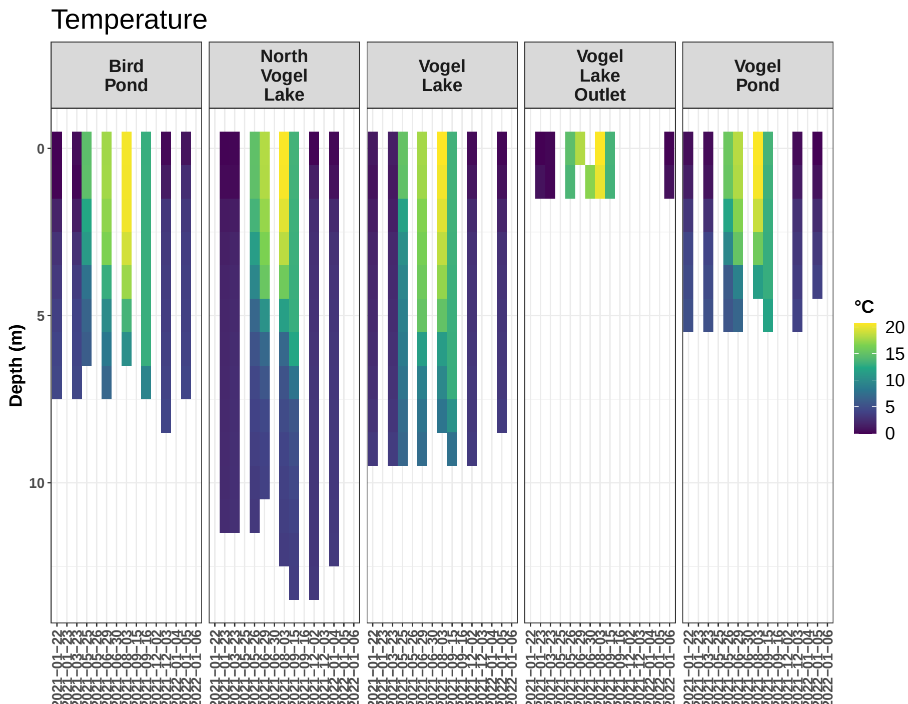

Figure 2.11: Water Temperature (C)

2.3 Site Summaries

A table of summary statistics for water quality parameters at each site will be provided here.

Chapter 3

Miller Creek Discharge & Flow Rate

3.0.1 Introduction

Hydrology fieldwork focusing on flow and discharge is being conducted throughout the Miller Creek drainage in Fall 2020 - Spring 2021.

- Near the mouth of Miller Creek, a discharge measurement station was installed in October 2020. At this site a pressure transducer measures water level, and discharge measurements are collected periodically using an Acoustic Doppler Velocimeter. These data, along with staff plate observations, are being used to create a rating discharge curve.
- An experiment to study stream flow rate in Miller Creek was conducted September 15-17, 2021. A plug of dissolved salt (NaCl) was discharged in to the creek, and the resultant spike in conductivity was observed downstream 0.64 km stream distance.

Raw water quality field data is stored in a Google Sheet that can be viewed at https://tinyurl.com/kwf-vogel-wqx-data under the “Discharge Measurements” tab.

Site photos are available through a point-and-click pop-up map at https://arcg.is/0fqvb0.

3.0.2 Miller Creek Discharge Rating Curve

A discharge station was established in October 2020 near the mouth of Miller Creek, including a staff plate and pressure transducer.

Site visits have been made opportunistically depending on precipitation throughout Summer/Fall 2021. At each site visit, the pressure transducer is downloaded and a discharge measurement is collected using a SondeTek Flowtracker. See Figure 3.1 for the discharge rates and staff plate values observed to date.

Once a minimum of eight discharge measurements are available in Fall 2021, a curve will be fit to the scatter plot of stage height vs. discharge. This relationship will be used in conjunction with pressure transducer data to create a flow hydrograph.

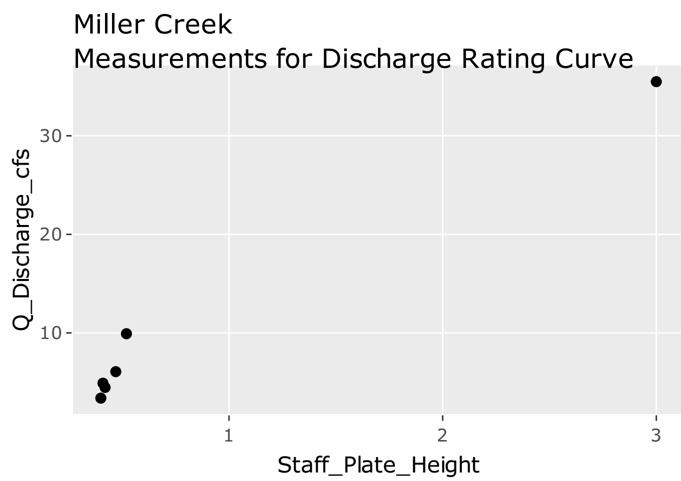

Figure 3.1: Measurements for Miller Creek Discharge Rating Curve

3.0.3 Discharge measurements at other sites

Additional discharge measurements were taken throughout Summer 2021 at two additional sites near Vogel Lake, near the outlets of Kuguyuk Pond and Bird Pond. See Figure 3.2 for discharge values observed to date.

3.0.4 Pressure Transducer Data

Work in progress here 8/10/2021

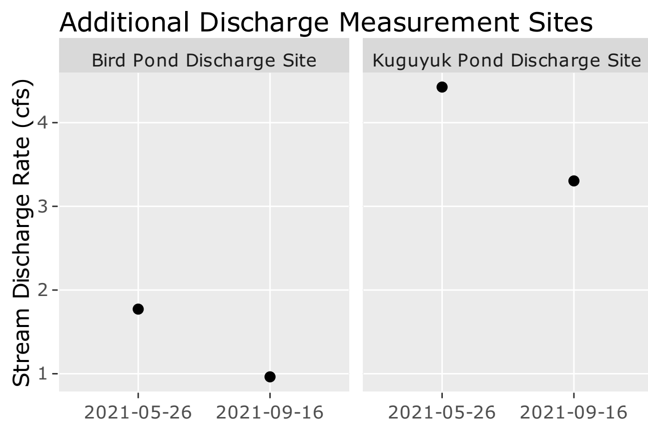

Figure 3.2: Other discharge measurements

3.0.5 Stream Flow Rate Experiment

On September 15-17, 2021 we conducted an experiment to examine stream flow rate in Miller Creek. We measured downstream transport time of dissolved solutes by deploying a plug of dissolved salt and measuring a resultant change in conductivity at a site downstream.

3.0.5.0.1 Methods We deployed a plug of dissolved salt into the Miller Creek stream channel and measured conductivity continuously at a downstream site. See Figure 3.3 for salt deployment and conductivity monitoring sites.

The Vogel Lake / Miller Creek system is a low-gradient drainage with little observable flow within 0.5 miles downstream of the lake outlet. We deployed our salt plug downstream from the Vogel Lake outlet at the first site with visibly evident surface flow, which was over the top of the first downstream beaver dam.

We released 140 lbs of dissolved NaCl by dissolving appx 15 lbs at a time in a 35 gallon trash can, then discharging it on the downstream side of the beaver dam into the stream channel. Our downstream site monitoring conductivity was 0.63 km (0.39 mi) downstream center-channel.

To record conductivity we used a pair of simultaneously deployed Hydrolab MS5

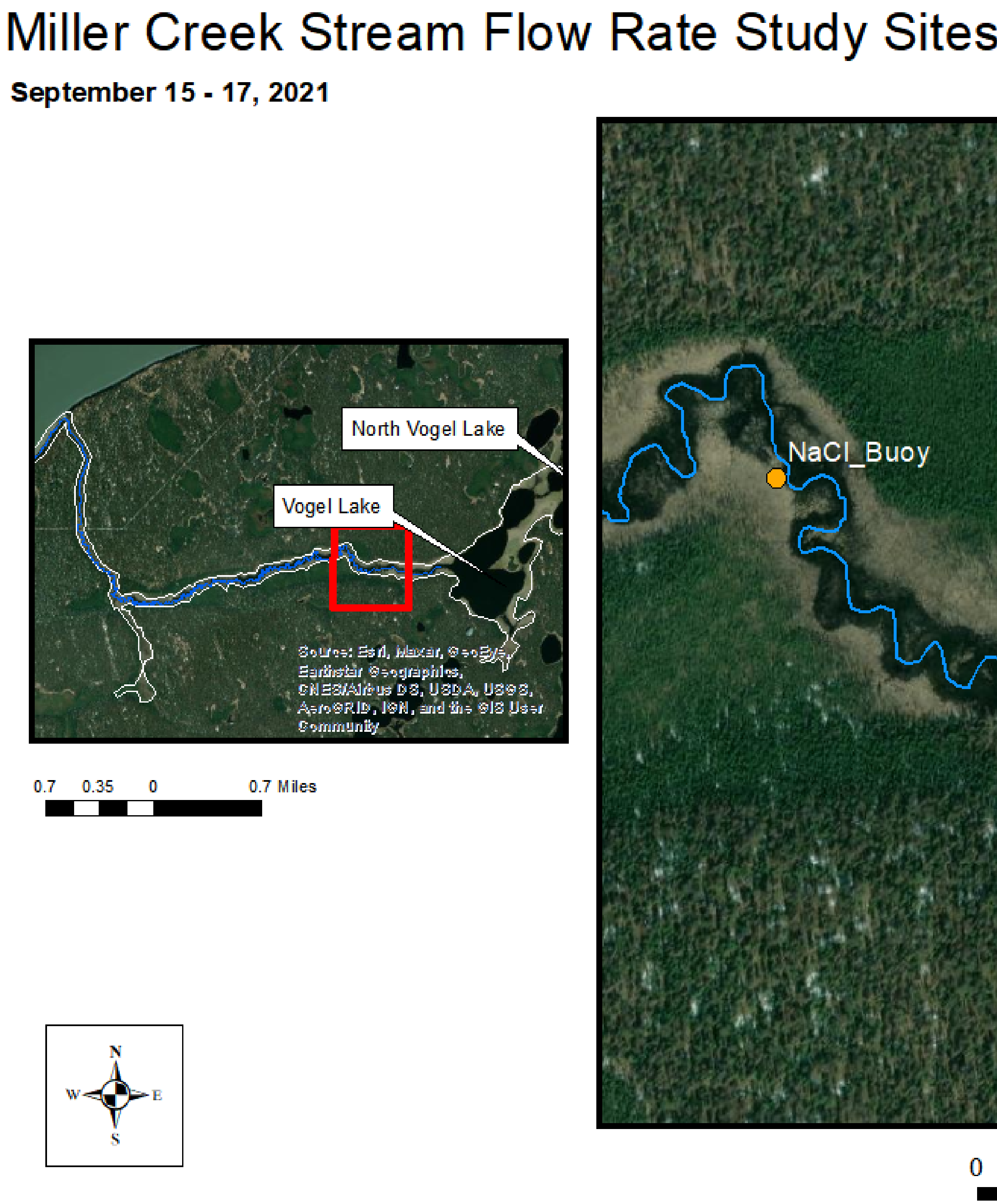

Figure 3.3: Stream Flow Rate Study Area. Stream distance between the NaCl release site and the downstream measurement site is 0.63 km (0.39 mi).

Sondes suspended from a floating buoy. We programmed the sondes to record at 0.25 hour intervals. We examined the resultant time series for exposure or errors and removed these data points. We averaged conductivity values between the two Hydrolab units in the final results.

3.0.5.0.2 Results We measured a readily evident rise in conductivity values at the downstream monitoring site. See Figure 3.4 for the time series of conductivity data.

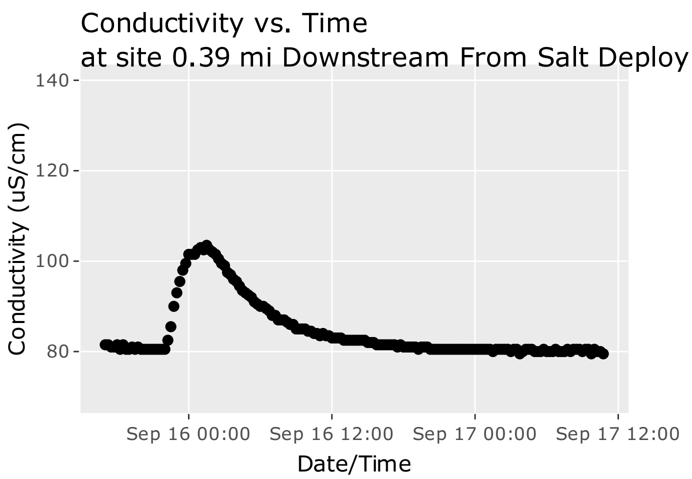

Figure 3.4: Conductivity values at the site downstream of the NaCl release site. The NaCl plug was released at 19:30 on 9/15/2021. The release and measurement site coordinates can be accessed at the ArcGIS Online Map at https://arcg.is/0LqOKH0.

In Figure 3.4 we can observe the following:

- Initial NaCl Deployment: 9/15/2021 19:30
- Start of the rising limb of the conductivity spike: 9/15/2021 22:00 (2.5 hrs after deployment)
- Maximum conductivity peak (~20% above baseline values): 01:30 9/16/2021 (6.0 hours after deployment)

- Return to baseline conductivity levels: 9/16/2021 15:00 (19.5 hrs after deployment)

Based on these results, peak concentration of the dissolved solute traveled though this section of Miller Creek at **0.11 km/h (0.06 mph)**.

Chapter 4

Watershed Mapping

- Watershed mapping efforts for this project include a combination of on the ground fieldwork and GIS based approaches.

- An ArcGIS Online interactive map outlining fieldwork sites and associated results is found at the following link: https://arcg.is/0Djmay

- Technicians walked the Miller Creek corridor on foot on May 27-28, 2021 to identify hydrologic features that may be difficult to identify from the air, such as seepages. The locations are visible in the ArcGIS Online map in the "Hydrologic Connectivity" layer, and may be downloaded here as .gpx files:

  - All hydrologic features (n = 67): miller_creek_features.gpx

  - Only seepage hydrologic features (n = 16): miller_creek_seepage_features.gpx


Sandpiper Lake
Vogel Lake
Kuguyuk Lake
Bird Lake

Chapter 5

Fish Rescue

5.1 Summary

On September 27-29, 2021, staff from Kenai Watershed Forum and Cook Inlet Aquaculture Association led fish rescue efforts in Lower Miller Creek prior to rotenone treatment. We used minnow traps to capture juvenile fish, which were later transported by helicopter to Bird Pond for winter residency until post-treatment rotenone levels decrease to safe levels. A fish barrier currently at the outlet of Bird Pond will be removed in Summer 2022 pending confirmation of safe conditions.

5.2 Methods

We captured juvenile fish in the segment of Miller Creek extending from it's mouth at Cook Inlet to a location upstream approximately 1.3 km from the mouth, N 60.99530, W -150.50760.

We used Gee minnow traps baited with cured, disinfected salmon eggs. We placed eggs placed inside perforated canisters to prevent consumption by the fish. We placed minnow traps in locations known to be preferred by juvenile salmonids, including areas with woody debris, pools, and areas with riparian cover. We deployed traps for time periods of 6-12 hours at a time, and returned with all captured fish in five-gallon buckets to a central location. We identified all captured fish to genus or species for the purpose of ensuring that no juvenile pike were included in the captured population.

After identifying fish taxa, we stored juvenile fish in three perforated five gallon buckets submerged within the creek on site. We placed stones at the bottom of each bucket to keep them submerged. These fish were stored until being retrieved by helicopter for transport to Bird Lake on 10/1/2021.

Table 5.1: Minnow trap deployment and fish capture, estimated data from Lower Miller Creek

Deployment_Date_Time	Retrieval_Date_Time	Trap_Count	Fish_Capture
2021-09-27 18:15:00	2021-09-28 10:00:00	48	400
2021-09-28 12:00:00	2021-09-28 18:00:00	48	150
2021-09-28 18:30:00	2021-09-29 09:00:00	30	75

Table 5.2: Fish capture data from Lower Miller Creek

Species	N	Notes
Rainbow Trout	330	Primarily mature adults
Coho Salmon	406	Primarily juveniles, a few that were likely landlocked adults
Sockeye Salmon	5	NA
Sculpin	92	NA

5.3 Results

Table 5.1 summarizes capture and effort data for fish rescue efforts in Lower Miller Creek. Due to limited available staff as a result of the COVID-19 pandemic, minimal formal data on fish capture was recorded in order to focus primarily on maximizing the quantity of fish captured prior to rotenone treatment. As a result, values in table 5.1 are estimates rather than exact quantities.

Fish captured from Lower Miller Creek were identified to species by ADF&G staff prior to placement into Bird Pond, although these fish were not segregated from fish also captured in the Vogel Lakes complex and Upper Miller Creek. Table 5.2 provides total capture counts for fish rescue efforts throughout the Miller Creek/Vogel Lakes complex.

5.4 Photos

Figure 5.1: Mouth of Miller Creek

Figure 5.2: Fish processing site

Figure 5.3: Juvenile Coho Salmon

Figure 5.4: Site for storage of perforated five-gallon bucket to store juvenile fish

Chapter 6

Rotenone monitoring

Rotenone application was performed in early October 2021 by ADF&G. ADF&G collected pre and post-treatment water samples as part of this event, and Kenai Watershed Forum will monitor degradation through until Summer 2022. Methods and results will be described here.

6.1 Sampling schedule

A proposed rotenone sampling schedule is described in table 6.1 or may be accessed in a Google Sheet linked here: https://tinyurl.com/8ba94nrn. Schedule is current as of 2022-01-14.

6.2 Rotenone concentration results

6.2.1 Sample results

Laboratory analysis of water samples is performed by the ASET Laboratory at the University of Alaska Anchorage Department of Chemistry in Anchorage, Alaska. Original results to date are available for download at the following link:

Link: Rotenone Degradation Laboratory Results.

Table X…

```
## lakes plot

ggplotly(rot_dat %>%
    # remove miller creek
```

Table 6.1: Vogel lake and Miller Creek rotenone sampling schedule

Field Sample Count	Sample	Field Sample Date	Status	Location	Depth	N
1	Rotenone	2021-09-27	Complete	Vogel Lake	Surface	P
1	Rotenone	2021-09-28	Complete	North Vogel Lake	Surface	P
1	Rotenone	2021-10-07	Complete	Vogel Lake	Surface	
1	Rotenone	2021-10-07	Complete	Vogel Lake	Benthic	
1	Rotenone	2021-10-07	Complete	North Vogel Lake	Surface	
1	Rotenone	2021-10-07	Complete	North Vogel Lake	Benthic	
1	Rotenone	2021-10-08	Complete	Miller Creek Head	Surface	
1	Rotenone	2021-11-10	Complete	Miller Creek Weir	Surface	
1	Rotenone	2021-11-10	Complete	North Vogel Lake	Surface	A
1	Rotenone	2021-11-10	Complete	Vogel Lake	Surface	A
1	Rotenone	2021-12-03	Complete	Miller Creek	Surface	
1	Rotenone	2021-12-02	Complete	North Vogel Lake	Surface	
1	Rotenone	2021-12-02	Complete	Vogel Lake	Surface	
1	Rotenone	2021-12-03	Complete	Miller Creek	Benthic	
1	Rotenone	2021-12-02	Complete	North Vogel Lake	Benthic	
1	Rotenone	2021-12-02	Complete	Vogel Lake	Benthic	
1	Rotenone	2022-01-05	Complete	Miller Creek	Surface	
1	Rotenone	2022-01-05	Complete	North Vogel Lake	Surface	
1	Rotenone	2022-01-05	Complete	Vogel Lake	Surface	
1	Rotenone	2022-03-05		Miller Creek	Surface	
1	Rotenone	2022-03-05		North Vogel Lake	Benthic	
1	Rotenone	2022-03-05		North Vogel Lake	Surface	
1	Rotenone	2022-03-05		Vogel Lake	Benthic	
1	Rotenone	2022-03-05		Vogel Lake	Surface	
1	Rotenone	2022-05-01		Miller Creek	Surface	
1	Rotenone	2022-05-01		North Vogel Lake	Benthic	
1	Rotenone	2022-05-01		North Vogel Lake	Surface	
1	Rotenone	2022-05-01		Vogel Lake	Benthic	
1	Rotenone	2022-05-01		Vogel Lake	Surface	
1	Rotenone	2022-06-01		Miller Creek	Surface	
1	Rotenone	2022-06-01		North Vogel Lake	Benthic	
1	Rotenone	2022-06-01		North Vogel Lake	Surface	
1	Rotenone	2022-06-01		Vogel Lake	Benthic	
1	Rotenone	2022-06-01		Vogel Lake	Surface	
1	Rotenone			TBD	TBD	D
1	Rotenone			TBD	TBD	D

Table 6.2: (#tab:results table)Vogel Lake, North Vogel Lake, and Miller Creek rotenone raw results

sample_name	lab_dup	field_sample_date	lab_analysis_date	rotenone_ppb	rotenolone_ppb	deg
Vogel_Surface	a	2021-09-27	2021-10-06	0.00	0.00	
Vogel_Surface	b	2021-09-27	2021-10-06	0.00	0.00	
N_Vogel_Surface	a	2021-09-28	2021-10-06	0.00	0.00	
N_Vogel_Surface	b	2021-09-28	2021-10-06	0.00	0.00	
Vogel_Surface	a	2021-10-07	2021-10-13	28.26	10.59	
Vogel_Surface	b	2021-10-07	2021-10-13	22.45	10.20	
Vogel_Benthic	a	2021-10-07	2021-10-13	18.75	9.05	
Vogel_Benthic	b	2021-10-07	2021-10-13	18.36	8.60	
N_Vogel_Surface	a	2021-10-07	2021-10-13	26.97	14.30	
N_Vogel_Surface	b	2021-10-07	2021-10-13	26.83	14.95	
N_Vogel_Benthic	a	2021-10-07	2021-10-13	13.67	7.33	
N_Vogel_Benthic	b	2021-10-07	2021-10-13	13.54	7.90	
Miller_Creek_1		2021-10-08	2021-10-13	22.96	13.27	
Vogel_Surface	a	2021-11-10	2021-11-12	12.39	7.69	
Vogel_Surface	b	2021-11-10	2021-11-12	13.08	8.50	
N_Vogel_Surface	a	2021-11-10	2021-11-12	15.05	10.87	
N_Vogel_Surface	b	2021-11-10	2021-11-12	15.62	11.77	
Miller Creek Weir	a	2021-11-10	2021-11-12	2.03	5.52	
Miller Creek Weir	b	2021-11-10	2021-11-12	1.99	4.99	
Vogel_Surface	a	2021-12-02	2021-12-06	8.79	7.63	
Vogel_Surface	b	2021-12-02	2021-12-06	8.83	6.98	
Vogel_Benthic	a	2021-12-02	2021-12-06	10.79	8.54	
Vogel_Benthic	b	2021-12-02	2021-12-06	10.64	8.54	
N_Vogel_Surface	a	2021-12-02	2021-12-06	13.81	12.26	
N_Vogel_Surface	b	2021-12-02	2021-12-06	13.61	11.64	
N_Vogel_Benthic	a	2021-12-02	2021-12-06	11.78	10.85	
N_Vogel_Benthic	b	2021-12-02	2021-12-06	12.78	12.58	
Miller_Creek_2	a	2021-12-03	2021-12-06	6.32	6.83	
Miller_Creek_2	b	2021-12-03	2021-12-06	6.85	6.93	

```
      filter(waterbody != "Miller_Creek") %>%
    group_by(sample_name,field_sample_date, waterbody,strata) %>%
    summarise(avg_rotenone_ppb = mean(rotenone_ppb)) %>%

    ggplot(aes(field_sample_date,avg_rotenone_ppb, color = strata)) +
    geom_point() +
    geom_line() +
    facet_grid(. ~ waterbody) +
      xlab("") +
      ylab("Rotenone Concentration (ppb)")
  )


# say that more detailed accuracy results can be accessed in the repo folder in the ex

# see journal article for methods
```

```
## creek plot

## join data with location estimates (distance down creek)


ggplotly(rot_dat %>%
    # include miller creek
      filter(waterbody == "Miller_Creek") %>%
    group_by(sample_name,field_sample_date, waterbody,strata) %>%
    summarise(avg_rotenone_ppb = mean(rotenone_ppb)) %>%

    ggplot(aes(field_sample_date,avg_rotenone_ppb, color = strata)) +
    geom_point() +
    geom_line() +
    facet_grid(. ~ waterbody) +
      xlab("") +
      ylab("Rotenone Concentration (ppb)")
  )
```

Chapter 7

Summary

Overall results described and interpreted here.