Stormwater Outfall Monitoring Program

Two year summary | May 2023

Summary

RE Sources began monitoring 6 stormwater outfalls and 2 urban creek outlets flowing into Bellingham Bay on a monthly basis starting in Feb 2021. In 2022, 2 urban creeks and 1 outflow were added resulting in a total of 11 monitoring sites for the second sampling year. Basic water quality parameters were measured including dissolved oxygen, water temperature, conductivity, pH, turbidity, and Escherichia coli (*E. coli*) bacteria. The water was also monitored for visuals (such as sheens or bubbles), odor, color, and flow.

Similar to 2021, all of the outfalls and creeks failed to meet water quality standards at least once during the 2022 sampling period, but there was great variability between the monitoring sites. *E. coli* is the most significant and concerning pollutant recorded by these monitoring efforts and could have adverse human and environmental health effects. One outfall was rated as **"Good"** because it only had only 2 times where water quality standards were exceeded. Two outfalls were rated as **"Watch"** because they had a moderate number of exceedances, some of which could have been due to natural causes. Four of the outfalls were rated as **"Threat**" because they frequently violated water quality standards mainly for *E. coli*. For the creek sampling, 3 out of the 4 creeks were rated as **"Threat"** because of chronic exceedances. Little Squalicum creek was rated as "**Watch"** because only 5 samples were taken in 2022 — the site was not always accessible due to restoration construction. None of the creeks were rated **"Good"**.

Purpose

Stormwater is the single largest source of pollution to the Salish Sea and is one of the biggest threats to this ecosystem — yet it is one of the most challenging forms of pollution to prevent. It is also harmful to people, particularly the Coast Salish who consume larger quantities of food from the Salish Sea than other groups. Monitoring large stormwater outfalls that dump into Bellingham Bay on a regular basis helps to pinpoint illicit discharges and other sources of pollution with the intent to find the source of pollution and fix it. The outfalls and creeks monitored here drain the majority of the built-out area of downtown Bellingham and includes residential housing, businesses, industry, and public parks and trails. The outfalls themselves drain a total of approximately 140,000 linear feet of pipe.

Stormwater permit holders such as the City of Bellingham (COB) and the Port of Bellingham (POB) have minimal monitoring requirements and are faced with staff and resource shortages, leaving them unable to adequately monitor all of the outfalls in Bellingham. Local and state stormwater managers were consulted during the early stages of this project and have been kept informed throughout. This project is helping to inform stormwater managers about the quality of the stormwater entering the Bay and hopefully help focus efforts on problem spots. To date, however, there have not been fixes to chronic problems this monitoring program has identified.

Methods

The 7 outfalls and 4 creeks that are monitored all discharge into Bellingham Bay and drain significant portions of the built-out areas of downtown Bellingham. See the end of Appendix 1 for a map of the outfall and stream sampling locations.

Outfall Names and Descriptions:

1. Broadway Street Outfall: This outfall drains much of Columbia Neighborhood — specifically the area bordered by Broadway St. to the southeast, W Illinois St. to the northwest, and Squalicum Creek to the northwest. It dumps into the I & J Waterway and is underwater during moderate to high tides.
2. C Street Outfall: This outfall drains much of the industrial area in the Central Waterfront property that is on either side of C St. just southwest of Roeder Ave. along with the Lettered Street neighborhood that resides in the area that is southwest of Dupont St.
3. Cornwall Avenue Outfall: This outfall drains Cornwall Ave. up to Laurel St.
4. Cedar Street Outfall: This outfall drains the hillside that originates up at Western Washington University.
5. Boulevard Outfall: This outfall drains the hillside that is directly above and north of Boulevard Park.
6. Bennett Street Outfall: This outfall drains the hillside that is directly above and south of Boulevard Park.
7. Willow Street Outfall (added 2022): This outfall drains the southern part of Edgemoor neighborhood.

Creek Names and Descriptions:

1. Little Squalicum Creek (added 2022): This creek is fed by springs and seeps located in Little Squalicum Park and stormwater runoff from Birchwood and Cedarwood neighborhoods as well as Bellingham Technical College and Oeser Company. The 36-inch culvert at the shoreline is considered a fish passage barrier.
2. Squalicum Creek: Squalicum Lake is the headwaters to this urban creek and is located near the intersection of SR 542 and the Y road. It drains approximately 22 square miles and flows through agricultural land, residential, commercial, and

industrial areas. Squalicum Way, a popular truck route, is near the outlet, which has considerable stormwater input. Much of the creek's watershed is developed and impervious. Its water levels rise and fall dramatically following rain events. Furthermore, it suffers from low flow events during the summer because it does not have snow melt to feed it. Pink, chum, and coho salmon as well as cutthroat trout use the stream. Steelhead trout, Chinook, and sockeye have also been documented in the stream on occasion.

3. Whatcom Creek: Lake Whatcom is the headwaters to this creek and the flow is controlled by a dam. The creek flows through built-out areas and heavily used areas such as public parks, industrial areas, along with residential and commercial areas. Coho, chum, and Chinook salmon as well as steelhead and resident sea-run cutthroat trout inhabit the stream.
4. Padden Creek (added 2022): The headwaters to Padden Creek are in the Chuckanut Mountains. It drains Lake Padden and approximately 6 square miles of South Bellingham. Connolly Creek is a major tributary. Chum and Coho use this stream. Chinook, Steelhead, and sea-run cutthroat trout have also been documented in the creek.

For a more detailed look at where stormwater flows in Bellingham visit the CIty of Bellingham's website (www.cob.org) and follow these steps.

- Go to "Maps"
- Go to "CityIQ"
- Open CityIQ (this takes a moment)
- Click on "I want to…"
- Select "change visible map layers".
- In the layers section - select "Utilities Information"
- Click on "Storm Utilities".
- Remove any unnecessary layers to simplify the map.

The water quality standards that are used for the 4 creeks in this study are taken from Water Quality Standards for Surface Waters of the State of Washington. The standards for the stormwater outfalls are taken from the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (link to references are below).

Sampling

Pilot testing began in December 2020 and monthly monitoring of all sites began in Feb 2021. Samples were collected by car and by kayak or canoe during times when the tides were + 2.0 or lower. Several of the outfalls are under water during higher tides. Testing done during the winter months (November, December, and January) were conducted during the evening with headlamps, as that was the only time the tide was low enough to monitor. See Appendix 1: Project Procedure Sheet and Appendix 2: Data Sheet for a detailed explanation of what data was collected, how it was collected, and which water quality standards are used here.

When exceedances are found, reports are sent to the Washington State Department of Ecology (Ecology's Emergency Response Tracking System) and/or the COB Stormwater Hotline. This helps hold both regulators and polluters accountable.

Results

All of the data is located and displayed within the Water Reporter Map (link). Below is an overview of the results for each of the monitoring sites for both 2021 and 2022. A year of sampling is from Feb. to Feb., because sampling started in February 2021. A summary table is also provided that includes an overall rating of the monitoring sites along with trends.

Note: The dissolved oxygen probe was not working for 2 sampling events: April and May, 2021. Ammonia was dropped for 2022 sampling season.

Water temperature was not considered when calculating ratings for outfalls because the researchers felt that ambient temperature was not well defined or measured. None of the temperature data collected suggest that there was abnormal water temperature associated with an illicit discharge. Water temperature was considered for creeks because there are specific water temperature criteria to support aquatic life, most notably salmon (see Appendix 2).

Overall Rating

Sites were assigned one of three ratings: Threat, Watch, or Good. In addition, an up or down arrow indicates if the sites improved or declined from 2021 to 2022.

- Threat (red): This signifies that the site has severe exceedances for any given parameter that occur regularly (not just once or twice).

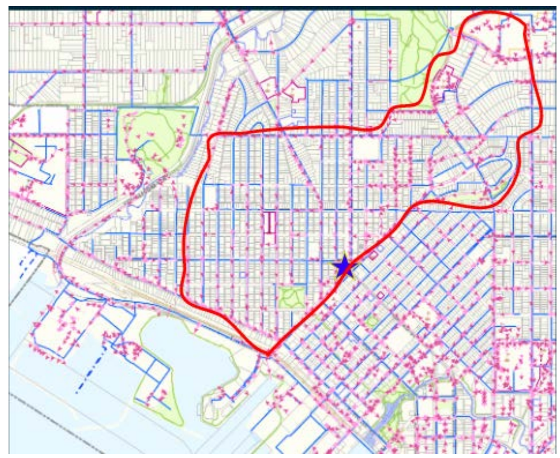
- Watch (yellow): This signifies that the site has some exceedances for any given parameter but they are either very infrequent or unable to link to a pollution source.
- Good (green): This signifies that the site rarely has an exceedance for any given parameter and when it does occur it is not egregious.

Table 1. Total number of Exceedances by year with overall rating.

Outfall	2021	2022	Rating
Broadway	3	11	Watch
C St	29	36	Threat
Cornwall	4	7	Watch
Cedar	11	24	Threat
Boulevard	5	7	Threat
Bennett	12	10	Threat
Willow	1	1	Good

Outfalls:

1. **Broadway Street Outfall:**

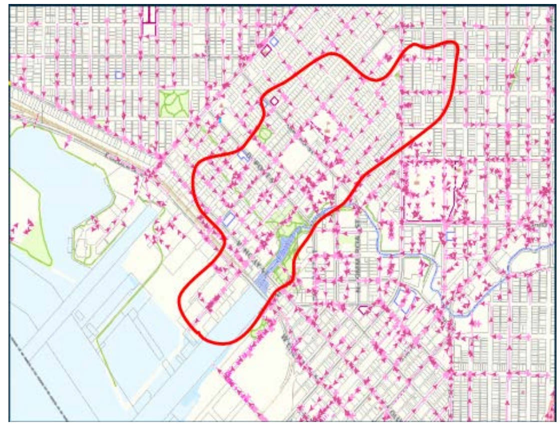
Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:

Parameter	2021	2022
Color	2	3
Visual	0	3
Conduct	0	2
E. coli	1	3

Rating: Watch

2. C Street Outfall:

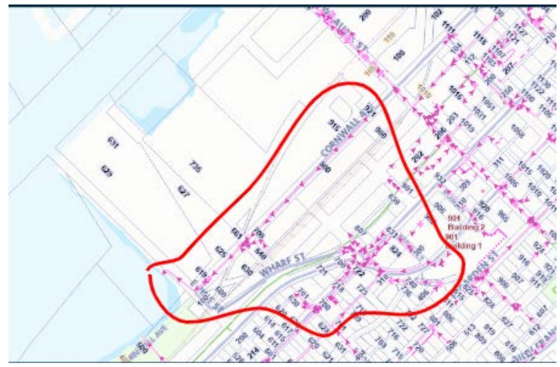
Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:

Parameter	**2021**	**2022**
Color	7	6
Odor	6	8
Visual	7	14
DO	4	1
Conduct	2	1
E. coli	3	6

Rating: Threat

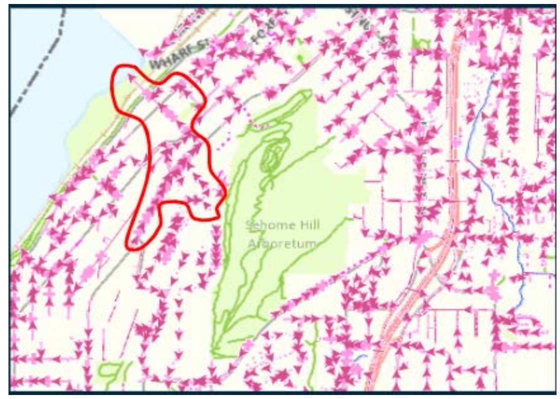
3. **Cornwall Avenue Outfall:**

Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:		
Parameter	**2021**	**2022**
Color	1	1
DO	1	3
E. coli	2	3

Rating: Watch

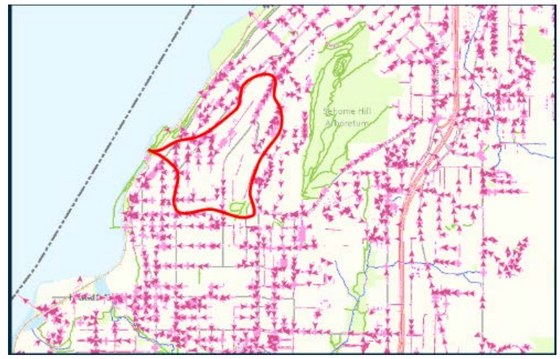
4. **Cedar Street Outfall:**

Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:		
Parameter	**2021**	**2022**
Color	0	4
Odor	1	3
Visual	0	1
Conduct	8	8
E. coli	2	8

Rating: Threat

5. **Boulevard Outfall:**

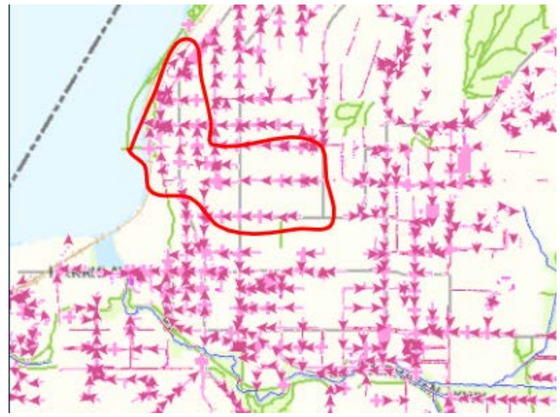
Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:

Parameter	2021	2022
Outflow	0	1
Color	0	1
Turbidity	0	1
E. coli	5	4

Rating: Threat

6. Bennett Street Outfall:

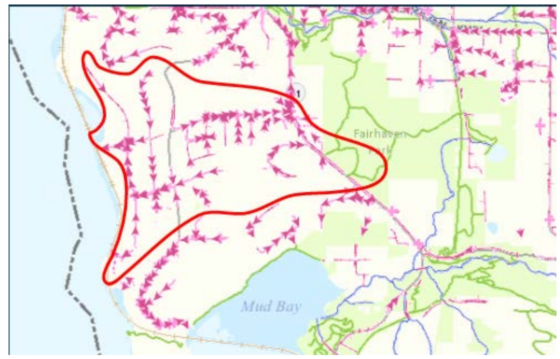
Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:

Parameter	2021	2022
Visual	0	2
E. coli	12	8

Rating: Threat

7. **Willow Street Outfall:**

Photo of Outfall:	Approximate drainage area:
	

Number of Exceedances:	
Parameter	**2022**
DO	1
E. coli	1

Rating: Good

Creeks:

1. **Little Squalicum Creek** (only 5 data points):

Photo of Creek:	Approximate drainage area:
	

Number of Exceedances:	
Parameter	2022
Color	1
E. coli	1

Rating: Watch

2. **Squalicum Creek:**

Photo of Creek:	Approximate drainage area:
	

Number of Exceedances:

Parameter	2021	2022
Color	7	10
Visual	6	6
DO	1	0
pH	1	1
Turbidity	3	0
E. coli	1	5

Rating: Threat

3. **Whatcom Creek:**

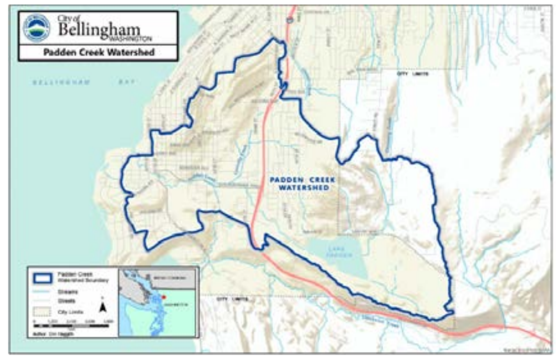
Photo of Creek:	Approximate drainage area:
	

Number of Exceedances:

Parameter	2021	2022
Color	0	1
Odor	0	1
Temp	4	4
DO	0	1
pH	0	2
Turbidity	0	1
E. coli	3	4

Rating: Threat

4. **Padden Creek:**

Photo of Creek:	Approximate drainage area:
	

Number of Exceedances:	
Parameter	**2022**
Color	7
Visual	3
Temp	2
DO	1
Conduct	2
E. coli	4

Rating: Threat

Discussion

The results from the second year of sampling mirrors the first year, confirming that the water flowing into Bellingham Bay chronically exceeds water quality standards set by Washington State. In 2022, *E. coli* bacteria was the most common water quality issue followed by (in order): color, visual, conductivity, odor, dissolved oxygen, and creek temperature. The total number of exceedances for 2022 was 155, which is 65 more than in 2021. Approximately half of the exceedances are observational (color, odor, and visual) which can be subjective and caused by natural and benign sources. However, often these reports note fossil fuel sheens and other illicit discharges. Nearly one-third of the 2022 exceedances were for *E. coli* which reiterates that the City of Bellingham has a bacteria problem.

C Street outfall continues to be a problematic one. It has a chronic yellow hue, sulfur/ fossil fuel smell, fossil fuel sheen, *E. coli* exceedances, and the presence of a white microbial mat. The white microbial mat was DNA analyzed and consists mostly of the 5 following species:

- *Methylomonas*
- *Pseudomonas*
- *Hydrogenophaga*
- *Sulfitobacter*
- *Flavobacterium*

Research suggests that these bacteria species may be growing in response to polluted water, potentially sewage. *Pseudomonas* is a known human pathogen.

Chronic, high bacteria counts continue to plague several of the outfalls and creeks. The average *E. coli* count for the Bennett outfall for 2021 and 2022 combined seasons is 2,343 coliform forming units per 100 ml (cfu/100 ml). This is 7 times the 320 cfu/100 ml *E. coli* standard set for recreational waters in Washington State. While there were fewer bacterial exceedances at the Bennett outfall in 2022 than in 2021, the exceedances were more extreme. The average *E. coli* sample in 2021 was 1,162 cfu/100 ml and in 2022 it was 3,818 cfu/100 ml. In 2022, the R-card replaced the Coliscan EasyGel as the method to culture and measure bacteria. The R-card is less ambiguous in identifying colonies and may, in part, explain the increase in numbers. But because the difference is so dramatic, there is likely an additional, environmental cause.

Boulevard, Cedar, and C Street outfalls also had two-year average bacteria counts that exceed the state standards (340, 443, and 410 cfu/100 ml, respectively). Bennett and Boulevard both discharge near public beaches and popular swimming spots. It is not unlikely that people could be directly exposed to the water being discharged from these pipes. These high bacteria counts are a direct threat to human health and the environment.

Padden, Whatcom, Squalicum, and Little Squalicum creeks also had two-year average bacteria counts that exceed state standards (378, 359, 455, and 905 cfu/100 ml, respectively). All of these creeks run through public parks where people and pets recreate regularly.

The continued high conductivity readings at the Cedar outfall are still unknown. However, the salinity readings are on average 0.30 ppt and may explain the high conductivity readings. This outfall is also plagued with high *E. coli* counts, as well as abnormal odors, color, and visuals. A strong sulfur smell has been documented on occasion along with discolored water and the presence of a white microbial mat similar to the one noted at C Street outfall.

On August 25, 2022, an illicit discharge was noted at the Boulevard outfall (also referred to as Olive St. outfall). The water was extremely turbid, rushing out of the pipe, and discolored the entire bay. The discharge was reported but no follow up information was provided.

Despite continued reporting of exceedances to regulatory agencies, to our knowledge, there has not been any significant work to address the chronic pollution occurring at the outfalls. The urban streams monitored in this program are all impaired bodies of water and are under different management strategies to improve their water quality (namely Total Maximum Daily Load, TMDL, programs). The outfalls, however, do not have any known management strategies to improve their discharges. This data shows chronic violations of stormwater permits that are directed by the Clean Water Act and pose substantial threats to human health and the environment for those who recreate or fish in Bellingham Bay, particularly vulnerable populations.

Resources

1. WA Stormwater Center: https://www.wastormwatercenter.org/
2. Stormwater Action Monitoring (SAM) Program
3. Water Quality Standards for Surface Waters of the State of Washington: Freshwater Designate Uses and Criteria

4. IC-ID Field Screening and Source Tracking Manual
5. COB Surface and Stormwater and Comprehensive Plan 2020

Appendix 1

Bellingham Bay Monitoring Project Procedure Sheet

Before you head out

- ❏ Calibrate the YSI (takes about 30 min)
- ❏ Assemble Equipment (take Coliscan broth out of freezer night before if possible and label with location and date)

Map of Sites	Plastic gloves	Ammonia strips and vial
Data sheets	YSI (2 extra C batteries)	Sampling container for FC
Procedure sheet	2 Buckets (big enough to fit YSI)	Coliscan broth (9)
Plastic folder	Distilled water	Pipette
Pen/pencil	Phone/watch/camera	Pipette tips (9)
Sharpee	Turbidity tube	Cooler bag and ice
Hand sanitizer		

- ❏ Fill out top of Bellingham Bay Stormwater Monitoring Data Sheet
- ❏ Randomly choose a location to duplicate (number between 1 and 8)

Tide height at start: NOAA Tides and Currents for Bellingham Bay
Rainfall past 72 hrs (in): NOAA Weather Bellingham Airport (3-day history, past 72 hrs)

Methods for when in the Field

1. Flow: Note the flow of water coming out of the creek or pipe. Creek: Low, Moderate, High (put L, M, or H in data box). Pipe: None, Trickle, or Moderate (put N, T, or M in data box)

2. Color: Color is assessed qualitatively using visual observations of how severely a sample is discolored. Observations included brown, reddish brown, light green etc… Record on a 0-3 scale (none, slight, moderate, strong). Ex: Brown (3)

3. Odor: Odor observations are documented by describing the intensity or severity of odor based on a scale of 0 to 3 (none, faint, moderate, or strong). A faint odor is barely noticeable, a moderate odor is easily detectable, and a strong odor can be detected from several feet away. Ex: rotten eggs (2)
4. Visual Indicators: Observe any sheen, floaters, foam etc... record on a 0-3 scale (none, few/slight, many/moderate, numerous/obvious), take a photo to document. Ex: sheen (1)

5. YSI multimeter:
    a. Water Temperature (T) °C
    b. Dissolved Oxygen (DO) mg/L
    c. Specific Conductivity (SPC) µS/cm
    d. Salinity (ppt)
    e. pH
    1. Be sure hands are clean or wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
    2. Rinse the plastic bucket 3 times with the outfall or creek water to be sampled and then collect a field sample. Avoid collecting sediment with the water sample.
    3. Rinse the probe with Distilled water
    4. Dip the probe in the water sample and stir gently for a few seconds. Allow up to 1 minute for the probe to adjust to the sample temperature and the readings to stabilize (when bars stop flashing). Note: parameters should be measured as soon as possible after the sample has been collected as conditions in the bucket will change quickly.
    5. Record the values shown on the meter on your field data sheet, notebook, or field laptop/tablet. Click enter to save data on the YSI under Bham SW.
    6. Dispose of sample back to source

6. Turbidity (cm): Turbidity Tube
    1. Place the turbidity tube on a level, stationary surface. It may be helpful to place a sheet of white paper or a white binder underneath the tube.
    2. Be sure hands are clean or wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
    3. Collect a field sample in a clean, sample bucket. Avoid collecting sediment with the water sample.
    4. Pour the field sample into the turbidity tube until it reaches the top. If you can see the Secchi disk (black and white symbol) record 55+ cm. Slowly let the water out of the bottom until the Secchi disk marking at the bottom of the tube just becomes visible.
    5. Read the gradation (marking) on the turbidity tube corresponding to the height of the sample in the tube.
    6. Optional: Convert the height (in centimeters) to nephelometric turbidity units (NTU) using the following table (based on tube length of 60 centimeters). Alternatively, turbidity can be calculated using the following equation and the tube depth (in centimeters): Turbidity (NTU) = 2198.1 * (Tube Depth^(-1.2765)). Conversion Chart.
    7. Dispose of sample back to source.

7. *E. coli* bacteria (#cfu/100 ml): Method: R-Card
    1. Be sure hands are clean and wear nitrile gloves in the field to avoid sample contamination and protect yourself from potential contaminants.
    2. Collect the water sample from flowing water at the site using a sterile bottle, flush the bottle 3 times with sample water before collecting the sample. If the flow is too low, collect the sample from the sampling bucket that has been flushed 3 times prior. Do not touch or contaminate the inside of the bottle or cap.
    3. Tightly screw the lid back on the sample bottle. Label the container with the location of the sampling spot if you haven't already.
    4. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler; place them in a refrigerator within 6 hours of sampling.

After sampling

- ❏ Look for exceedances and circle on data sheet contact COB/ECY if significant exceedances.
- ❏ Rinse, dry equipment
- ❏ Culture bacteria
    1. Label the R Cards with unique ID, location, and date with a permanent marker.
    2. Take a sterile pipette and flush it 3 times with the sample water. Lift the film of the R card with sterile tweezers and apply 1 ml sample to the middle of the R card. Or, if wanting a larger quantity, filter a larger quantity of water through a filter (10 ml - 100ml) using aseptic technique and a filter paper.
    3. If filtering, open the film and put the filter paper on the R card using sterile tweezers, add 1 ml drop of sterile water to the top of the filter paper before laying down the film.
    4. Let the sample sit for 1 min to gel then place the R card in an incubator at 35ºC (95ºF) for at least 24 hours. If an incubator is not available, incubate at room temperature for 48 hours. Note: An incubator is recommended for improved control, temperature consistency, and faster incubation.
    5. Inspect the R Card
        a. Fill out the top parts of the Template for all sampling sites. The locator is the name of the sampling site and unique ID# (BBSW_1, BBSW_2)
        b. Count all the easily-seen blue, round colonies on the R card or filter to quantify E. coli bacteria present.
        c. Disregard other colored colonies, irregularly shaped colonies, or any “pinprick” size colonies. However, if in serious doubt as to whether a colony color is blue enough or round enough, it is acceptable to err on the side of caution and count “ambiguous” colonies as E. coli bacteria.
        d. Report the results in terms of colony forming units (CFU) per 100 mL of water. To do this, multiply the plate count by the appropriate multiplier to

obtain *E. coli* CFU/100 mL. For example, for 5 mL sample aliquots, the multiplier is 20.
   e. Photograph the R card, typically with a completed plate count template, for documentation and for future reference if needed. Name the photo file with the unique ID.
   f. Dispose of the R Cards by throwing them directly into the trash.
   g. Disinfect your bottles and pipette tips by placing them into a bowl of bleach water (100 ml bleach/gallon water) for at least 5 minutes. Drain them and let them air dry trying not to contaminate them.
   h. Disinfect your work surface, incubator, phone, pencil/pens using a dilute bleach solution and paper towel.

❏ Enter all data as written on the data sheet with these exceptions:
   1. Water Temp (2 places to record)
      a. Actual: Record what is on the data sheet.
      b. Categorical: If the water temperature is less or equal to the highest air temperature during sampling time then enter 0, if the water temperature is above the highest air temperature then enter 1. The 1 will indicate that this is an exceedance.
   2. Specific Conductivity (2 places to record)
      a. Actual: Record what is on the data sheet.
      b. Fresh Water: Record ONLY if the salinity is less or equal to 0.5 ppt. Marine water intrusion will cause very high SPC values which don't need to be recorded as exceedances.

Descriptions of Parameters - What they indicate

1. Outflow: Flow in an outfall during dry weather is an indicator that a water source other than stormwater is flowing through the storm drainage system. It could be natural groundwater flow but could also be sanitary sewer cross-connection, potable water (swimming pool, hydrant flushing), or illegal dumping.

2. Color: The color of water is influenced by the presence or absence of substances such as metallic salts, organic matter, dissolved or suspended materials. Color can indicate when stormwater has been contaminated by an illicit discharge or illicit connection, but not all illicit discharges will have a color.

3. Odor: Odor should be assessed qualitatively in the field using your nose to determine if a water sample has a distinct smell. Odor observations are subjective and may include descriptions such as a petroleum, sewage, or chemical odor.

4. Visual Indicators: Visual indicators other than color, odor, and flow can often indicate when stormwater has been contaminated by an illicit discharge or illicit connection; however, not all illicit discharges will have visual indicators. Visual indicators are assessed qualitatively by field staff using simple visual observations. Ex: abnormal vegetation, algae/bacteria/fungus, deposits/staining, fish kills, floatable, surface film/sum/sheen, or trash/debris.

5. YSI multimeter
    a. *Water Temperature (T) °C*: Temperature extremes can threaten the health and survival of fish and other aquatic species in many life stages including embryonic development, juvenile growth, and adult migration. Water temperature can be useful in identifying contamination by sanitary wastewater or industrial cooling water. Household and commercial sewage produces heat due to microbial activity during anaerobic decomposition, while industrial cooling water is heated as it is circulated through heat exchangers. Water temperature measurements are typically the most useful for IDDE when indicator sampling is being conducted during cold weather and temperature differences can be significant.
    b. *Dissolved Oxygen (DO) mg/L:* DO is an important parameter for salmonids and other aquatic organisms. Low dissolved oxygen levels can be harmful to larval life stages and respiration of juveniles and adults. DO depends on local hydraulic conditions affecting the oxygenation of the discharge. For this reason, DO is not a widely useful indicator for illicit discharges.
    c. *Specific Conductivity (SPC) µS/cm:* Specific conductivity, also referred to as specific conductance, is a measure of how well water can conduct an electrical current based on ionic activity and content. Specific conductivity is an indicator of dissolved solids from potential pollutant sources such as sewage and washwater, and can help distinguish groundwater from illicit discharges and identify commercial/ industrial liquid waste if used in combination with another parameter such as Hardness, Turbidity, or Detergents/Surfactants. Specific conductivity can also be used in combination with caffeine or pharmaceuticals (see Other Indicators) to indicate sanitary wastewater.
    d. *Salinity (ppt):* This is the saltiness or dissolved inorganic salt content of water. The Pacific Ocean has an average salinity of 34 parts per thousand (ppt) compared to 29 ppt in Puget Sound. Measuring salinity will indicate if there is saltwater intrusion in the outfall or creek.
    e. *pH:* pH measures the hydrogen ion activity on a scale from 1 to 14. Water with a pH below 7.0 is acidic and water with a pH above 7.0 is alkaline or basic. pH values that are lower than 6.5 or higher than 8.5 may be harmful to fish and other aquatic organisms. A low pH can cause heavy metals to leach out of stream sediments, resulting in an increase in dissolved metals concentrations. A high pH

can produce a toxic environment, in which ammonia becomes more poisonous to aquatic organisms.

6. Turbidity (cm): Turbidity is a measure of how transparent or clear water is based on the amount of sediment or suspended particulates. Large amounts of suspended material can affect fish growth and survival by impairing their vision, gill function, and affecting egg and larval development. Higher turbidity can also increase temperature and thereby decrease dissolved oxygen concentrations in water bodies, affecting the growth of both aquatic animals and plants. High turbidity in water can be attributed to many different sources including soil erosion, construction activities, sanitary wastewater, excessive algal growth, or industrial processes.

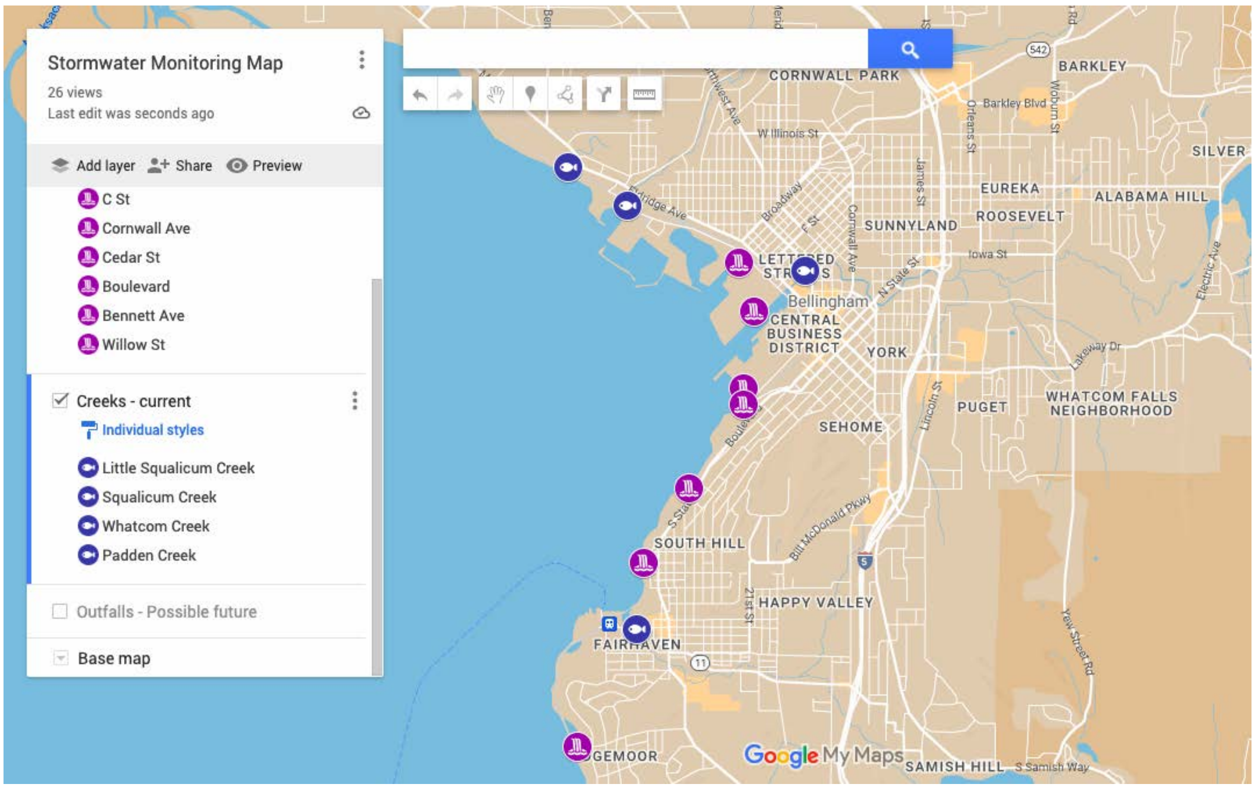
7. Ammonia (mg/L): Ammonia is produced by the decomposition of plant and animal proteins and is also a main ingredient in fertilizers. The presence of ammonia in surface water usually indicates contamination from fertilizers (including manure), pesticides, sanitary wastewater (including human waste, wash water, and septic system), or a commercial/industrial source. Trace amounts over time can be toxic to fish and higher concentrations can result in low DO.

8. *E. coli* bacteria (#/100 ml): have been typically-used as indicators of fecal contamination of stormwater and natural waters, as they are present in the fecal waste of warmblooded animals, including humans. A relatively elevated test result for fecal coliform bacteria or E. coli bacteria may indicate an illicit discharge or illicit connection associated with sewage or a failing septic system. However, it may indicate waste related to large domestic animals (such as cows, llamas, etc.), pets, or wild animals.

Sampling Locations

Name	**Latitude, Longitude**
Little Squalicum Creek	48.76494, -122.51736
Squalicum Creek	48.761139, -122.508478
Whatcom Creek	48.754550, -122.483300
Padden Creek	48.71998, -122.50712
Broadway St OF	48.755745, -122.492252
C St OF	48.750420, -122.489911

Cornwall St OF	48.743003, -122.490756
Cedar St OF	48.741621, -122.491588
Boulevard Park OF	48.733642, -122.499516
Bennett St OF	48.726423, -122.506205
Willow St OF	48.708532, -122.515914



Resources and Equipment

WA Stormwater Center: https://www.wastormwatercenter.org/
Stormwater Action Monitoring (SAM) Program
IC-ID Field Screening and Source Tracing Manual
COB Surface and Stormwater and Comprehensive Plan 2020
www.hach.com - ammonia test strips
Forestry suppliers - 60 cm turbidity tube
Waterproof map cover -
Eight Sampling Locations:

Appendix 2

Bellingham Bay Stormwater Monitoring Data Sheet DATE: _________

Investigator(s):	
Tide Height:	Rainfall past 72 hr (in):
Observed Weather (circle): Sunny/Clear Partly Cloudy Overcast Light Rain Moderate Rain Heavy Rain Snow	
Air T (ºC) - Start: Finish:	Time - Start (24h): End (24h):

CREEK SAMPLING:

Sampling Site:	**Little Squal Ck**	**Squal Creek**	**What Creek**	**Pad Creek**	**WA State Freshwater Standards***
Arrival Time					--------------------------------
Flow (**L**ow, **M**oderate, **H**igh)					--------------------------------
Color (0-3)					Any non natural source (≥ 1)
Odor (0-3)					Any non natural source (≥ 1)
Visual (0-3)					Any non natural source (≥ 1)
Water T (ºC)					> 16ºC (1≤ 16; 2 > 16)
DO (mg/L)					< 8.0 mg/l
SPC (μS/cm)					None but note if > 500 μS/cm
Salinity (ppt)					n/a (>0.5 = likely marine intrusion)
pH					< 6.5 or > 8.5
Turbidity (cm)					Squalicum: < 46 cm** Whatcom: < 60 cm
Ammonia (mg/L)					> 1 mg/L
E. coli (cfu/100 ml)					> 320 cfu/100 ml (100 geomean)
Notes					

*Salmonid Core Summer Habitat and Primary Contact **5 NTU above calculated background data from COB 2011-2020 monthly sampling

OUTFALL SAMPLING:

Sampling Site:	Broadway St OF	C St OF	Cornwall St OF	Cedar St OF	BLVD Park OF	Bennett Ave OF	Willow St OF	Duplicate_____	Ecology Standards
Arrival Time									-------------------------
Outflow (**N**one, **T**rickle, **M**oderate)									1 = normal; 2 = M+ during dry weather
Color (0-3)									Any non natural phenom (≥ 1)
Odor (0-3)									Any non natural phenom (≥ 1)
Visual (0-3)									Any non natural phenom (≥ 1)
Water T (°C)									1 < ambient air T; 2 > ambient air T
DO (mg/L)									< 6 mg/L
SPC (µS/cm)									> 500 µS/cm
Salinity (ppt)									(>0.5 = likely marine intrusion)
pH									< 5 or > 9
Turbidity (cm)									< 19 cm
Ammonia (mg/L)									> 1.0 mg/L
E.coli (#/100 ml)									> 300 cfu/100 mL
Other									

Data Entered by: _________________________ date: _____________
Data Verified by: _________________________ date: _____________