Waterbody Field Report
Pullen Creek, Skagway, Alaska

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Abstract

Pullen Creek, located in Skagway, Alaska, has been classified as an impaired waterbody due to heavy metal contamination from historical ore operations. A Total Maximum Daily Loads (TMDLs) for metals in the waters of Pullen Creek was developed in 2010. This 2024 field study aimed to assess water quality through analytical and in situ monitoring, supporting the Skagway area watershed plan. Sampling was conducted at five sites in April, July, and August, with bacteria, dissolved metals, nutrients, minerals, conventionals, and microbial source tracking (MST) for water, and polycyclic aromatic hydrocarbons (PAHs) and total metals for sediment. Sampling sites were selected from previous studies to enable comparisons to historical data. Results indicate localized exceedances in turbidity, dissolved oxygen in water, and metal concentrations and PAHs in sediment. Notably, cadmium and copper levels in sediment at two sites were greater than the TMDL loading capacity, and lead, zinc, and PAHs in sediment were above at all sites. Bacterial analysis in water found one exceedance of fecal coliform, but no species DNA markers for MST.

Figure 1. Environmental Specialist Eric Dye collecting in situ measurements at the Railyard site.

[1] Skagway Traditional Council, project #ACWA-23-07 funded by DEC from an EPA pass-through grant

Basic Waterbody Information

Table 1. Basic Waterbody Information

Assessment Unit ID	AK_R_1030302_007				
Assessment Unit Name	Tributary 1	Fish Hatchery	Pullen Pond	Tributary 2	Railyard
Location description	Located just downstream of the AP&T outfall between 4th and 5th Avenues.	Just downstream of a spring east of the railroad tracks on 9th Avenue.	Downstream from the footbridge south of Pullen Pond.	Downstream of the confluence of Pullen Creek and a spring fed tributary on the north side of the Public Safety Building, 18th Avenue.	Headwater pond on the south end of WPYR railyard, across the highway between Alaska and State Streets.
Hydrologic unit code	1901030302 Skagway River				
Water Type	Freshwater Stream				
Area sampled	Point sampled at 59.45419, -135.31325	Point sampled at 59.45667, -135.30917	Point sampled at 59.45193, -135.317767	Point sampled at 59.46277, -135.30244	Point sampled at 59.46635, -135.29832
Time of year sampled	Water - dissolved metals, nutrients, minerals, conventionals; Sediment - PAHs, total metals: April 2, 2024		Water - dissolved metals, nutrients, minerals, conventionals; Sediment - PAHs, total metals: April 2, 2024; Bacteria: July 11, 2024 – August 7, 2024; MST: July 25, 2024		

Water Quality Evaluation

Background

Pullen Creek, located in Skagway, Alaska, has been listed as an impaired waterbody on the Clean Water Act Section 303(d) Impaired Waterbody List for Alaska since 1990. While Pullen Creek was originally listed in 1990 with Skagway Harbor, the lower mile of the stream was separated into its own listing in 2006 after monitoring data collected in 2004-2005 showed elevated concentrations of various heavy metals in the sediment. The metals impairments in Pullen Creek are thought to be due to sediment contamination resulting from historical operations in the harbor and surrounding area related to the transport and transfer of mining ores. A Total Maximum Daily Load (TMDL) recovery plan was completed for Pullen Creek in 2010.[2]

Skagway Traditional Council (STC) conducted sampling in 2015-2016 to compare to previous sampling efforts and determine whether best management practices (BMPs) outlined in the 2012 Skagway Stormwater Best Management Practices document were being effective. The authors concluded that heavy metal contamination in sediments continued to be over loading limits and that further monitoring was recommended. The current project reassessed water and sediment conditions in Pullen Creek through screen sampling at the five sites used in past investigations (Figure 2). Water quality effectiveness monitoring in Pullen Creek included two (2) events: spring 2024 metals, nutrients, minerals, conventionals (water), and PAHs and metals (sediment); and summer 2024 bacteria and MST (water).

Objective

This project specifically addressed the water quality effectiveness monitoring in Pullen Creek and included two (2) events: spring 2024 metals, nutrients, minerals, conventionals (water), and PAHs and metals (sediment); and summer 2024 bacteria and MST (water). The monitoring demonstrated that Pullen Creek water quality had not improved with the implementation of BMPs and that more intensive monitoring is needed along with community outreach explaining BMPs.

Quality Assurance Review

STC staff followed all protocols and standard operating procedures (SOPs) as defined by the project QAPP. Sampling was conducted at five sites (Figure 2) in April 2024 with one duplicate for dissolved metals at Pullen Pond, one event was scheduled, and one set of samples was delivered to the lab for a completeness total of 100%. Bacteria sampling took place in July and August 2024, five consecutive events were scheduled, and five sets of samples were delivered to the lab for a completeness total of 100%. Three bacteria sampling sites were selected based on the highest likelihood of representativeness: Pullen Pond, Tributary 1, and Railyard (Figure 2). One rotating duplicate sample for E. coli and fecal coliform was

[2] Because the impairment in Pullen Creek is based on elevated levels of metals in bottom sediments, the TMDL establishes sediment quality targets that represent attainment of water quality standards, including designated uses, and sets the loading capacity equal to those targets. The TMDL target and loading capacity are set equal to the toxicological screening level Threshold Effects Low (TEL), presented in the National Oceanic and Atmospheric Administration (NOAA) *Screening Quick Reference Tables* (Buchman 2008). TELs define chemical sediment concentrations below which toxic effects are rarely observed in sensitive species. A supplemental analysis is included as part of these TMDLs to illustrate that once sediment concentrations meet targets, water column concentrations will also likely decrease and meet applicable water quality criteria.

collected for each sampling day. One set of MST bacteria samples was collected in July 2024, one event was scheduled, and one set of samples was delivered to the lab for a completeness total of 100%. All holding times and temperatures were within acceptable range and no discrepancies, errors, data qualifiers, or QC flags were reported. Calibration/verification was performed prior to and following each event on the Hach turbidimeter, and pre-sampling calibration was performed on the YSI Pro Quatro handheld unit for each event as per the manufacturer's recommendation. Calibrations logs and verification records were completed for the monitoring program. Relative percentage difference values for duplicate samples were all within acceptable limits.

Figure 2. Overview of sampling sites for abiotic and bacteria sampling, with sample sites marked with yellow and black triangles.

Methods

Water quality effectiveness monitoring was conducted in Pullen Creek during two (2) events: April 2024 dissolved metals, nutrients, minerals, conventionals (water), and PAHs and total metals (sediment); and July/August 2024 bacteria and MST (water). In situ field measurements were collected at the same date/time as the water quality samples, including pH, dissolved oxygen, specific conductivity, turbidity, and temperature using a YSI multimeter probe and Hach turbidity meter.

The April 2024 samples were collected from the same five (5) site locations (plus 1 duplicate) as the 2004 and 2015-16 monitoring efforts as shown in 2016 Pullen Creek Monitoring Project – A 10-year Comparative Analysis (as shown on Figure 1 of that report and Figure 2 of this document) and consisted of co-located water and sediment samples. Clean Hands/Dirty Hands methodology was followed to prevent cross-contamination of samples. Composite sediment samples were collected with a plastic scoop from multiple locations at each site. Analytes are outlined in Appendix A.

The July/August bacteria samples were collected from a subset of the sampling sites: Pullen Pond, Tributary 1, and Railyard (Figure 2). E. coli and fecal coliforms were measured along with the in situ parameters listed above. One set of MST samples was collected during the July 25, 2024, event for analysis of three DNA markers: canine, avian, and human.

All water quality samples were packed into a hard-sided cooler with blue ice packs to maintain a temperature range between 4.0 and 10.0 °C. Samples were analyzed at AmTest Laboratories in Kirkland, WA; bacteria and MST were analyzed at Admiralty Environmental in Juneau, AK and LuminUltra Technologies Inc. in Linthicum Heights, MD, respectively. Laboratories provided sampling kits, instructions, and Chain of Custody forms. AmTest samples were shipped FedEx First Overnight the day following the sampling effort, and Admiralty samples were shipped within 6 hours of the first sample collection to meet analytical holding time requirements. LuminUltra samples were field preserved using their GeneCount qKit preservation method, which increased holding times negating the need to ship FedEx First Overnight.

Results

In situ

Environmental field measurements were within expected ranges, although results should be interpreted with the caveat that Tributary 1 and Fish Hatchery were only sampled once during the April 2024 water quality sampling event (Table 2). The three other sites were sampled a total of six times: once in April 2024, four times in July 2024, and once in August 2024. Turbidity averages at all but one site were around or below 1.0 NTU, with the exception of Railyard which averaged 4.4 NTU. This increase is due to a single datapoint on July 18th, 2024 (14.0 NTU). 18 AAC 70 Alaska Water Quality Standards (WQS) limit turbidity to 5 NTU above natural conditions, making this measurement a single exceedance. According to WQS, dissolved oxygen in fish-bearing waters should be between 7 and 17 mg/L for support of salmonids in all stages of life. Two measurements at Railyard (6.85 mg/L on 7/18/24, and 6.93 mg/l on 7/25/24) and one measurement at Fish Hatchery (5.77 mg/L on 4/2/24) were outside of this range. Fish have been observed at both sites, and White Pass and Yukon Railroad (WPYR) has installed fish habitat enhancement features just downstream of Fish Hatchery to mitigate railroad easement encroachments on the stream.

Table 2. Summary of in situ measurements from Pullen Creek sampling, 2024.

Analyte	Site	Mean	Median	Range
Air Temperature (°C)	Pullen Pond	12.0	13.3	4.3 - 14.8
	Tributary 1	5.2	5.2	5.2 - 5.2
	Fish Hatchery	4.1	4.1	4.1 - 4.1
	Tributary 2	12.5	13.6	4.4 - 15.3
	Railyard	13.1	14.6	5.1 - 15.6
Water Temperature (°C)	Pullen Pond	8.5	9.1	2.5 - 11.8
	Tributary 1	2.9	2.9	2.9 - 2.9
	Fish Hatchery	4.6	4.6	4.6 - 4.6
	Tributary 2	4.7	4.7	4.6 - 4.8
	Railyard	4.7	4.7	4.6 - 4.8
Specific Conductance (µS/cm)	Pullen Pond	67.9	56.9	49.9 - 126.6
	Tributary 1	134.8	134.8	134.8 - 134.8
	Fish Hatchery	233.2	233.2	233.2 - 233.2
	Tributary 2	168.1	168.3	167.3 - 168.5
	Railyard	163.3	162.3	162.3 - 165.6
pH	Pullen Pond	7.35	7.34	7.27 - 7.50
	Tributary 1	7.73	7.73	7.73 - 7.73
	Fish Hatchery	8.00	8.00	8.00 - 8.00
	Tributary 2	7.29	7.24	7.15 - 7.55
	Railyard	7.27	7.27	7.20 - 7.39
DO (mg/L)	Pullen Pond	12.21	12.18	10.84 - 14.11
	Tributary 1	13.28	13.28	13.28 - 13.28
	Fish Hatchery	5.77	5.77	5.77 - 5.77
	Tributary 2	8.78	8.81	8.45 - 9.08
	Railyard	7.59	7.72	6.85 - 8.18
Turbidity (NTU)	Pullen Pond	0.75	0.70	0.40 - 1.10
	Tributary 1	1.16	1.16	1.16 - 1.16
	Fish Hatchery	0.33	0.33	0.33 - 0.33
	Tributary 2	0.46	0.33	0.19 - 1.07
	Railyard	4.40	2.21	0.42 - 14.00

Water

Heavy metals in water were sampled at all five sites in 2024, but only one sample was collected at Fish Hatchery in 2003, three samples at Tributary 2 in 2003, 2015, and 2016, and Railyard had a total of seven previous samples, one in 2003, four in 2004, and two in 2016. WQS for dissolved metals are hardness dependent, a summary of criteria specific to this sampling event can be found in Table 3. All analytes investigated were below these criteria (Figure 3, A-G).

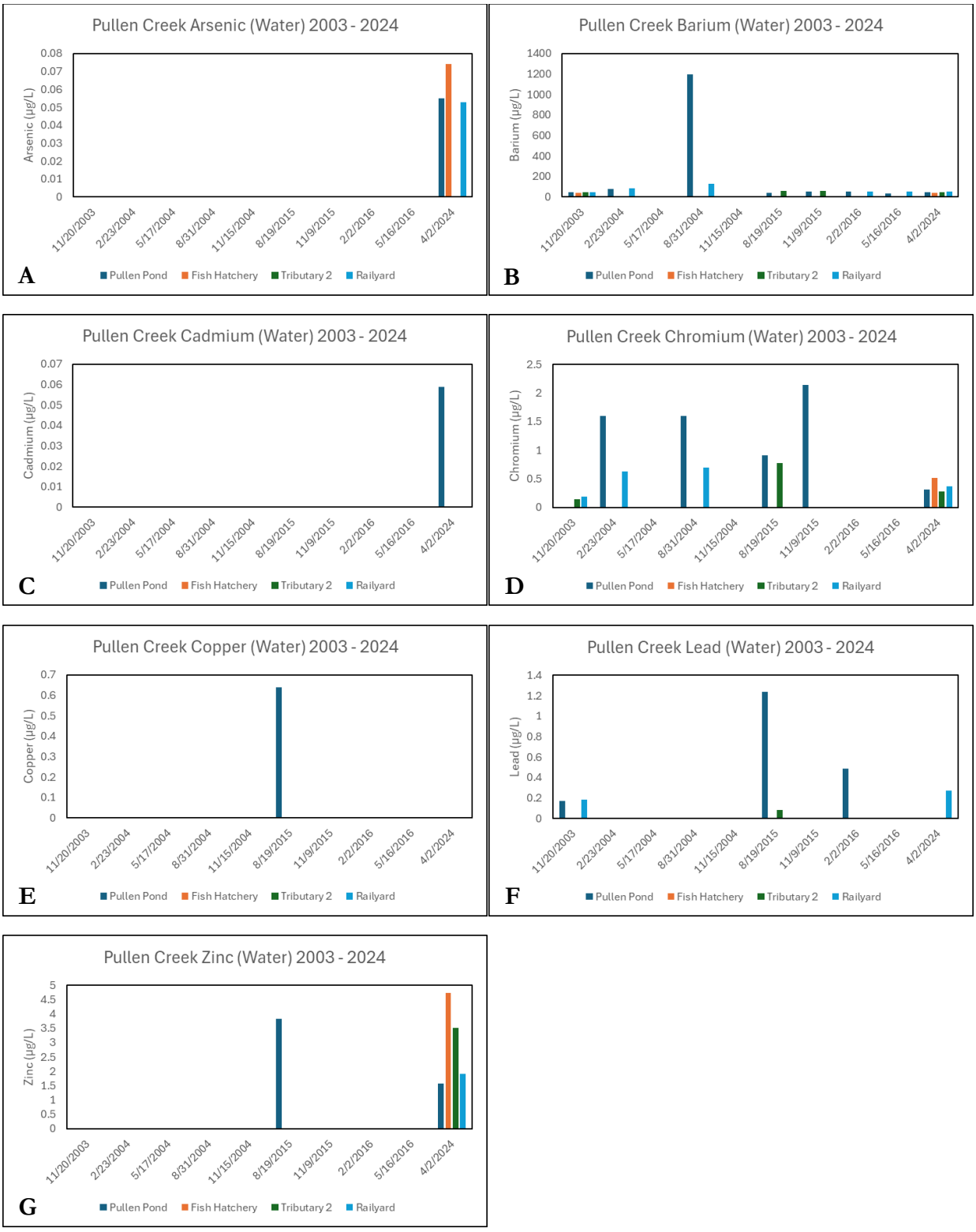

Figure 3. Matrix of heavy metal results in water from Pullen Creek sampling 2003 - 2024.

Table 3. Calculated hardness-dependent water quality standards, sample specific for Pullen Creek heavy metals in water.

Acute WQS[3] (CMC)								
Site	Hardness	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Zinc
Pullen Pond	57	340	2000	1.165	359.547	7.913	34.844	72.779
Tributary 1	54	340	2000	1.106	343.974	7.520	32.820	69.520
Fish Hatchery	100	340	2000	2.014	569.763	13.439	64.581	117.180
Tributary 2	69	340	2000	1.404	420.448	9.474	43.021	85.568
Railyard	69	340	2000	1.404	420.448	9.474	43.021	85.568
Chronic WQS (CCC)								
Site	Hardness	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Zinc
Pullen Pond	57	150	2000	0.166	46.770	5.540	1.358	73.375
Tributary 1	54	150	2000	0.160	44.744	5.290	1.279	70.089
Fish Hatchery	100	150	2000	0.246	74.115	8.956	2.517	118.139
Tributary 2	69	150	2000	0.190	54.692	6.522	1.676	86.268
Railyard	69	150	2000	0.190	54.692	6.522	1.676	86.268

Arsenic at Pullen Pond, Fish Hatchery, and Railyard was detected and the results different from all past investigations where arsenic results were below method detection levels (MDL). It should be noted that current metal analytical test methods have MDLs up to 3 orders of magnitude lower than previously used analytical test methods. Barium levels in 2024 were comparable to previous years with no discernible increase or decrease in magnitude. Cadmium at Pullen Pond in 2024 was the only detected result, all others were below MDL. Chromium was lower in Pullen Pond, Railyard, and Tributary 2 from previous sampling years, with only a slightly higher concentration at Fish Hatchery in 2024. No copper was detected in 2024, the only previous detection was at Pullen Pond in 2015. Lead was only detected at Railyard in 2024, all other sites were below MDL. Zinc was detected at all sites in 2024, with higher concentrations than previous sampling years at all sites except Pullen Pond.

Conventionals, nutrients, and minerals were sampled at all five sites in 2024, no comparable previous investigation into these analytes was conducted. All samples and sites passed established WQS (Table 4).

[3] 18 AAC 70 Water Quality Standards amended as of January 8, 2025, and Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances as amended through September 8, 2022

Table 4. Pullen Creek laboratory results and water quality standards for conventionals, nutrients, and minerals (water), April 2, 2024.

Group	Analyte	WQS[4]	Pullen Pond	Tributary 1	Fish Hatchery	Tributary 2	Railyard
Conventionals	Dissolved Organic Carbon (mg/L)	NA	1.7	2.7	2.1	1.5	1.4
	Settleable Solids (mL/L)	<=5% above natural conditions	ND	ND	ND	ND	ND
	Total Solids (mL/L)	1000 mg/L	ND	ND	ND	ND	ND
	Total Sulfide (mg/L)	2.0 mg/L	ND	ND	ND	ND	ND
Nutrients	Ammonia-N (mg/L)	pH/temp dependent	ND	0.023	ND	0.021	ND
	Dissolved Phosphorus (mg/L)	NA	0.001	0.0016	0.0076	0.0017	0.0023
	Total Phosphorus (mg/L)	NA	0.0016	0.0018	0.0079	0.0018	0.0023
	Total Nitrate and Nitrite - N (mg/L)	10 mg/L	0.106	0.113	0.221	0.333	0.342
Minerals	Hardness (CaCO, mg/L)	NA	57	54	100	69	69
	Alkalinity (CaCO, mg/L)	>= 20 mg/L	54	71	95	63	65
	Calcium (mg/L)	NA	19	18	35	23	23
	Magnesium (mg/L)	NA	2.3	2.2	4.0	2.7	2.7
	Sodium (mg/L)	NA	2.87	2.71	5.33	4.65	4.55
	Sulfate (mg/L)	NA	3.9	3.55	8.42	7.71	7.68
	Chloride (mg/L)	NA	3.35	2.99	8.14	9.63	6.97

[4] 18 AAC 70 Water Quality Standards amended as of January 8, 2025. NA = Not Applicable, ND = Not Detected.

Sediment

Heavy metals in sediment were sampled at all five sites in April 2024, and past investigations provided more data points for comparison than heavy metals in water: four samples were collected at all five sites in 2004, two at all sites in 2015, and two at all sites in 2016. TMDLs for Pullen Creek sediment were outlined in Pullen Creek Monitoring Project – a 10 Year Comparative Analysis, and the April 2024 results were appended to the tables in this document. Figures were generated from the synthesis (Figure 4A-G[5]).

Arsenic, barium, and chromium were within the TMDLs loading capacity at all sites in 2024 (Figure 4A-B, & 4D). Cadmium was over the loading capacity at Tributary 2 (1.06 µg/g, 4/2/24, Figure 4C) and Railyard (0.673 µg/g, 4/2/24, Figure 4C). Copper was over loading capacity at Tributary 2 (74.7 µg/g, 4/2/24, Figure 4E) and Railyard (71.5 µg/g, 4/2/24, Figure 4E). Lead and zinc were over the loading capacity at all sites (Figure 4F-G).

The overall trend of heavy metal concentrations between 2004 and 2024 shows a decrease in all analytes except copper, with most decrease occurring between 2004 and 2015. Copper was not sampled during four of the eight previous years' efforts (February 2004, May 2004, August 2004, and November 2015, Figure 4E).

[5] 1 milligram/kilogram (mg/kg) = 1 microgram/gram (µg/g). TMDL shows loading capacity in mg/kg, lab results are reported in µg/g.

Figure 4. Matrix of heavy metal results in sediment from Pullen Creek sampling 2004 - 2024.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) were sampled from all five sites in 2024, no previous studies assessed this group of analytes and there are no established state standards governing PAHs in sediment. Results in this study are compared to threshold effects levels (TEL) for total PAHs outlined in the EPA Assessment and Remediation of Contaminated Sediments (ARCS) program publication EPA 905-R96-008, set at 264.1 µg/kg. All sites exceeded the TEL, with Railyard having the highest concentration (4,372.3, 4/2/24; Figure 5).

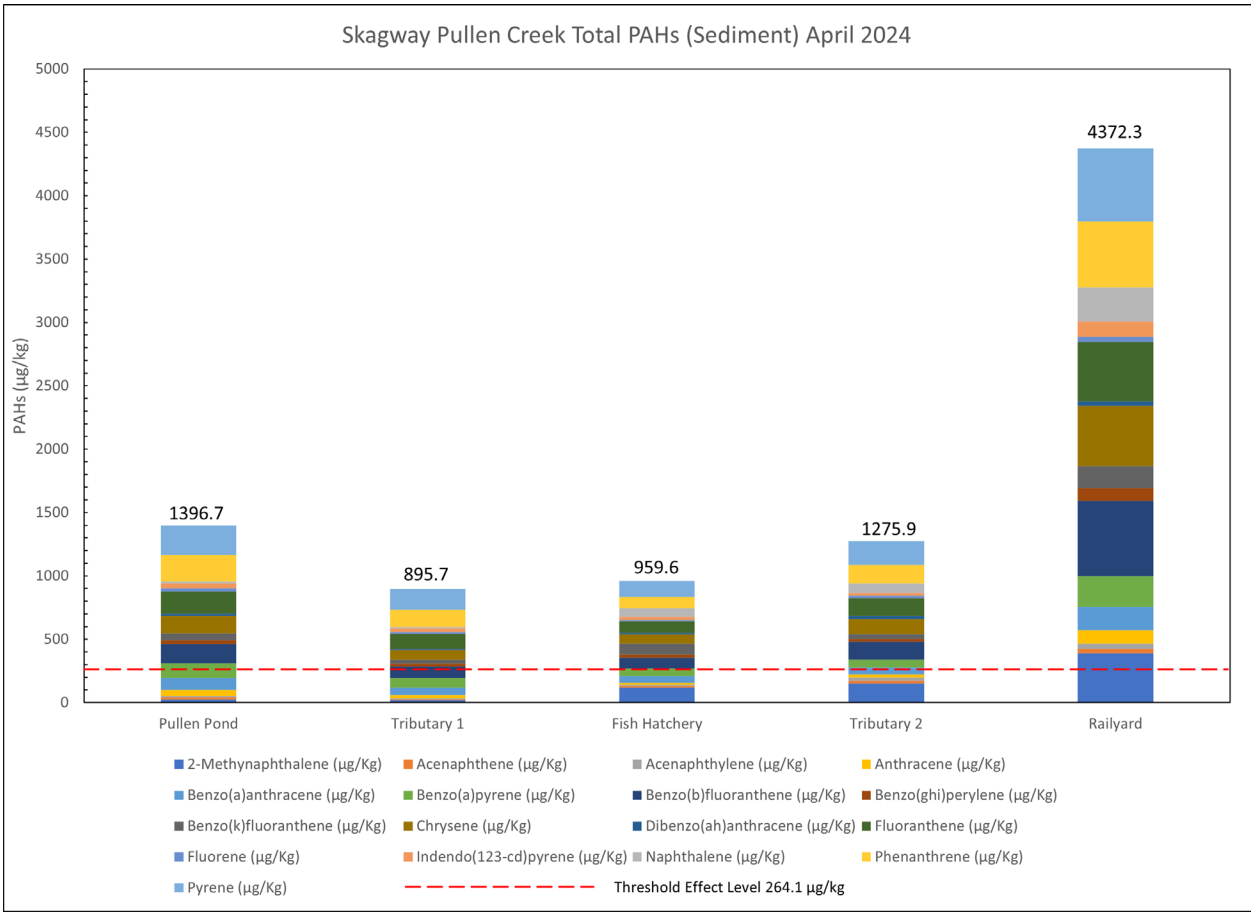

Figure 5. PAH results from Pullen Creek, 2024. Total PAHs are shown in the data labels above bars.

It is expected to see an increase in levels moving downstream as more urban areas of the watershed contribute overland and stormwater flow to the system. Tributary 2 and Pullen Pond followed the expected trend. Tributary 1 and Fish Hatchery are both located on short groundwater fed tertiary branches of Pullen Creek, potentially explaining their relatively lower levels of total PAHs and departure from the expected trend. Railyard is located at the headwaters of an intermittently connected branch of Pullen Creek, within the White Pass and Yukon Railroad maintenance yard and nearby an active contaminated site (DEC file number 1526.38.005 White Pass & Yukon Railroad Yard), with historic detections of chlorinated and petroleum hydrocarbons in groundwater and soils. Residents in past years have observed fish in this reach when the stream flow was reportedly higher, however construction activities and backfilling of the mainstem have fragmented this stream section, potentially causing hydrological alterations. Water only reaches the culvert crossing State Street during high-discharge

events, the rest of the year streamflow terminates at a manmade pond just upstream of the culvert. The fragmentation of the stream reach can be seen in a relative elevation model (REM) created by STC staff from 2014 LiDAR data available from the Alaska Division of Geological & Geophysical Surveys (DGGS), which normalizes elevation data to a gradient of interest (in this case State Street) to enable more precise visualization of slight elevation changes (Figure 6). The vestigial stream section can be seen as lighter green/yellow areas on the map bisected by streets and houses.

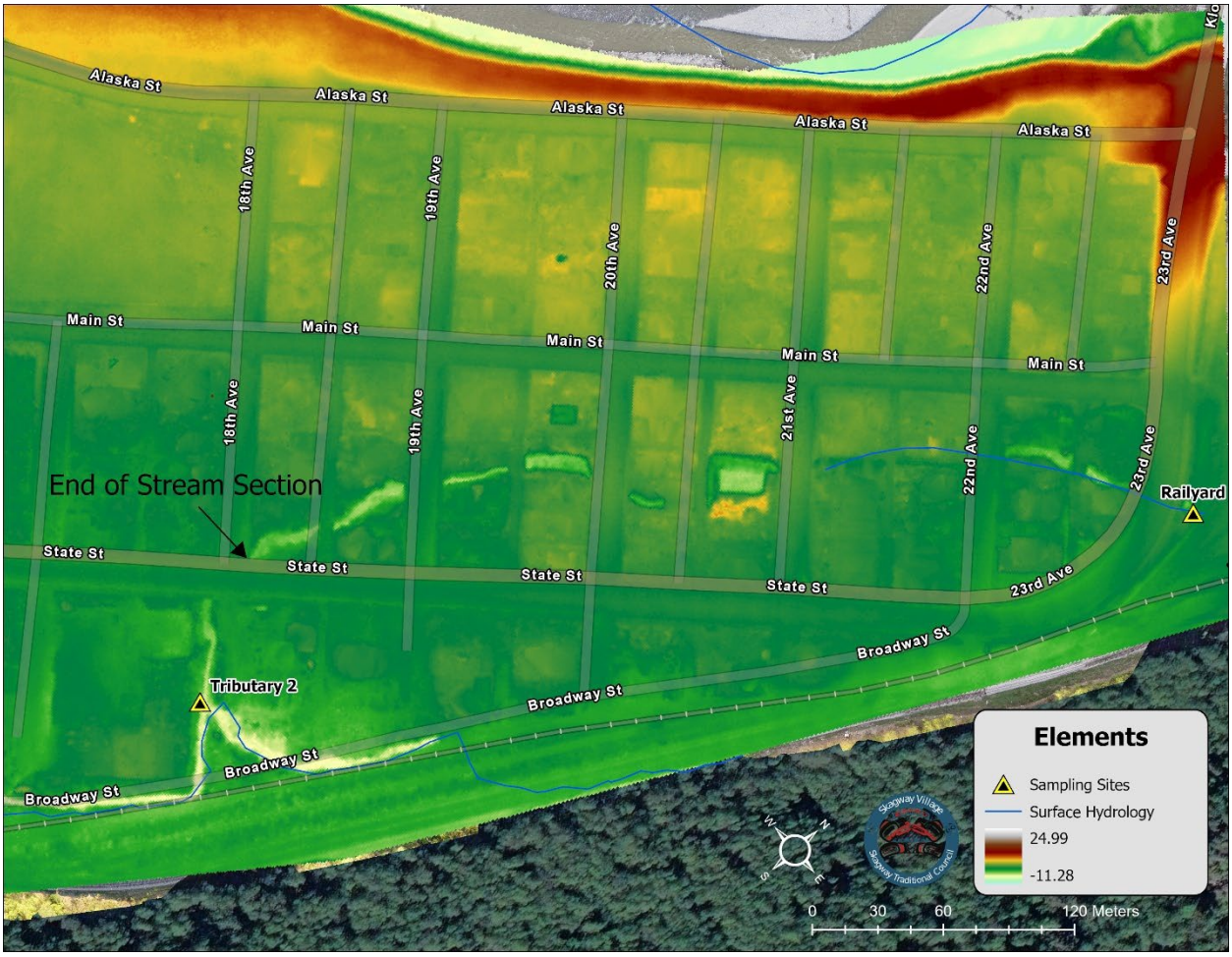

Figure 6. Relative elevation model showing remnant fragments of Pullen Creek between the Tributary 2 and Railyard sites. The label "End of Stream Section" denotes the upstream end of a culvert crossing State Street.

Bacteria

All E. coli results were under the threshold for contact recreation (Figure 7 & Table 5). The designated use 'Water Supply – drinking, culinary, and food processing' for fecal coliform is exceeded if more than 10% of the samples is greater than 40 CFU/100ml. The geometric mean criterion for fecal coliform is exceeded if the geometric mean within a 30-day period is greater than 20 CFU/100ml. One site exceeded 20% (1 sample out of 5 samples) for the individual sample criterion (Figure 8 & Table 5): Pullen Pond on 8/7/2024 (58 CFU/100 mL).

MST results did not identify markers for any target species: avian, canine, or human (Table 6).

Table 5. E. coli and fecal coliform results from Pullen Creek, 2024 showing percentages of WQS individual exceedances in red.

Analyte	Site	Individual Criteria[6]	% of samples Exceeding Threshold	Geometric Mean Criteria	Maximum 30-day Geomean Result
E. coli (MPN/100 mL)	Pullen Pond	410 MPN/100 mL	0%	126 MPN/100 mL	3.22
	Tributary 2		0%		0.87
	Railyard		0%		0.50
Analyte	**Site**	**Individual Criteria**	**% of samples Exceeding Individual Criteria**	**Geometric Mean Criteria**	**Maximum 30-day Geomean Result**
Fecal Coliform (FC/100 mL)	Pullen Pond	40 CFU/100 mL	20%	20 CFU/100 mL	7.93
	Tributary 2		0%		2.04
	Railyard		0%		1.00

Table 6. MST analytical results from Pullen Creek, 7/25/24.

Site	Bacteroidetes	Result[7]
Pullen Pond	Avian	ND
	Canine	ND
	Human	ND
Tributary 2	Avian	ND
	Canine	ND
	Human	ND
Railyard	Avian	ND
	Canine	ND
	Human	ND

[6] 18 AAC 70, Water Quality Standards amended as of January 8, 2025.

[7] ND = Not Detected; DNQ = Detected, not quantifiable; units are copies/100 mL.

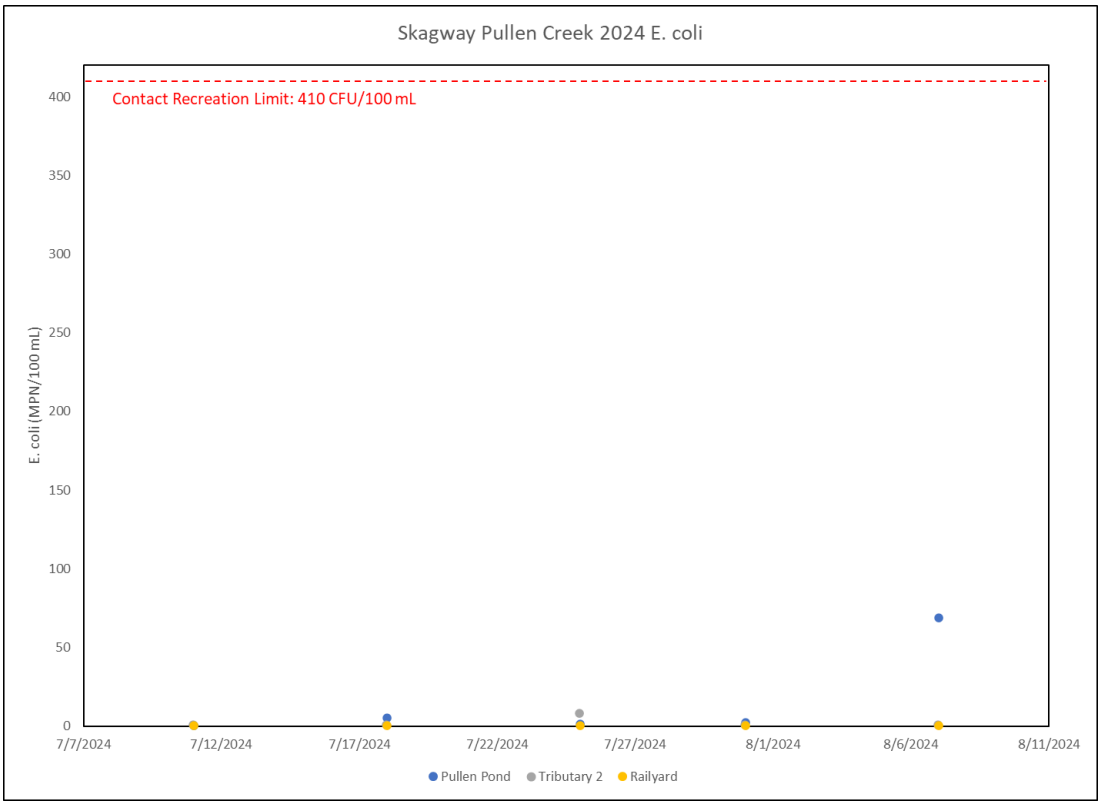

Figure 7. Pullen Creek E. coli analytical results, 2024, all sites.

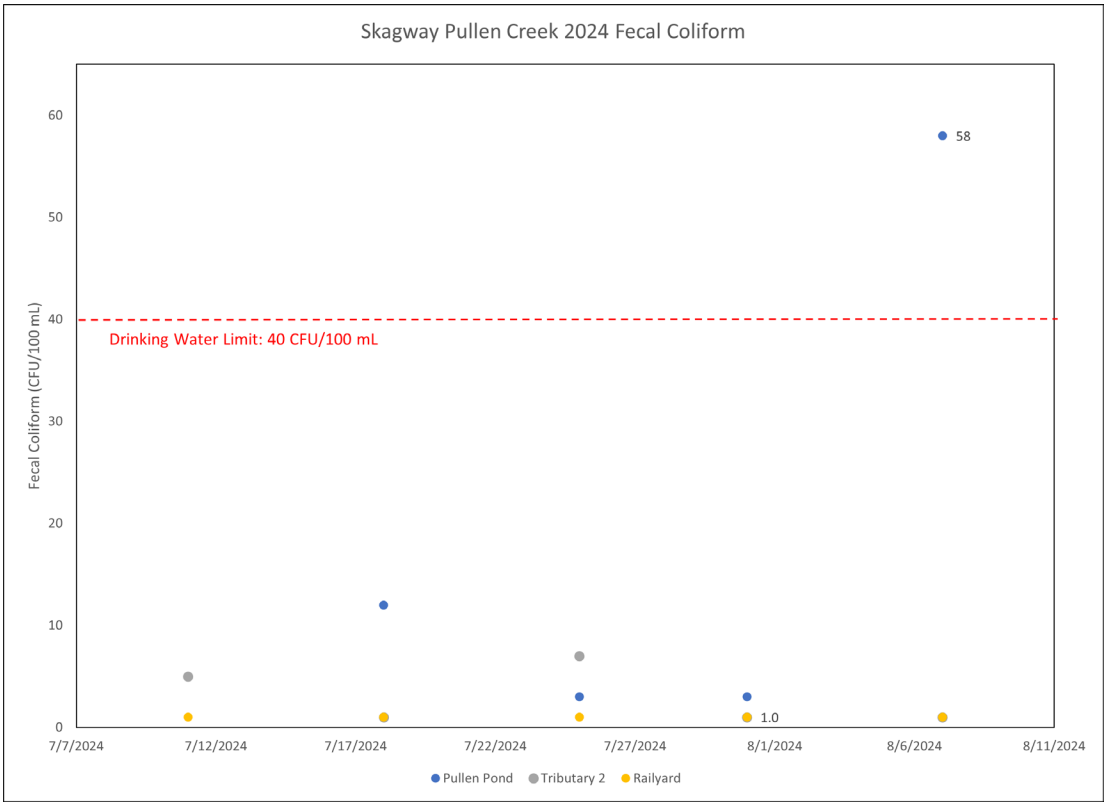

Figure 8. Pullen Creek fecal coliform analytical results, 2024, all sites.

Conclusion

Pullen Creek screening sampling was successfully implemented in 2024. Results suggest that sediment heavy metal concentrations have generally reduced since 2003, but several analytes remain above the screening level TMDL loading capacities including cadmium, copper, lead, and zinc. Heavy metals in water all complied with state WQS. In situ measurements broadly met WQS, with the exception of dissolved oxygen at Railyard and Fish Hatchery, and turbidity at Railyard. Total PAHs in sediment at all sites were above TMDL loading capacity, with the highest concentration occurring at Railyard and relatively lower measurements at Tributary 1 and Fish Hatchery. Bacteria levels mostly complied with WQS, however Pullen Pond had one fecal coliform exceedance for the consumption of raw aquatic organisms. MST analysis revealed no DNA markers for target species: avian, human, and canine.

Sources of historic heavy metal pollution have included fugitive dust from transferring mining ores at the Ore Terminal and uncovered ore trucks transporting minerals through Skagway, however these practices were improved by covering the conveyance system at the harbor and implementing covered transport vehicles, which may explain the reduction of heavy metals in sediment since 2003. Other potential sources of sediment heavy metals are metal roofs, vehicle brake dust, tire particulates, and paints conveyed to the stream by the Skagway stormwater system which empties directly into Pullen Creek at several locations. These inputs are not filtered and there are no longer any nature-based stormwater solution installations functioning to mitigate overland flow into the system, the only existing structure having been decommissioned in 2023 by the Municipality of Skagway. Additionally, the riparian cover along Pullen Creek is fragmented, due to a lack of municipal regulations designating minimum riparian buffers in Skagway, which decreases natural treatment of overland flow entering the stream. Increasing riparian buffers and nature-based stormwater solutions such as bioretention ponds, bioswales, and rain gardens may be beneficial to the further reduction of heavy metals in Pullen Creek. PAHs are typically sourced from combustion activities including wood fires, cooking, vehicle exhaust, and municipal incinerators. All activities occur within the Skagway townsite except for incineration, which takes place approximately seven miles up the valley. The primary pathway for these compounds to enter Pullen Creek is through sediment-laden overland flow via the stormwater system, which again could be mitigated using nature-based stormwater solutions.

STC suggests continuing to screen heavy metals, PAHs, and bacteria in Pullen Creek, and additionally include sampling efforts that target stormwater outfalls surrounding precipitation events to assess the composition of inputs in terms of metals, PAHs, and sediment loads.

Appendix A. Analytes

Table 7. Analytes from Pullen Creek water and sediment sampling, 4/2/24.

Group	Analyte	Units	Method	Matrix
Conventionals	Dissolved Organic Carbon	mg/L	SM 5310B	Water
	Settleable Solids	mL/L	SM 2450F	Water
	Total Solids	mL/L	SM 2540B	Water
	Total Sulfide	mg/L	SM 4500-S2-D	Water
Nutrients	Ammonia	mg/l	EPA 350.1	Water
	Dissolved Phosphorus	mg/l	SM 4500-PF	Water
	Total Phosphorus	mg/l	SM 4500-PF	Water
	Total Nitrate and Nitrite - N	mg/l	EPA 353.2	Water
Minerals	Hardness (CaCO)	mg/l	EPA 200.7 calc	Water
	Alkalinity (CaCO)	mg/l	SM 2320B	Water
	Calcium	mg/l	EPA 200.7	Water
	Magnesium	mg/l	EPA 200.7	Water
	Sodium	mg/l	EPA 200.7	Water
	Sulfate	mg/l	EPA 300.0	Water
	Chloride	mg/l	EPA 300.0	Water
Metals	Arsenic	µg/L; µg/g	EPA 200.8/6010D	Water; Sediment
	Barium	µg/L; µg/g		Water; Sediment
	Cadmium	µg/L; µg/g		Water; Sediment
	Chromium	µg/L; µg/g		Water; Sediment
	Copper	µg/L; µg/g		Water; Sediment
	Lead	µg/L; µg/g		Water; Sediment
	Zinc	µg/L; µg/g		Water; Sediment
PAHs	2-Methynaphthalene	µg/kg	EPA 8270-SIM	Sediment
	Acenaphthene			
	Acenaphthylene			
	Anthracene			
	Benzo(a)anthracene			
	Benzo(a)pyrene			
	Benzo(b)fluoranthene			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Chrysene			
	Dibenzo(ah)anthracene			
	Fluoranthene			
	Fluorene			
	Indendo(123-cd)pyrene			
	Naphthalene			
	Phenanthrene			
	Pyrene			

Appendix B. Pullen Creek 2024 In Situ Results

Table B1. In situ results from Pullen Creek, 2024.

Analyte	Site	4/2/24	7/11/24	7/18/24	7/25/24	7/31/24	8/7/24
Air Temperature (°C)	Pullen Pond	4.3	13.8	12.3	13.0	13.5	14.8
	Tributary 1	5.2					
	Fish Hatchery	4.1					
	Tributary 2	4.4	15.3	13.8	13.4	15.3	12.9
	Railyard	5.1	15.6	13.8	14.2	15.1	15.0
Water Temperature (°C)	Pullen Pond	2.5	8.8	8.5	9.4	9.7	11.8
	Tributary 1	2.9					
	Fish Hatchery	4.6					
	Tributary 2	4.6	4.8	4.7	4.7	4.7	4.6
	Railyard	4.7	4.8	4.7	4.6	4.6	4.6
Specific Conductance (µS/cm)	Pullen Pond	126.6	49.9	51.5	53.2	60.6	65.7
	Tributary 1	134.8					
	Fish Hatchery	233.2					
	Tributary 2	168.5	168.4	168.5	168.2	167.7	167.3
	Railyard	165.6	163.2	163.1	163	162.3	162.3
pH	Pullen Pond	7.5	7.39	7.28	7.31	7.36	7.27
	Tributary 1	7.73					
	Fish Hatchery	8					
	Tributary 2	7.55	7.37	7.17	7.25	7.23	7.15
	Railyard	7.39	7.28	7.29	7.2	7.21	7.25
DO (mg/L)	Pullen Pond	14.11	12.3	12.3	12.06	11.67	10.84
	Tributary 1	13.28					
	Fish Hatchery	5.77					
	Tributary 2	9.08	8.86	8.63	8.76	8.91	8.45
	Railyard	8.18	8.12	6.85	6.93	7.56	7.88
Turbidity (NTU)	Pullen Pond	1.04	0.58	1.1	0.81	0.4	0.54
	Tributary 1	1.16					
	Fish Hatchery	0.33					
	Tributary 2	0.36	0.3	1.07	0.6	0.19	0.21
	Railyard	1.43	0.42	14	2.07	2.34	6.13

Appendix C. Pullen Creek 4/02/2024 Results Water

Table C1. Water analytical results from Pullen Creek, 4/2/24. ND = Not Detected.

Group	Analyte	Pullen Pond	Tributary 1	Fish Hatchery	Tributary 2	Railyard
Conventionals	Dissolved Organic Carbon (mg/L)	1.7	2.7	2.1	1.5	1.4
	Settleable Solids (mL/L)	ND	ND	ND	ND	ND
	Total Solids (mL/L)	ND	ND	ND	ND	ND
	Total Sulfide (mg/L)	ND	ND	ND	ND	ND
Nutrients	Ammonia-N (mg/L)	ND	0.023	ND	0.021	ND
	Dissolved Phosphorus (mg/L)	0.001	0.0016	0.0076	0.0017	0.0023
	Total Phosphorus (mg/L)	0.0016	0.0018	0.0079	0.0018	0.0023
	Total Nitrate and Nitrite - N (mg/L)	0.106	0.113	0.221	0.333	0.342
Minerals	Hardness (CaCO, mg/L)	57	54	100	69	69
	Alkalinity (CaCO, mg/L)	54	71	95	63	65
	Calcium (mg/L)	19	18	35	23	23
	Magnesium (mg/L)	2.3	2.2	4.0	2.7	2.7
	Sodium (mg/L)	2.87	2.71	5.33	4.65	4.55
	Sulfate (mg/L)	3.9	3.55	8.42	7.71	7.68
	Chloride (mg/L)	3.35	2.99	8.14	9.63	6.97
Metals	Arsenic (µg/L)	0.055	0.107	0.074	ND	0.053
	Barium (µg/L)	48.9	49.3	41.9	49.9	50.9
	Cadmium (µg/L)	0.059	0.025	0.025	0.025	0.025
	Chromium (µg/L)	0.32	0.24	0.52	0.28	0.37
	Copper (µg/L)	ND	ND	ND	ND	ND
	Lead (µg/L)	ND	ND	ND	ND	0.269
	Zinc (µg/L)	1.57	1.04	4.73	3.52	1.92

Table C2. Water analytical results from Pullen Creek, 2003 - 2016. ND = Not Detected.

Pullen Pond										
Analyte	PRG	11/20/03	2/23/04	5/17/04	8/31/04	11/15/04	8/19/15	11/9/15	2/2/16	5/16/16
Arsenic	50	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	2000	45.9	77	ND	1200	0.046	42.9	50.6	56.2	35.3
Cadmium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	100	ND	1.6	ND	1.6	ND	0.918	2.14	ND	ND
Copper	1300			ND	ND	ND	0.638			ND
Lead	15	0.168	ND	ND	ND	ND	1.24	ND	0.484	ND
Zinc	11000		ND	ND	ND	0.003	3.84	ND	ND	ND

Fish Hatchery										
Analyte	PRG	11/20/03	2/23/04	5/17/04	8/31/04	11/15/04	8/19/15	11/9/15	2/2/16	5/16/16
Arsenic	50	ND								
Barium	2000	40.5								
Cadmium	5	ND								
Chromium	100	ND								
Copper	1300									
Lead	15	ND								
Zinc	11000									

Tributary 2										
Analyte	PRG	11/20/03	2/23/04	5/17/04	8/31/04	11/15/04	8/20/15	11/10/16	2/2/16	5/16/16
Arsenic	50	ND					ND	ND		
Barium	2000	50.1					57.2	59.3		
Cadmium	5	ND					ND	ND		
Chromium	100	0.148					0.778	ND		
Copper	1300						ND			
Lead	15	ND					0.083	ND		
Zinc	11000						ND	ND		

Railyard										
Analyte	PRG	11/21/03	2/24/04	5/17/04	8/31/04	11/15/04	8/20/15	11/10/16	2/2/16	5/16/16
Arsenic	50	ND	ND	ND	ND	0.0002			ND	ND
Barium	2000	49.2	84	ND	130	0.052			54.9	55.7
Cadmium	5	ND	ND	ND	ND	ND			ND	ND
Chromium	100	0.189	0.63	ND	0.7	ND			ND	ND
Copper	1300					0.001				ND
Lead	15	0.181	ND	ND	ND	0.001			ND	ND
Zinc	11000		ND	ND	ND	ND			ND	ND

Appendix D. Pullen Creek 4/02/2024 Results Sediment

Table D1. Sediment analytical results from Pullen Creek, 4/2/24. Non-detects for PAHs are replaced with 2x MDL for total PAH calculations, shown in blue. Results over the load capacity/WQS shown in red. ND = Not Detected.

Group	Analyte	Pullen Pond	Tributary 1	Fish Hatchery	Tributary 2	Railyard
PAHs	2-Methynaphthalene (µg/Kg)	25.1	20.9	119.0	149.0	388.0
	Acenaphthene (µg/Kg)	17.3	5.7	13.5	24.2	36.3
	Acenaphthylene (µg/Kg)	9.5	8.1	8.8	24.2	41.1
	Anthracene (µg/Kg)	47.5	23.8	15.5	24.1	107.0
	Benzo(a)anthracene (µg/Kg)	96.0	60.4	51.9	53.1	183.0
	Benzo(a)pyrene (µg/Kg)	116.0	74.6	61.3	64.0	242.0
	Benzo(b)fluoranthene (µg/Kg)	150.0	90.8	86.2	141.0	596.0
	Benzo(ghi)perylene (µg/Kg)	32.0	22.3	22.9	24.2	99.5
	Benzo(k)fluoranthene (µg/Kg)	53.6	32.8	86.2	36.2	174.0
	Chrysene (µg/Kg)	137.0	76.0	71.4	120.0	476.0
	Dibenzo(ah)anthracene (µg/Kg)	17.3	9.5	13.5	24.2	34.5
	Fluoranthene (µg/Kg)	175.0	118.0	90.9	141.0	469.0
	Fluorene (µg/Kg)	25.9	14.3	8.8	16.9	39.9
	Indendo(123-cd)pyrene (µg/Kg)	38.9	26.1	24.9	22.9	120.0
	Naphthalene (µg/Kg)	15.6	12.4	69.4	74.9	271.0
	Phenanthrene (µg/Kg)	207.0	138.0	89.6	146.0	520.0
	Pyrene (µg/Kg)	233.0	162.0	126.0	190.0	575.0
	Total PAHs	1396.7	895.7	959.6	1275.9	4372.3
Metals	Arsenic (µg/g)	2.03	1.93	2.14	2.89	5.13
	Barium (µg/g)	194	257	141	239	222
	Cadmium (µg/g)	ND	ND	ND	1.06	0.673
	Chromium (µg/g)	8.58	6.90	7.23	17.0	14.1
	Copper (µg/g)	22.7	22.7	11.1	74.7	71.5
	Lead (µg/g)	66.8	54.7	38.0	92.7	133
	Zinc (µg/g)	136	147	94.2	260	166
Conventionals	Total Solids (%)	38.0	68.8	48.1	27.3	55.0

Table D2. Sediment analytical results from Pullen Creek, 2004 – 2016. ND = Not Detected. Results over the load capacity in red. ND = Not Detected.

Pullen Pond									
Analyte	TMDL	2/24/2004	5/17/2004	8/31/2004	11/15/2004	8/20/2015	11/9/2015	2/2/2016	5/16/2016
Arsenic	5.9	13	0.8	2.9	2.4	1.15	ND	ND	ND
Barium	ND	1290	250	394	1687	169	120	98.2	121
Cadmium	0.596	ND	ND	ND	2.1	0.24	ND	ND	ND
Chromium	37.3	20	5.5	3.6	7.3	6.32	4.52	2	4.4
Copper	35.7				34	12.5		6.42	103
Lead	35	422	80	52.8	113	57	21.4	25	33.5
Zinc	123	293	110	137	174	158	91.9	73.6	91.2

Tributary 1									
Analyte	TMDL	2/24/2004	5/17/2004	8/31/2004	11/15/2004	8/19/2015	11/9/2015	2/2/2016	5/16/2016
Arsenic	5.9	7.1	1.2	2.3	5.5	2.04	1.95	ND	ND
Barium	ND	1080	190	99.7	172	230	163	122	1329
Cadmium	0.596	0.7	ND	ND	3.1	0.176	ND	ND	ND
Chromium	37.3	12	5.5	2.7	12	9.11	8.16	2.88	6.65
Copper	35.7				29	23.6		17.2	19.5
Lead	35	263	75	60.7	108	79.4	58.8	59.6	80.9
Zinc	123	551	240	179	353	170	172	81.7	150

Fish Hatchery									
Analyte	TDML	2/23/2004	5/17/2004	8/31/2004	11/15/2004	8/19/2015	11/9/2015	2/2/2016	5/16/2016
Arsenic	5.9	19.2	3.4	4.8	4.5	3.32	2.63	ND	ND
Barium	ND	1340	180	180	172	295	187	104	264
Cadmium	0.596	1.7	ND	ND	2.5	0.44	0.567	ND	ND
Chromium	37.3	43.5	14	7.1	11.2	10.2	9.78	1.96	5.85
Copper	35.7				14.3	24.6		14.6	17.5
Lead	35	207	98	64.4	70	80.8	49	36.5	55.3
Zinc	123	835	770	218	170	226	225	84	150

Tributary 2									
Analyte	TDML	2/24/2004	5/17/2004	8/31/2004	11/15/2004	8/20/2015	11/10/2015	2/2/2016	5/16/2016
Arsenic	5.9	15	1.6	8.6	4	2.27	ND	ND	ND
Barium	ND	1070	200	248	136	287	182	74.8	164
Cadmium	0.596	2	ND	1	3.1	0.675	0.407	ND	ND
Chromium	37.3	32	5.6	14	4.3	8.85	6.86	3.61	8.6
Copper	35.7				9.7	29.7		23	41
Lead	35	373	66	232	53	88.6	44.1	53.1	77.7
Zinc	123	913	200	565	91	251	153	105	200

Railyard									
Analyte	TDML	2/23/2004	5/17/2004	8/31/2004	11/15/2004	8/20/2015	11/10/2015	2/2/2016	5/16/2016
Arsenic	5.9	17.5	1.2	7.8	4.2	4.11	5.32	2.07	3.76
Barium	ND	1840	170	397	159	148	182	106	176
Cadmium	0.596	1.6	ND	0.6	2.3	0.434	0.729	ND	ND
Chromium	37.3	30.6	6.9	14	12	1	16	5.89	13.5
Copper	35.7				32	98.4		47.9	77.1
Lead	35	633	130	159	123	207	236	124	184
Zinc	123	557	160	145	139	178	222	110	178

Appendix F. Pullen Creek 2024 Bacteria Results

Table F1. Bacteria analytical results from Pullen Creek, 2024. Exceedances shown in red. ND = Not Detected.

Analyte	Date	Pullen Pond	Tributary 2	Railyard
E. coli	7/11/2024	ND	ND	ND
	7/18/2024	5.0	ND	ND
	7/25/2024	1.0	8.0	ND
	7/31/2024	2.0	ND	ND
	8/7/2024	69	ND	ND
Fecal Coliform	7/11/2024	5.0	5.0	ND
	7/18/2024	12	ND	ND
	7/25/2024	3.0	7.0	ND
	7/31/2024	3.0	ND	ND
	8/7/2024	58	ND	ND

Table F2. Bacteria geometric mean results from Pullen Creek, 7/11/24 - 8/7/24.

Analyte	Site	Geomean 7/11/24 - 8/7/24
E. coli	Pullen Pond	3.22
	Tributary 2	0.87
	Railyard	0.50
Fecal Coliform	Pullen Pond	7.93
	Tributary 2	2.04
	Railyard	1.00

Table F3. MST analytical results from Pullen Creek, 7/25/24. ND = Not Detected.

Site	Bacteroidetes	Result
Pullen Pond	Avian	ND
	Canine	ND
	Human	ND
Tributary 2	Avian	ND
	Canine	ND
	Human	ND
Railyard	Avian	ND
	Canine	ND
	Human	ND

Appendix G 18 AAC 70(2) Water Quality Standards Bacteria in Fresh Water

Water Quality Standards for Designated Uses	
POLLUTANT & WATER USE	**CRITERIA**
(2) BACTERIA, FOR FRESH WATER USES (See note 1)	
(A) Water Supply (i) drinking, culinary, and food processing	In a 30-day period, the geometric mean may not exceed 20 fecal coliform/100 ml, and not more than 10% of the samples may exceed 40 fecal coliform/100 ml. For groundwater, the fecal coliform concentration must be less than 1 fecal coliform/100 ml, using the fecal coliform Membrane Filter Technique, or less than 3 fecal coliform/100 ml, using the fecal coliform most probable number (MPN) technique.
(A) Water Supply (ii) agriculture, including irrigation and stock watering	In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (2)(A)(i), apply.
(A) Water Supply (iii) aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml. For products not normally cooked, the criteria for drinking water supply, (2)(A)(i), apply.
(A) Water Supply (iv) industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml.
(B) Water Recreation (i) contact recreation	In a 30-day period, the geometric mean of samples may not exceed 126 *Escherichia coli (E. coli)* colony forming units (CFU)/ 100ml, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 410 *E. coli* CFU/100 ml.
(B) Water Recreation (ii) secondary recreation	In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 ml, and not more than 10% of the total samples may exceed 400 fecal coliform/100 ml.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	Not applicable.

Appendix H. Pullen Pond Field Photos

Appendix I. Tributary 2 Field Photos

Appendix J. Fish Hatchery Field Photos

Appendix K. Tributary 1 Field Photos

Appendix L. Railyard Field Photos