2022 Water Quality Final Report Kenai River, Alaska

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Cover photo: ADEC water quality staff, Sarah Apsens, collects a water sample on the Kenai River, AK.

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Abstract

The Alaska Department of Environmental Conservation (ADEC) conducted water quality monitoring on the Kenai River during the ice-free period (i.e., April through November) in 2021 and 2022. The Kenai River is approximately 82 miles long and flows through a patchwork of protected wilderness, rural development, and urban settings. The river supports all five species of Pacific Salmon, and in turn, serves as the centerpiece for the regional tourism economy through sport and commercial fishing, rafting, and wildlife viewing. In 2021 and 2022, ADEC set out to evaluate the status of dissolved metals, notably copper and zinc, in the Kenai River after concern over these metals was raised by local stakeholders. Water quality samples were collected between the months of April and November at 15 sample sites, spanning from river mile five near the outlet to Cook Inlet to river mile 82.1 at the outlet of Kenai Lake. Sampling events occurred eight times in 2021 and seven times in 2022. Water samples were analyzed for total metals (copper and zinc), dissolved metals (copper, zinc, and a suite of additional metals), hardness (as $CaCO_3$), total dissolved solids, and dissolved organic carbon. Measurements for water temperature, pH, dissolved oxygen, salinity, and turbidity were also collected at each site during each monitoring event. No exceedances of State of Alaska Water Quality Acute Criteria were observed for copper and zinc.

ADEC encountered numerous quality control issues related to copper and zinc. Both metals are found naturally in the environment and can be discharged through commercial/industrial activities. Zinc is ubiquitous in the environment and is especially sensitive to sample contamination. A total of 63 routine dissolved zinc samples were collected in 2022[1]. Of those, 42 were rejected for failing to meet quality control criteria. Of the samples that passed the quality control criteria, three had detectable levels of dissolved zinc and 18 had no detectable dissolved zinc. A total of 63 routine dissolved copper samples were collected in 2022. Of those, three were rejected due to failing to meet quality control criteria. Of the samples that passed, two had detectable levels of copper and 58 had no detectable levels of copper. Incorporating additional quality control measures allowed ADEC to identify, respond to, and take adaptive action when issues arose. ADEC strongly recommends monitoring programs that include dissolved zinc sampling and analysis to include additional quality control measures. Data collected under this monitoring program were submitted for inclusion in Alaska's 2024 Integrated Water Quality Monitoring and Assessment Report (Integrated Report). ADEC has no plans for additional monitoring at this time. ADEC will continue to support regional partners with water quality protection and monitoring efforts.

[1] For details on the 2021 monitoring results see: ADEC (Alaska Department of Environmental Conservation). 2021.b. Waterbody Field Report 2021 Kenai River Water Quality Monitoring. Prepared by S. Apsens and J. Petitt. Division of Water. Soldotna, AK. 36pg.

Basic Waterbody Information

Table 1. Waterbody Information

Assessment Unit Name	Lower Kenai River	Middle Kenai River
Assessment Unit ID	AK_R_2030218_002_001	AK_R_2030218_002_002
Location description	Mouth of Kenai River to Slikok Creek	Slikok Creek to outlet of Skilak Lake
Water Type	Freshwater, River	Freshwater, River
Area sampled	Downstream of Warren Ames Memorial Bridge (RM 5) to, but not including, Slikok Creek (RM 19)	Upstream of Slikok Creek (RM 19.1) to Bing's Landing (RM 40)
Time of year sampled	April through November	April through November

Assessment Unit Name	Upper Kenai River	Kenai Lake
Assessment Unit ID	AK_R_2020214_007	AK_L_2030212_001
Location description	Inlet of Skilak Lake to Outlet of Kenai Lake	22-mile lake (13, 831 acres) near Cooper Landing, AK. Headwaters of the Kenai River.
Water Type	Freshwater, River	Freshwater, Lake
Area sampled	Jims' Landing (RM 70) to Resurrection Pass Trailhead (RM 76)	Upstream (RM 82.1) and downstream (RM 82) of the Cooper Landing bridge.
Time of year sampled	April through November	Twice during a sample season, once in May and once in August/September.

Water Quality Evaluation

Background

The Kenai River is an 82-mile-long glacially fed river that flows east to west across the Kenai Peninsula in Southcentral Alaska. The river crosses over multiple state and federal land management units, tribal lands, private property. The lower 23 miles run through the communities of Soldotna and Kenai. The river supports commercial, recreational, and subsistence salmon fisheries. The Kenai River has been the focus of multiple historic and ongoing monitoring efforts due to its significant ecological, economic, and cultural importance in the region.

The Alaska Department of Environmental Conservation (ADEC) Kenai River Water Quality Monitoring Project was developed in response to a community concern over potential elevated dissolved metals concentrations in the Kenai River and its tributaries. This concern evolved out of a review of the water quality data collected under the Kenai River Multi Agency Baseline study (KWF 2017.b, KWF 2021). Data collected in 2017, 2018, and 2019 under the Baseline study were submitted to ADEC for inclusion in the 2020 Integrated Report. A routine quality assurance review of the baseline data conducted by ADEC revealed that the submitted data did not meet multiple data quality thresholds (see ADEC 2021.b and Appendix D for further discussion of this issue). ADEC developed the 2021-2022 Kenai River WQ Monitoring project to fill in data gaps and determine dissolved metals levels in the Kenai River mainstem, particularly for dissolved copper and zinc.

Dissolved copper and zinc are both found naturally in the environment but can be detrimental to aquatic life at elevated concentrations. Natural background levels of copper and zinc can be a result of local geology and soil chemistry. Anthropogenic sources of copper include automobile brake pads, antifouling paint, lawn care chemicals, mining activities, water pipes and other construction materials. Anthropogenic zinc sources include galvanized metals, lawn care chemicals, personal care products, automobile oil and tires. Residues from these sources and other contaminants build up on impervious surfaces and can enter waterways during rain events if not intercepted by a stormwater treatment system. Exposure to elevated copper concentrations can cause organ and tissue damage in fish and aquatic invertebrates (Malhotra et al. 2020). Likewise, zinc exposure can impact calcium uptake in fish and negatively impact growth and metabolic processes (Santore et al. 2002). The toxicity of both copper and zinc is highly dependent on water chemistry (U.S. EPA 1980, U.S. EPA 2007). The State of Alaska uses a hardness-based criteria for aquatic organisms for both copper and zinc (18 AAC 70).

The ADEC Kenai River Water Quality Monitoring Project occurred between May and August 2021 and between April and November 2022. Monitoring locations were located across multiple assessment units (AU) representing varying levels of anthropogenic influence (see Figure 1 for monitoring locations). Monitoring locations did not differ between the 2021 and 2022 monitoring seasons. An April sampling event was added to the 2022 monitoring plan to

assess conditions immediately post ice-breakup on the Kenai River. A final sampling event was added in November 2022 to meet data objectives (ADEC 2021.a). Both the April and November sampling events only visited a subset of monitoring locations due to limited site access because of ice and snow.

This report describes the results of the second year of monitoring and provides a summary of both monitoring years. A summary of the 2021 field season and results is available in ADEC 2021.b. This report is not intended to serve as a waterbody impairment evaluation.

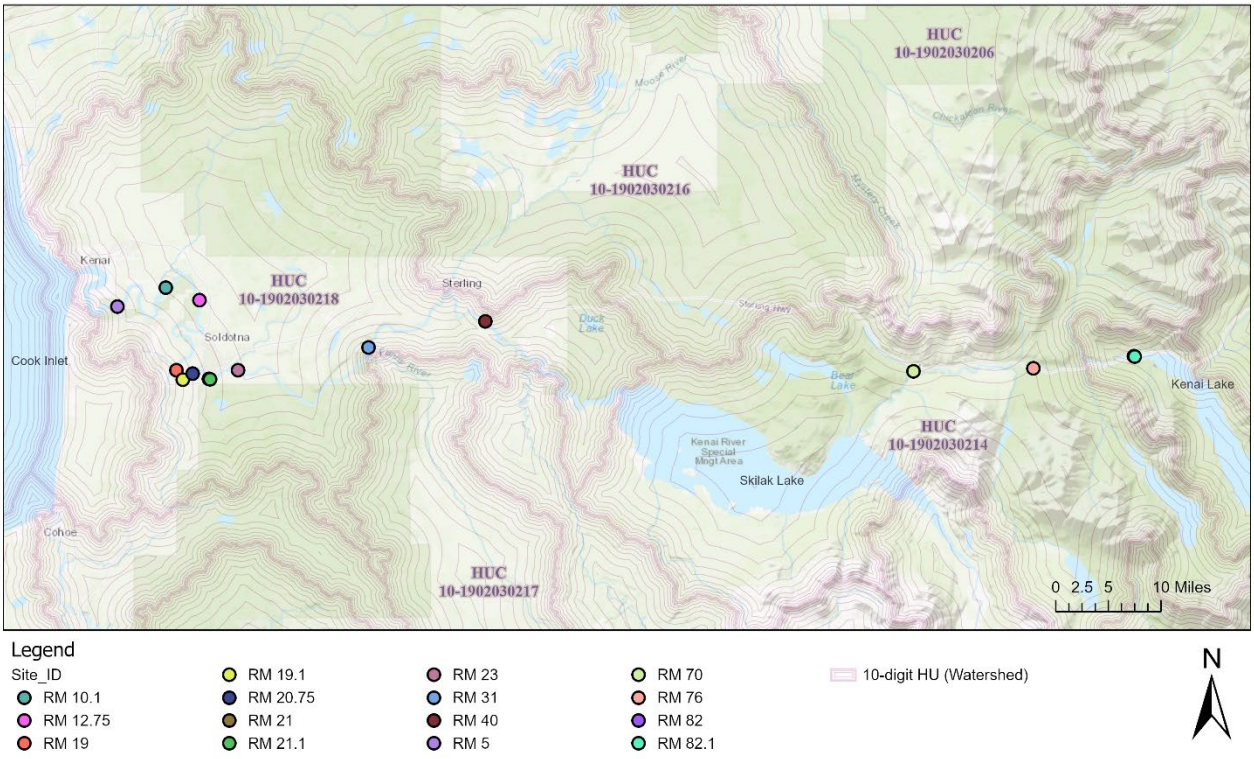

Figure 1. Map of the monitoring locations for the 2021-2022 Kenai River Water quality Monitoring project.

Data Quality Review 2022

All samples were collected under the protocols outlined in the approved project Quality Assurance Project Plan (QAPP) (DEC 2021.a). Monitoring equipment was maintained, validated, and calibrated according to maintenance requirements outlined in the QAPP and manufacturer's recommendations.

A total of four duplicate samples were incorporated into each sampling event in 2022. Duplicate sites were selected using a random number generator. A field blank was included with each sampling event of the 2022 monitoring season, for a total of seven blanks. Field blanks were conducted in the field, and the location of the filed blank collection rotated between boat sites and vehicle access sites. Field blanks were conducted with ultra-pure deionized water sourced from the contracted commercial laboratory in Anchorage. The

deionized water was 'collected' in the same dipper cup used to collect routine samples. Field blank bottles were labeled and shipped with the routine samples to the lab for analysis.

All samples were analyzed by a commercial laboratory in Anchorage, except for a subset of samples from the September and November 2022 events that were analyzed by the State of Alaska Environmental Health Lab (see Inter-Lab Sample Split). Method blanks and matrix spikes were performed by both laboratories.

Relative Percent Difference (RPD)

Precision was measured using relative percent difference (RPD) between a routine sample and a paired duplicate sample. RPD was calculated as follows:

$$RPD = \frac{(A - B)}{(\frac{A + B}{2})} * 100$$

Where A was the result of the routine sample and B was the result of the paired duplicate. The precision goal for this project was an RPD ≤ 10% for all paired samples. Estimate values (detected at levels lower than the practical quantitation limit (PQL)) were treated as non-detect for the purpose of this analysis. A set of paired samples was evaluated for RPD only if: one or both samples were above the PQL; and if one or both samples were at least two times the PQL. Pass rates varied among analytes and between years (Table 2 and Table 3).

Table 2. Relative percent difference comparison for dissolved metals and total dissolved solids (TDS) in 2022. The precision goal for this project was an RPD of 10%. The 20% RPD summary data is provided to allow comparison to historic projects.

Analyte	# Paired Samples	Count of >10%	10% RPD Pass	Count of >20%	20% RPD Pass
Aluminum	28	10	64%	7	75%
Cadmium	28	0	100%	0	100%
Calcium	28	1	96%	1	96%
Copper	28	3	89%	3	89%
Lead	28	0	100%	0	100%
Magnesium	28	2	93%	1	96%
Organic carbon	24	1	96%	1	96%
Potassium	28	2	93%	1	96%
Selenium	28	0	100%	0	100%
Sodium	28	3	89%	2	93%
Total dissolved solids	28	12	57%	4	86%
Zinc	28	15	46%	12	57%

Field Blanks

A total of seven field blanks were collected during the 2022 field season (Table 3).

Table 3. Field blank results for the 2022 season. The qualifier 'U' indicates the analyte was not detected. Detected analyte results are bolded. Frequency of analyte detected in field blank is provided. The September 2022 monitoring event is excluded (see Appendix F).

		Date of Field Blank Collection							
	Analyte	**19-Apr**	**17-May**	**13-Jun**	**20-Jul**	**15-Aug**	**8-Sep**	**3-Nov**	**Freq.**
Total Metals	Calcium	U	U	U	U	U	-	U	0%
	Copper	U	U	U	U	U	-	U	0%
	Hardness	U	U	U	U	U	-	U	0%
	Magnesium	U	U	U	U	U	-	U	0%
	Zinc	U	U	U	**62.3**	**123**	-	U	33%
Dissolved Metals	Aluminum	**26.7**	**59.2**	U	U	U	-	U	33%
	Cadmium	U	U	U	U	U	-	U	0%
	Calcium	U	U	U	U	U	-	U	0%
	Copper	U	U	U	U	U	-	U	0%
	Lead	U	U	U	U	U	-	U	0%
	Magnesium	U	U	U	U	U	-	U	0%
	Potassium	U	U	U	U	U	-	U	0%
	Selenium	U	U	U	U	U	-	U	0%
	Sodium	U	U	U	U	U	-	U	0%
	Zinc	U	**138**	U	**86.8**	**58.9**	-	U	50%
	Dissolved Solids	U	**18**	**10**	U	U	-	U	33%
	Organic Carbon	U	-	U	U	U	-	U	0%

Inter-Lab Sample Split

Aliquots from the 2022 September and November sampling events were retrieved from the contract commercial laboratory and sent for analysis at the State of Alaska Environmental Health Laboratory in Anchorage, Alaska for an inter-lab split comparison. See Appendix E for more information.

Methods

A total of fifteen sampling events occurred between 2021 and 2022, eight in 2021 and seven in 2022. In 2022, the seven events occurred between April and November. Monitoring locations, methods, and staff did not differ between 2021 and 2022. The April 2022 event was added to extend the temporal representativeness of the sample plan. Only a subset of monitoring locations was sampled during the April event due to extremely low water levels and dangerous conditions for the sampling crew. Samples were collected on set calendar dates, no matter the weather condition. See Appendix A for list of sample locations and dates of sampling.

Sample locations were accessed by foot or from a motorized boat. Samples were collected upstream of the sample collector to avoid contamination from upturned sediment or the boat hull. Modified sampling methods were incorporated into the 2021 and 2022 standard operating procedures for this project. These methods included the use of a swing sampler, incorporating modified 'clean hands, dirty hands', and the inclusion of additional quality assurance samples (i.e., field blanks, total metals, and additional duplicate samples). All samples were collected using a swing sampler. A swing sampler consisted of a plastic sample cup attached to an extendable fiberglass pole (aka a 'dipper' pole). A 'clean hands, dirty hands' technique was used by the sampling team to collect all water samples (modified from EPA 1996). All staff wore powder free nitrile gloves for all sample collection and handling. Samples were stored in double layered clean plastic bags during transport.

In situ measurements were collected simultaneously using a handheld probe at all sample locations (In-Situ® Aqua TROLL 500 Multiparameter Sonde). Parameters included water temperature, specific conductivity, dissolved oxygen, pH, and turbidity.

Water samples were analyzed by SGS Laboratory in Anchorage, Alaska. Filtering of dissolved metals samples was conducted by the contract laboratory using 0.45 µm pore membrane filters to minimize potential contamination of samples in the field. Total metals and hardness samples were field collected in bottles with acid preservative (HNO_3). All samples were analyzed using approved EPA methods (Table 4).

Resulting data underwent a quality assurance review before further analysis. See the quality assurance section of this report for more detail.

Dissolved zinc and copper were evaluated against water quality criteria (18 AAC 70). Both the acute and chronic criteria for aquatic life are site specific and are calculated using hardness. The site-specific hardness criteria were calculated using analyte specific formulas listed in ADEC 2008.

Methods for the GIS analysis are available in Appendix B.

Table 4. Grab sample analytical methods summary.

METHOD	DESCRIPTION	PARAMETERS
200.8 DISS	Dissolved metals in drinking water by ICP-MS	Aluminum; Cadmium; Calcium; Copper; Lead; Magnesium; Potassium; Selenium; Sodium; Zinc
200.8	Total metals in water by ICP-MS	Total calcium; Total copper; Total magnesium; Total zinc
SM 5310B	Dissolved Organic Carbon (DOC)	DOC
SM21 2540C	Total dissolved solids (TDS)	TDS
SM21 2340B	Hardness as $CaCo_3$ by ICP-MS	$CaCO_3$

Results

A total of 126 dissolved copper and zinc metals samples, 126 total copper and zinc total metals samples, 24 duplicate samples, and 6 field blanks were collected over the 2022 sampling season[2]. In situ measurements were collected at each sample site, during each sample event. A total of 15 sampling events occurred between the 2021 and 2022 monitoring seasons. The raw dissolved copper and zinc data used for this analysis are available for review in Appendix C. A discussion of the September 2022 sampling event that was excluded from the following analysis is available in Appendix E.

Copper (dissolved)

A total of 63 (see footnote 1) routine dissolved copper samples were collected in 2022. Of those, three (3) were rejected for failing to meet quality control criteria. Of the samples that passed the quality control criteria, two (2) had detectable levels of copper (≥ LOQ), and 58 had no detectable level of dissolved copper in the sample (Figure 2). The average observed dissolved copper was 1.6 µg/L. Maximum observed dissolved copper was 5.3 µg/L at RM 40. No exceedance of Alaska's acute water quality criteria for copper was observed (18 AAC 70) (Appendix C).

[2] Total excludes samples collected in September 2022. See Appendix E for more information.

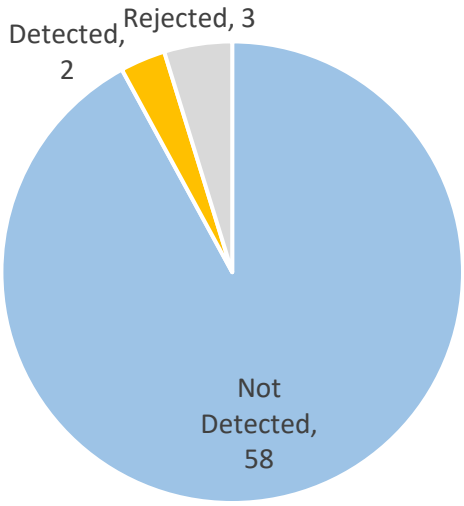

Figure 2. Summary of 2022 dissolved copper.

Zinc (dissolved)

A total of 63[2] dissolved zinc samples were collected in 2022. Of those, 42 were rejected for failing to meet quality control criteria. Of the samples that passed the quality control criteria, three (3) had detectable levels of dissolved zinc (≥ LOQ), and 18 had no detectable dissolved zinc (Figure 3). The average observed dissolved zinc was 8.2 µg/L. Maximum observed dissolved zinc was 46.9 µg/L at RM 5. No exceedance of the acute criteria for zinc was observed for the samples that passed quality control (18 AAC 70) (Appendix C).

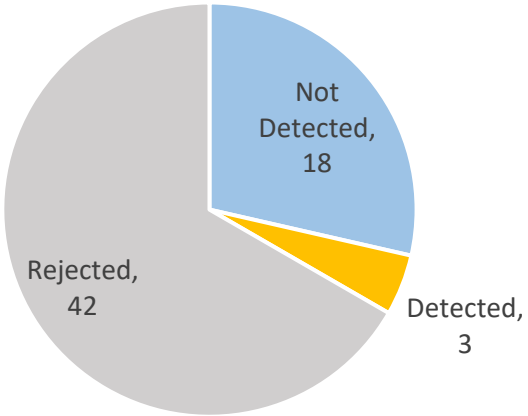

Figure 3. Summary of 2022 dissolved zinc.

In Situ Field Measurements

In situ field measurements were collected at all monitoring locations and events during the 2022 season (see Appendix F for summary table and graphs). Dissolved oxygen was highest in spring (April and May), decreased through the summer, and then increased in November. The opposite trend was seen with water temperature that increased late summer and reached

minimum observed values in spring and late fall. pH displayed no obvious trend and fluctuated between 6.9 and 8.3. The highest observed turbidity, total dissolved solids, and salinity were observed at river mile 5 suggesting marine water inundation at this site. Salinity hovered between 0.019 PSU at river mile 20.75 and 0.5 PSU at river mile 70 on the Kenai River mainstem. Salinity peaked in June (0.065 PSU) and August (0.064 PSU) in Slikok Creek, the one tributary included in this study.

Conclusions

All water quality measurements from this study met Alaska Water Quality Standards (18 AAC 70). No dissolved copper or zinc samples exceeded acute or chronic water quality criteria (18 AAC 70) during the 2022 monitoring season. The 2022 season results mirror the 2021 season results in that no exceedances for copper or zinc were observed. The data from 2021 and 2022 suggest that the Kenai River mainstem meets State of Alaska water quality criteria for acute exposure for aquatic life for copper and zinc. All other water quality measurements also met water quality criteria (18 AAC 70). The data from this project will be submitted for inclusion in the next Integrated Report cycle.

Quality Control

The frequency of exceedances of data quality assurance thresholds was greater in 2022 than in 2021, particularly for dissolved zinc. For example, in 2022 67% of the dissolved zinc samples failed one or more quality assurance thresholds, compared to only 2% in 2021 (ADEC 2021.b). The monitoring staff, collection methods, collection tools (i.e., dipper pole, boat, gloves), did not change between the 2021 and 2022 seasons. Likewise, no changes in the lab used or the analytical methods used occurred apart from changing the lab project manager in early 2022. The source of contamination could not be determined and indicated that even with a highly trained sample staff and use of additional sampling protocols (i.e., EPA method 1669), contamination by dissolved zinc can still occur. More importantly, this study showed the value of having a strong quality assurance plan and good communication among study participants.

The additional quality assurance steps were successful in that they helped easily identify when potential sample contamination occurred (e.g., dissolved metals being greater than total metals). In addition, strong communication among sampling staff, ADEC management staff, and the lab allowed the project team to take corrective actions when contamination was suspected. Response actions included requesting different sample bottles, adding additional sample events, and cross validating lab data with an outside lab[3] (Appendix E). It is also important to note that contamination was not common with other metals monitored. For example, in both 2021 and 2022 only 2% and 5% respectively of dissolved copper samples were rejected due to failing to meet data quality thresholds. Dissolved zinc in surface water is notorious for contamination (Shiller and Boyle 1985, EPA 1996). Future projects that include the assessment

[3] The State of Alaska Environmental Health Lab was used to reanalyze and cross validate sample data.

of dissolved zinc are highly encouraged to incorporate strong quality assurance protocols and practices to identify if, and when, dissolved zinc contamination occurs.

In Situ Measurement Observations

The in situ parameters were collected to provide a more holistic view of water quality conditions in the Kenai River mainstem. Observed in situ measurements generally mirrored those observed in 2021. One difference between the two monitoring seasons was the inclusion of early spring (April) and fall (November) water measurements in the 2022 season. The April event was included to capture conditions at, or as close as possible, to 'break-up' conditions. The November event was added to meet data needs as outlined in the QAPP (ADEC 2021.a), but ultimately allowed for an observation of late fall conditions. Early spring conditions reflected the cold air temperatures, low water levels, and relatively high dissolved oxygen (see Appendix F). Similar conditions were observed in November 2022.

Salinity

Salinity ranged from 0.036 PSU and 17.066 PSU in April 2022, with the lowest value observed just upstream at the Soldotna Bridge (RM 21.1) and the highest observed at the Warren Ames Memorial Bridge (RM 5). The relatively high observed salinity value at the Warren Ames Memorial Bridge suggests marine water infiltration at the site. The observed salinity in April reached 17.06 PSU at this site. For reference, average ocean salinity is 34.7 PSU, and the average 2022 observed salinity value across all sample events and all sites for the Kenai River was 0.04 PSU. River height or flow was not collected under this program but was available from the U.S. Geological Survey's stream gauge at the Soldotna bridge (15266300)[4]. Water height measured 5.54ft on April 19th and was noted by the sample crew as being low during field collection. Low river levels combined with an outgoing high tide of 23.55 (high tide occurred approximately 1.5 hours before sample event)[5] likely resulted in the marine water inundation and the high observed salinity value. Direct comparison to the next upstream site (RM 10.1) on the same date was not possible due to persistent snow, ice shelves, and low water levels inhibiting sample collection at RM 10.1. However, a salinity of 0.037 was recorded at RM 21 during the April 2022 event. Likewise, the average observed salinity at RM 5 across the 2022 May and November sample events averaged 0.04 PSU, and similar values were observed in 2021.

The extent of marine water inundation in the lower Kenai River has been heavily debated in the past with some suggesting that marine surface water can extend beyond Pillars Boat Launch (RM 12.75). These phenomena were not observed during this project and the 2021-2022 salinity measurements suggest that marine inundation of the surface water (approximately 0-3 ft in depth) is minimal to nonexistent above RM 10.1 even at low flow conditions. This does not,

[4] https://waterdata.usgs.gov/monitoring-location/15266300/#parameterCode=00065&startDT=2022-03-01&endDT=2022-11-25

[5] Tide information sourced from NOAA Tides and Currents, https://tidesandcurrents.noaa.gov/

however, exclude the possibility of a wedge of marine water below the surface layer (> 3ft below surface).

Spatial Analysis

The degree of impact from nonpoint source pollution is often correlated with land use in a watershed. As the percent coverage of impervious surfaces increases within a watershed, the potential for stormwater runoff into surface water increases (U.S. EPA 2003). A GIS product produced as part of a previous ADEC Alaska Clean Water Actions grant[6] was used to assess land use patterns among the assessment units (AU) of the Kenai River (see Appendix B). The percent land development was greatest in the lower river (RM 5 to Slikok Creek). Land development was far lower at the upper section and Kenai Lake (RM 70 to RM 82.1). The number of bridge crossings within each HUC-12 watershed was quantified as well. Interestingly, the number of bridge crossings was greatest in the Kenai Lake HUC-12 based assessment unit. The results of this tabletop GIS exercise could guide outreach efforts and installation of best management practices to reduce nonpoint source pollution. For example, the lower section of the Kenai River would benefit from outreach efforts pertaining to semi urban development and private property owners. The upper section of the river may benefit more from a focus on low impact infrastructure design and maintenance.

Baseline Monitoring

ADEC's intensive monitoring effort would not have occurred if not for the efforts of the Kenai Watershed Forum and the Multi-Agency Baseline Monitoring program. ADEC's study did not find evidence of heavy metal contamination in the Kenai River and the lessons learned regarding having a strong QA process will be shared and applied to the Baseline Program and other monitoring efforts statewide. ADEC will continue to support the Baseline Program through technical assistance and participating in biannual monitoring. Long term monitoring is necessary to detect potential issues before they escalate and become expensive and time consuming to fix.

Recommended Next Steps

ADEC Agency Action

ADEC will include this dataset in an upcoming Integrated Report cycle. Water quality data from this project will be made available to the public through the EPA's Water Quality Portal[7] .

Water Quality Monitoring Efforts

The following are recommended actions for future ambient water quality monitoring by ADEC and partners:

[6] Alaska Clean Water Action Grant #ACWA-19-02: Kenai River Water Quality Monitoring and Assessment
[7] https://www.epa.gov/waterdata/water-quality-data

- Incorporate EPA Method 1669 'Clean Hands, Dirty Hands' when collecting water samples for dissolved metals.
- Include at least one field blank per sampling event when collecting water samples for dissolved metals.
- Include total metals when collecting water samples for dissolved copper and zinc.
- Review lab results as soon as possible upon receipt from the laboratory to identify potential contamination issues and respond in a timely manner.

Local Monitoring and Conservation Efforts

The following are suggested actions to prevent future impairment of the Kenai River:

- Protect the Kenai River and its tributaries by promoting low impact development strategies such as green infrastructure installation.
- Support existing protective ordinances of riparian zones.
- Continue efforts to promote local awareness and knowledge of nonpoint source pollution in key stakeholder groups. An example would be promoting low impact lawn care methods to homeowners with property near local rivers and streams.
- Provide capacity development and share lessons learned to local ambient water quality monitoring efforts.

Acknowledgements

This project would not have been possible without extensive collaboration with ADEC's Nonpoint Source section staff including Laura Eldred and Jenny Petitt. Thank you also to Christina Harris from the ADEC Drinking Water program for serving as the boat operator during both the 2021 and 2022 seasons. Thank you to the Alaska Department of Fish and Game and Colton Lipka for supplying a boat and providing mechanical assistance. Thank you to Alaska State Parks and the Kenai River Center for allowing us to use the Pillars Boat Launch and advising on river access when developing this project.

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Appendix A: 2022 Monitoring Locations

Table A. 1. Monitoring locations sampled as part of the Kenai River Water Quality monitoring effort. Monitoring locations occurred in four different assessment units and were designated by closest approximate river mile (RM). All sites except RM 19 occurred on the mainstem of the Kenai River.

Assessment Unit (AU) Section Name	***RM***	***Latitude***	***Longitude***	***Type***	***Site Description***	***Access***	***Number of site visits in 2022***	*Total Site visits 2021-2022*
AK_R_2030218_002_001 Lower Kenai River	5	60.52565	151.2088	Main	Warren Ames Memorial Bridge	Truck	6	14
	10.1	60.53928	-151.142	Main	Upstream of Beaver Creek	Boat	5	13
	12.5	60.53374	-151.099	Main	Upstream of Pillars Boat Launch	Boat	5	13
	19	60.48232	-151.127	Tributary	Slikok Creek	Boat/Truck[8]	5	13
AK_R_2030218_002_002 Middle Kenai River	19.1	60.47824	-151.122	Main	Upstream of Slikok Creek	Boat	5	13
	20.75	60.48173	-151.093	Main	Downstream of Centennial Park	Boat	5	13
	21	60.47663	-151.082	Main	Downstream of the Soldotna Bridge	Truck	6	14
	21.1	60.4764	-151.082	Main	Upstream of the Soldotna Bridge	Truck	6	14
	23	60.48034	-151.031	Main	Swiftwater Park	Truck	5	12
	31	60.49828	-150.863	Main	Morgan's Landing	Truck	6	14
	40	60.51544	-150.702	Main	Bings Landing	Truck	5	13
AK_R_2030214_007 Upper Kenai River	70	60.48185	-150.114	Main	Jim's Landing	Truck	6	14
	75	60.48663	-150.001	Main	Sportsman's Landing	Truck	5	13
	76	60.48402	149.9513	Main	Resurrection Pass	Truck	5	13
AK_L_2030212_001 Kenai Lake	82	60.492	-149.811	Main	Cooper Landing Bridge downstream	Truck	2	4
	82.1	60.49189	-149.81	Main	Cooper Landing Bridge upstream	Truck	2	4

[8] Monitoring location for RM 19 was moved approximately 600ft upstream from original site during the June 2022 sampling event. This was done for ease of access due to high water levels in July, August, and September 2022.

Monitoring Locations and Descriptions

River Mile 5 – Warren Ames Memorial Bridge

RM 5 was the monitoring location closest to the outlet of the Kenai River into Cook Inlet (Figure A. 1). This site is tidally influenced and often exhibited characteristics of estuarine habitats. The site was accessible on foot from a small parking lot off Bridge Access Road. Personal use fishing occurs in the spring for Eulachon (*Thaleichthys pacificus*) and in July for Sockeye salmon (*Oncorhynchus nerka*). Mud and silt were the dominant substrate at the site and turbid conditions were commonly observed. River mile 5 was historically monitored for pathogens under the Kenai BEACH Program from 2010 to 2020.

Figure A. 1. River mile 5 looking north. Photo collected in August 2022.

River Mile 10.1 – Upstream of Beaver Creek

RM 10.1 was a boat accessible monitoring location upstream of the Beaver Creek tributary (Figure A. 2). Sample collection occurred river left of midchannel near a steep cut bank. Tidal influence was less noticeable than at RM 5. Seals were observed multiple times near this site. Fishing boats were often anchored downstream of sampling crew. The Multi-Agency Baseline Monitoring project also monitored a site upstream of Beaver Creek.

Figure A. 2. River mile 10.1 looking east. Boat facing upstream. Photo collected August 2022.

River Mile 12.5 - Upstream of Pillars Boat Launch

RM 12.5 was a boat accessible monitoring location upstream of the Pillars Boat Launch (Figure A. 3). Sample collection occurred river right of a large island near a steep cut bank. This site was upstream of the Pillars Boat Launch and boat traffic was common.

Figure A. 3. River mile 12.5 looking south. Boat is facing upstream. Photo collected August 2022.

River Mile 19 – Slikok Creek

RM 19 was the only tributary of the Kenai River monitored under the ADEC 2021-2022 Kenai River Water Quality Monitoring Project. RM 19 was categorized as a boat access site in all of 2021 and through June 2022. The boat access RM 19 was characterized by a broad flat wetland (Figure A. 4). Access to RM 19 was changed to a vehicle access site in July 2022. The vehicle access site was approximately 600 ft from the boat access RM 19 and was characterized as dense forested habitat (Figure A. 5).

Figure A. 4. River mile 19 looking west. Photo collected in June 2022.

Figure A. 5. River mile 19 looking east. Photo collected August 2022.

River Mile 19.1 – Upstream of Slikok Creek

RM 19.1 was a boat access site located approximately 300m upstream of the confluence of Slikok Creek and the Kenai River. This site was upstream of a fish wheel operated by the Alaska Department of Fish and Game.

Figure A. 6. River mile 19.1 looking southeast. Photo collected in September 2022.

River Mile 20.75 – Centennial Park

RM 20.75 was the farthest upstream boat access site sampled under this project. Samples were collected midchannel just downstream of the handicap access fishing dock at Centennial Park. Boat traffic was common during June and July. Large numbers of partially submerged boulders made this site difficult to access during low flow conditions.

Figure A. 7. River mile 20.75 looking northeast. Photo collected September 2022.

River Mile 21 – Downstream of Soldotna Bridge

RM 21 was located approximately 100 m downstream of the Soldotna Bridge and was accessible from a elevated platform used for fishing access. ADEC staff collected water samples with the dipper pole off the bottom step of aluminum staircase seen in Figure A.8. A fish cleaning table was located upstream, and fish guts were commonly seen at this site.

Figure A. 8. River mile 21 looking northeast. Photo collected September 2022.

River Mile 21.1 – Upstream of Soldotna Bridge

RM 21.1 was located just upstream of the Soldotna Bridge and was accessed by using the pedestrian path under the bridge. People fishing were commonly encountered at this location during June and July. Several large boulders and rusted metal debris could be observed when the water level was low. Litter and used fish line were common.

Figure A. 9. River mile 21.1 looking northeast. Photo collected in September 2022.

River Mile 23 – Swiftwater Park

RM 23 was located upstream of the City of Soldotna. This was a popular fishing spot during June and July. The sample site was accessed by climbing down multiple elevated stairways. The sample crew collected the water sample while standing on the bottom step of the staircase. Water conditions were often very swift as the name suggests.

Figure A. 10. River mile 23 looking south. Photo collected in June 2022.

River Mile 31 – Morgan's Landing

RM 31 was a foot access monitoring site located at Morgan's Landing State Park. The site was accessed by walking down a short foot trail and walking down a short wooden staircase to the site. Samplers used the dipper pole to sample beyond the fish table seen in Figure A.11. River currents and wind were usually calm at this site, however flying insects could be atrocious.

Figure A. 11. River mile 31 looking southeast. Photo collected in June 2022.

River Mile 40 – Bing's Landing

RM 40 was a foot access site located at a popular boat launch for the middle Kenai River and Skilak Lake (upstream). RM 40 was included as a historic site, as it had been sampled under the Multi-Agency Baseline Monitoring program. The sampling crew accessed the site by walking on the floating dock downstream of the boat launch (Figure A.12). The dipper pole was used to sample away from the floating dock and samplers waited for a break in boat launches before collecting a sample.

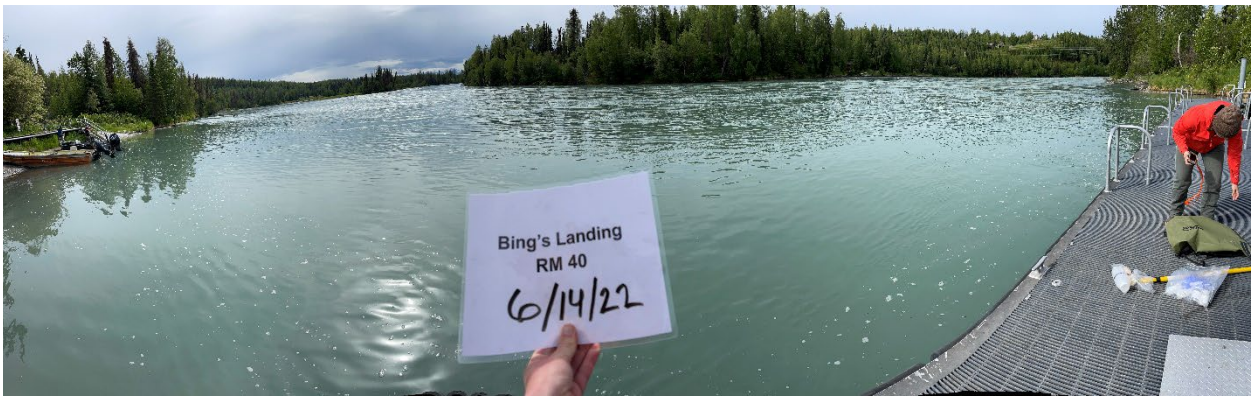

Figure A. 12. River mile 40 photographed in June 2022.

River Mile 70 – Jim's Landing

RM 70 was located within the Kenai National Wildlife Refuge. Water samples were collected with the dipper pole from the gravel boat launch pad (Figure A.13).

Figure A. 13. River mile 70 looking southwest. Photo taken in July 2021.

River Mile 76 – Resurrection Pass

RM 76 was a foot access site located near the pullout for the Resurrection Pass Trail on the Sterling Highway. The site was accessed by parking at the pullout before the bridge and walking down a short trail (10m). High brush and trees limited visibility at this site.

Figure A. 14. Photo collected May 2021 looking east.

River Mile 82 and 82.1 – Cooper Landing Bridge, Downstream and Upstream

RM 82 and 82.1 were foot access sites located downstream and upstream of the Cooper Landing Bridge (Figure A.15). River mile 82 was located approximately 10m downstream of the boat launch. River mile 82.1 was located approximately 5 upstream of the bridge.

Figure A. 15. River mile 82 looking northeast. River mile 82.1 was located just upstream of the bridge (see upper right section of photo).

Appendix B: Geographic Information Systems (GIS) Analysis Kenai River Watershed

Prepared by: J. Petitt and S. Apsens[9]

Background

The following analysis using geographic information systems (GIS) products was completed by DEC in 2022 to provide a broader view of the Kenai River watershed. The source geodatabase used for this exercise was originally provided to DEC as a deliverable under Alaska Clean Water Actions Grant ACWA-19-03: Kenai River Water Quality Monitoring and Assessment. The geodatabase was supplemented by DEC with publicly available GIS data. DEC then completed GIS analyses for each HUC12 included in the 2021-2022 Kenai River water quality study conducted by DEC.

Methods

For percent area developed calculations, the National Land Cover Dataset (NLCD)[10] layer was clipped to the extent of HUC12 sub watersheds within the Kenai River Watershed using ArcGIS. Definitions used by the NLCD for development intensity were used as follows: Open Space (0-20%), Low Intensity (20-49%), Medium Intensity (50-79%), and High Intensity (80-100%). An Excel table was generated containing the percent development intensity at the HUC12 sub watershed level. Sample sites were grouped by HUC12 sub watershed, and the HUC12 sub watersheds that flow towards the site of interest were included in the percent developed calculations. Figure B.1 shows the sample sites grouped by assessment unit on the X-axis, and percent of total land area on the Y-axis. River mile 19 (Slikok Creek) is a legacy site included in the lower assessment unit, although it is a tributary to the Kenai River. Figure B.2 illustrates Kenai River watershed overlayed with land use polygons.

The Kenai Peninsula Borough's (KPB) Road dataset and Bridge dataset[11] were clipped to the extent of the HUC12 sub watersheds within the Kenai River watershed using ArcGIS. Road length in miles and count of bridges were analyzed for each HUC12 sub watershed, and the HUC12 sub watersheds that flow towards the site of interest were included in the total calculations. KPB Roads dataset was updated March 2022. The KPB bridges feature layer dataset was last updated June 2022. Figure B.3 shows sample sites within HUC12s grouped by assessment unit on the X-axis, length of road in miles on the primary left Y-axis, and count of bridges on the secondary right Y-axis.

[9] Nonpoint Source Pollution Group, Water Quality Section, Division of Water
[10] U.S. Geological Survey, source: https://www.usgs.gov/centers/eros/science/national-land-cover-database
[11] Kenai Peninsula Borough GIS Department, source: https://geohub.kpb.us/search?categories=transportation&collection=Dataset

Results

Percent developed land use cover increased as river mile decreased (Figure B.1 and Figure B.2). The assessment unit (AU) with the highest developed percent land use cover was the lower AU, between river mile 5 (Warren Ames Bridge) and river mile 19 (Slikok Creek). River mile 5 had approximately 12% low intensity development, and 10% cleared or higher intensity development landcover. The upper AU and Kenai Lake exhibited the lowest percent developed landcover.

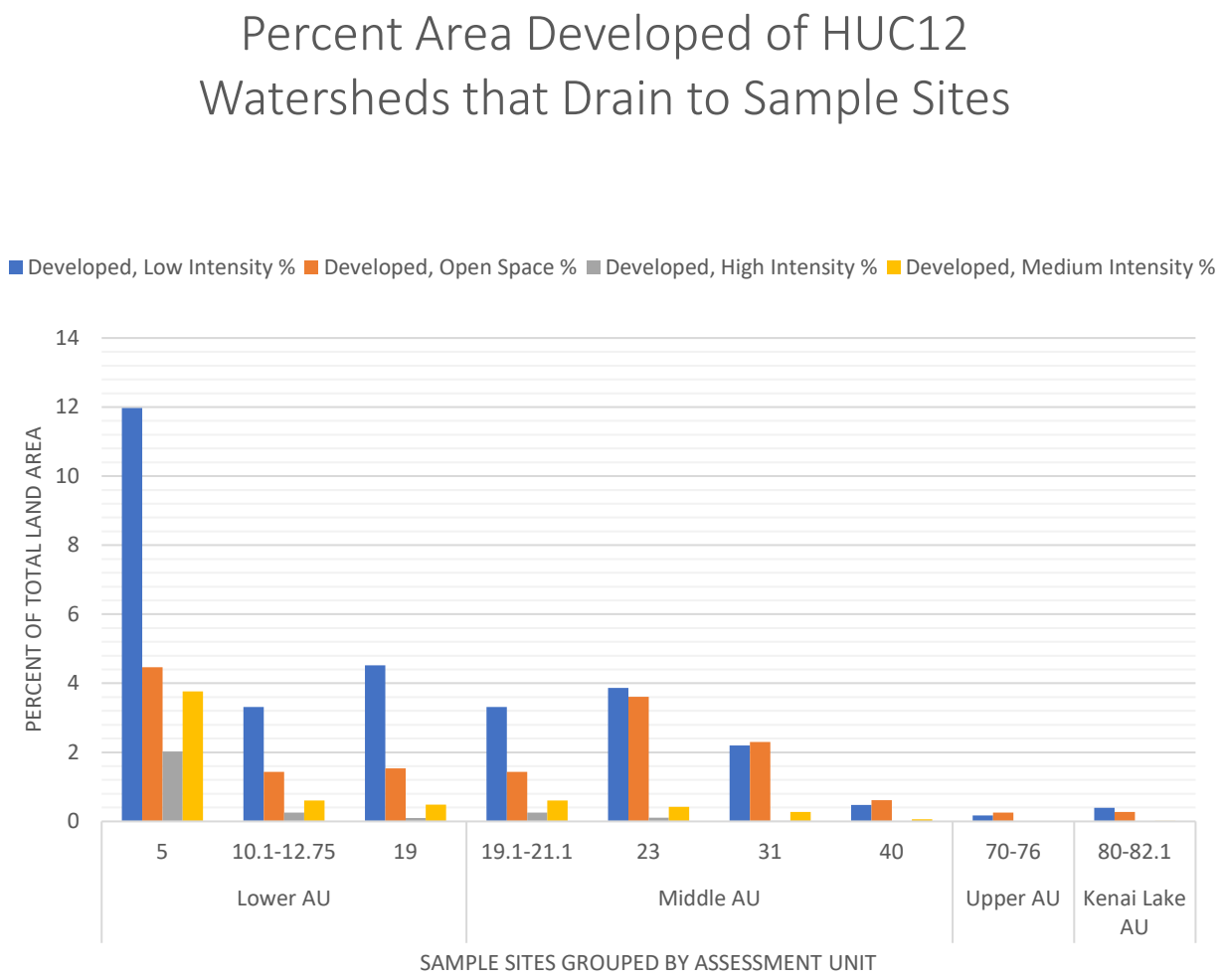

Figure B 1. Percent area developed using National Land Cover Data. Calculations include the HUC12 watershed that each sample site is in and the HUC12 watersheds connected by drainage. Sites are grouped into assessment units; lower, middle, upper, and Kenai Lake.

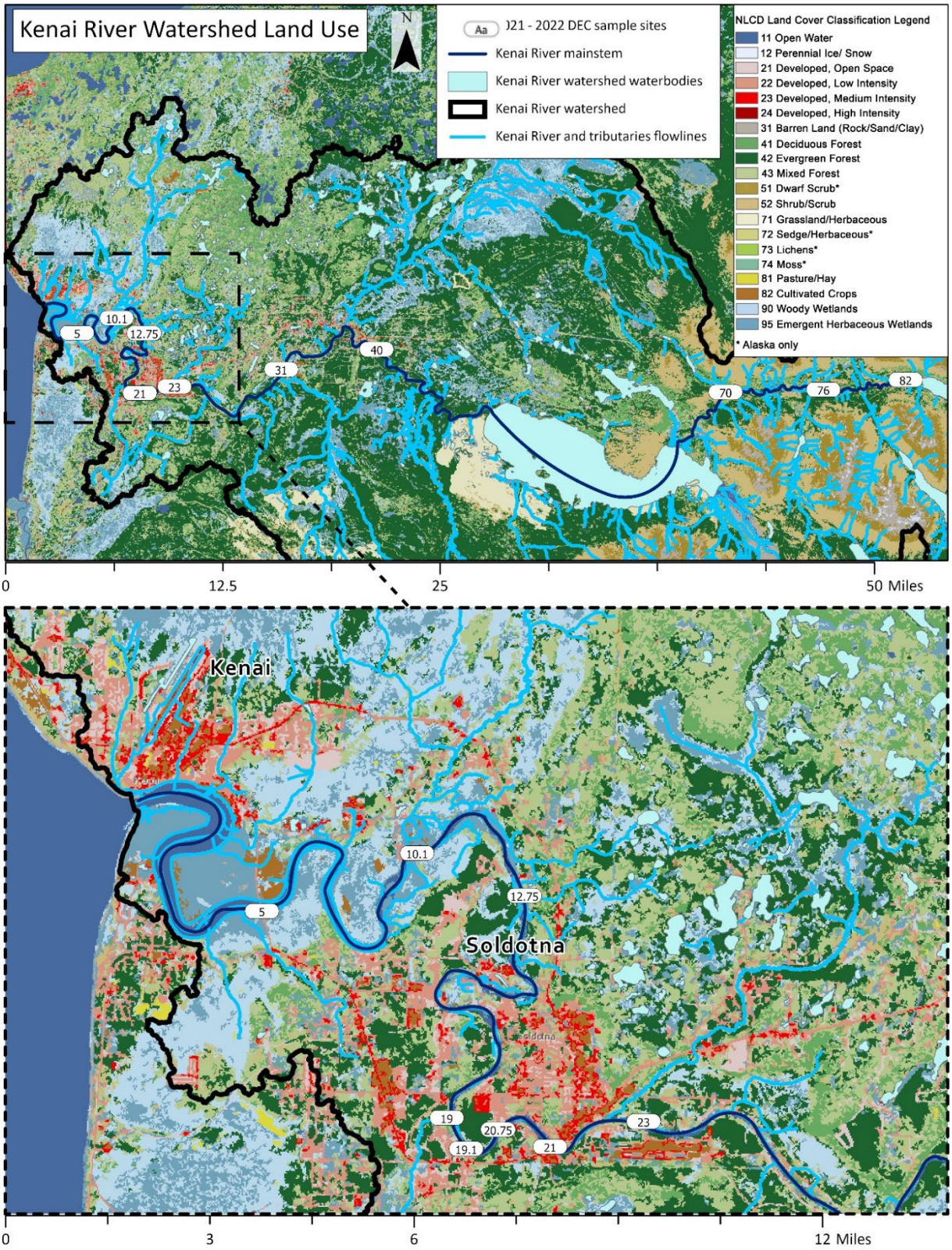

Figure B 2. The Kenai River watershed overlayed with land use polygons. The upper chart shows the entirety of the Kenai River mainstem. The lower chart zooms in the lower 23 river miles.

The number of road miles was highest in the lower and middle AUs, but the number of actual bridge crossings was highest in the upper and Kenai Lake AUs (Figure B.3). Bridge crossings include culverts, and smaller bridge structures within the HUC12 watershed (Figure B.4).

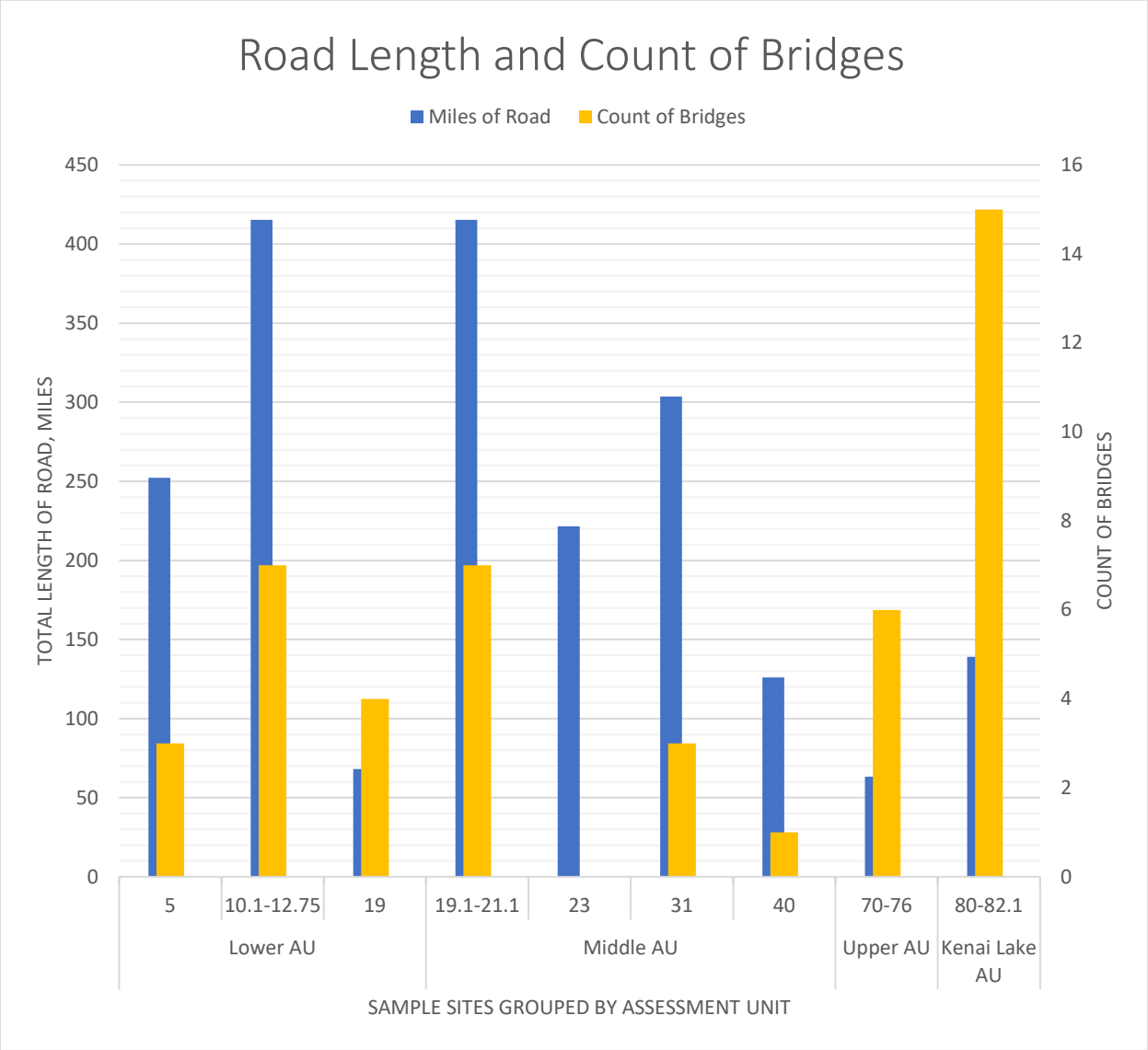

Figure B 3. Total road length in miles and count of bridges per sample site HUC12s connected by drainage.

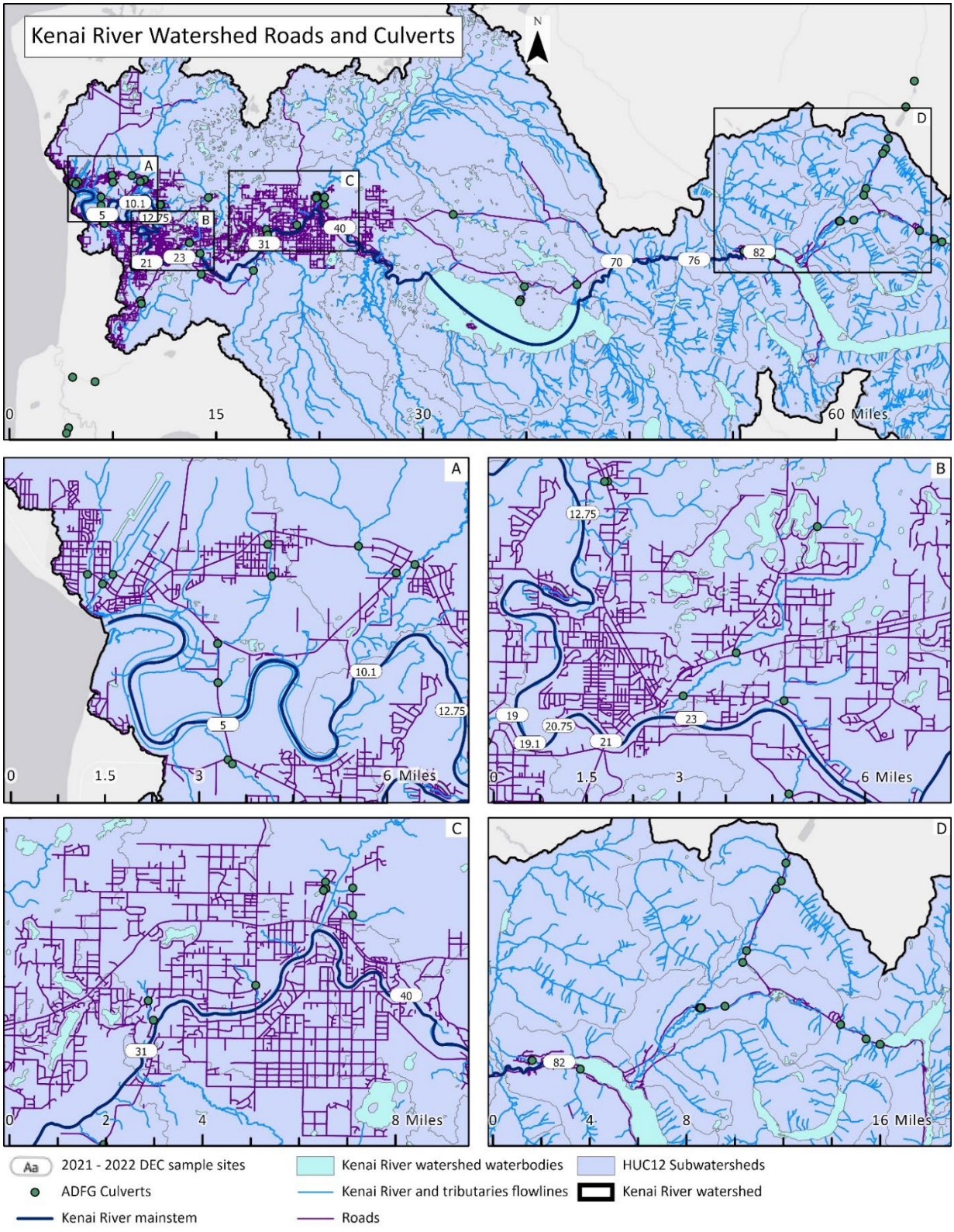

Figure B 4. Roads and road crossings within the Kenai River watershed.

An overlay of historic (2000-2019) forest fires was also generated (Figure B.5) using shapefiles from the ACWA-19-02 project deliverable.

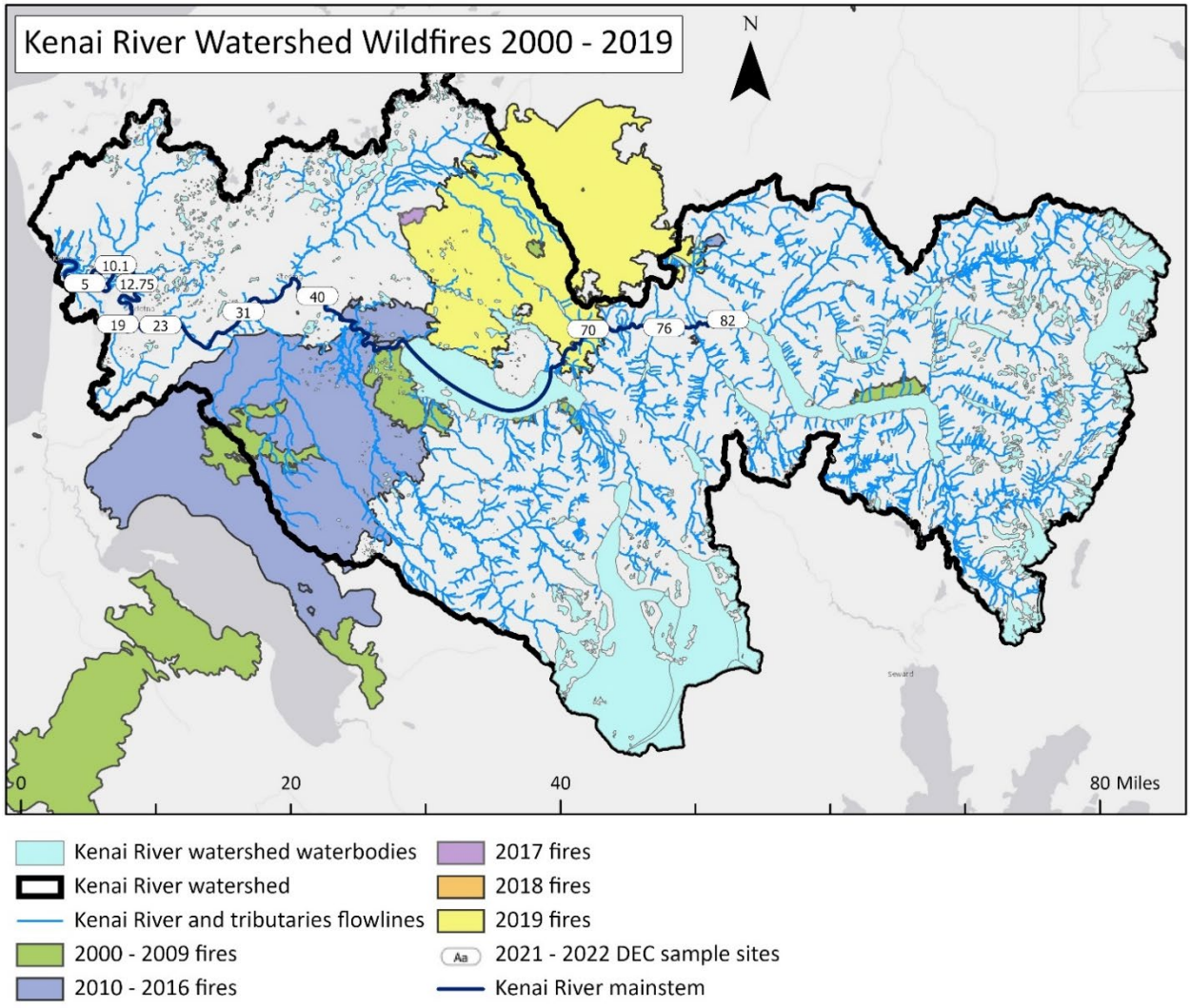

Figure B 5. Map of forest fires within the Kenai River watershed.

Appendix C: 2022 Data Review

2022 Dissolved Copper Summary

Table C. 1. Summary of dissolved copper (Cu) samples collected over the 2022 monitoring season. Sample sites are identified by river mile (RM) and are grouped by assessment units (AU). The average (Avg.), maximum (Max), minimum (Min), and standard deviation (St. Dev) of dissolved copper observed are provided. Table excludes rejected results and results from September 2022 (Event 14). See Appendix E for exclusion rationale.

Sample Locations by AU	Number of Samples Collected	Cu Avg. (µg/L)[12]	Cu Max (µg/L)	Cu Min (µg/L)	St. Dev (µg/L)
AK_L_2030212_001	2	1.5	1.5	1.5	0.0
RM 82	1	1.5	1.5	1.5	-
RM 82.1	1	1.5	1.5	1.5	-
AK_R_2020214_007	9	1.5	1.5	1.5	0.0
RM 70	5	1.5	1.5	1.5	0.0
RM 76	4	1.5	1.5	1.5	0.0
AK_R_2030218_002_001	13	1.6	3.2	1.5	0.5
RM 5	4	1.9	3.2	1.5	0.9
RM 10.1	4	1.5	1.5	1.5	0.0
RM 12.75	5	1.5	1.5	1.5	0.0
AK_R_2030218_002_002	32	1.6	5.3	1.5	0.7
RM 19.1	3	1.5	1.5	1.5	0.0
RM 20.75	4	1.5	1.5	1.5	0.0
RM 21	6	1.5	1.5	1.5	0.0
RM 21.1	5	1.5	1.5	1.5	0.0
RM 23	5	1.5	1.5	1.5	0.0
RM31	5	1.5	1.5	1.5	0.0
RM40	4	2.5	5.3	1.5	1.9
Slikok Creek	4	1.5	1.5	1.5	0.0

[12] When reported observed value was not detected, one half the limit of quantitation (0.5*LOQ, or 0.5*3 = 1.5 µg/L) was used for reporting purposes.

Sample Locations by AU	Number of Samples Collected	Cu Avg. (µg/L)[12]	Cu Max (µg/L)	Cu Min (µg/L)	St. Dev (µg/L)
RM 19	4	1.5	1.5	1.5	0.0
Total	**63**	**1.6**			

Table C. 2. Copper (Cu), both dissolved and total, and corresponding hardness (mg/L) observed during the 2022 monitoring season. The acute freshwater criteria for copper are also provided. Non-detects are presented as zeros. Relative percent difference (RPD) provided when RPD was greater than 10%.

RM	Hardness (mg/L)	Copper Dissolved (µg/L)	Copper Total (µg/L)	Acute Criteria	Result Condition
Event 9 - April 2022					
Field Blank	0	0	0	-	-
5	3880	169	153	422	Reject, RPD >10% (RPD=61%)
21	37.9	0	0	5	Below Acute Criteria
21.1	38.8	0	0	6	Below Acute Criteria
31	42.3	0	3.58	6	Below Acute Criteria
70	53.1	9.7	0	7	Reject, RPD >10% (RPD=98%)
Event 10 - May 2022					
Field Blank	0	0	0	-	-
5	52.3	3.2	0	7	Below Acute Criteria
10.1	39.8	0	5.5	6	Below Acute Criteria
12.75	39	0	0	6	Below Acute Criteria
19	36.4	0	0	5	Below Acute Criteria
19.1	37.5	0	0	5	Reject, RPD >10% (RPD=174%)
20.75	38.8	0	0	6	Below Acute Criteria
21	38.2	0	0	5	Below Acute Criteria
21.1	37.6	0	0	5	Below Acute Criteria

RM	*Hardness (mg/L)*	*Copper Dissolved (µg/L)*	*Copper Total (µg/L)*	*Acute Criteria*	*Result Condition*
23	41.4	0	0	6	Below Acute Criteria
31	42.9	0	0	6	Below Acute Criteria
40	38.3	5.3	0	5	Below Acute Criteria
70	52.2	0	0	7	Below Acute Criteria
76	50.5	0	0	7	Below Acute Criteria
82	50.6	0	0	7	Below Acute Criteria
82.1	144	0	22.7	19	Below Acute Criteria
Event 11 - June 2022					
Field Blank	0	0	0	-	-
5	46.2	0	4.43	6	Below Acute Criteria
10.1	37.9	0	0	5	Below Acute Criteria
12.75	38	0	0	5	Below Acute Criteria
19	68.2	0	0	9	Below Acute Criteria
19.1	37.2	0	0	5	Below Acute Criteria
20.75	37.2	0	0	5	Below Acute Criteria
21	37.6	0	0	5	Below Acute Criteria
21.1	37.7	0	0	5	Below Acute Criteria
23	38.1	0	0	5	Below Acute Criteria
31	39.2	0	0	6	Below Acute Criteria
40	37.2	0	0	5	Below Acute Criteria
70	48.5	0	0	7	Below Acute Criteria
76	48	0	0	7	Below Acute Criteria
Event 12 - July 2022					
Field Blank	0	0	0	-	-
5	42.3	0	0	6	Below Acute Criteria
10.1	40.5	0	0	6	Below Acute Criteria

RM	*Hardness (mg/L)*	*Copper Dissolved (µg/L)*	*Copper Total (µg/L)*	*Acute Criteria*	*Result Condition*
12.75	39.8	0	0	6	Below Acute Criteria
19	60	0	0	8	Below Acute Criteria
19.1	44.8	0	0	6	Below Acute Criteria
20.75	40	0	0	6	Below Acute Criteria
21	35.8	0	0	5	Below Acute Criteria
21.1	36.6	0	0	5	Below Acute Criteria
23	40	0	0	6	Below Acute Criteria
31	40.8	0	0	6	Below Acute Criteria
40	39.5	0	0	6	Below Acute Criteria
70	49.7	0	0	7	Below Acute Criteria
76	49.4	0	0	7	Below Acute Criteria
Event 13 - August 2022					
Field Blank	0	0	0	-	-
5	44	0	7.73	6	Below Acute Criteria
10.1	38.9	0	15.2	6	Below Acute Criteria
12.75	39.4	0	0	6	Below Acute Criteria
19	69.7	0	4.94	10	Below Acute Criteria
19.1	38.8	0	0	6	Below Acute Criteria
20.75	39	0	0	6	Below Acute Criteria
21	38.6	0	0	5	Below Acute Criteria
21.1	39	0	0	6	Below Acute Criteria
23	39.7	0	4.13	6	Below Acute Criteria
31	39	0	3.62	6	Below Acute Criteria
40	38	0	3.08	5	Below Acute Criteria
70	48.5	0	0	7	Below Acute Criteria
76	48.4	0	7.39	7	Below Acute Criteria

RM	*Hardness (mg/L)*	*Copper Dissolved (µg/L)*	*Copper Total (µg/L)*	*Acute Criteria*	*Result Condition*
Event 14 - September 2022					
Event Rejected - See Appendix E					
Event 15 - November 2022[13]					
Field Blank	0	0	0	-	-
12.75	37.2	0	0	5	Below Acute Criteria
21	35.9	0	0	5	Below Acute Criteria
23	36.6	0	0	5	Below Acute Criteria
70	45.6	0	0	6	Below Acute Criteria

[13] November samples (Event 15) were cross verified at the State of Alaska Environmental Health Lab (EH Lab).

2022 Dissolved Zinc Summary

Table C. 3. Summary of dissolved zinc (Zn) samples collected over the 2022 monitoring season. Sample sites are identified by river mile (RM) and are grouped by assessment units (AU). The average (Avg.), maximum (Max), minimum (Min), and standard deviation (St. Dev) of dissolved zinc observed are provided. Table excludes results from May 2022 (Event 10), July (Event 12), August (Event 13), and September 2022 (Event 14). See Table C.2 and Appendix E for exclusion rationale.

Sample Locations by AU	*Number of Samples Collected*	***Zn Avg. (µg/L)[14]***	***Zn Max (µg/L)***	***Zn Min (µg/L)***	***St. Dev (µg/L)***
AK_R_2020214_007	3	9.1	17.3	5.0	7.1
RM 70	2	5.0	5.0	5.0	0.0
RM 76	1	17.3	17.3	17.3	-
AK_R_2030218_002_001	5	13.4	46.9	5.0	18.7
RM 5	2	26.0	46.9	5.0	29.6
RM 10.1	1	5.0	5.0	5.0	-
RM 12.75	2	5.0	5.0	5.0	0.0
AK_R_2030218_002_002	12	5.5	10.5	5.0	1.6
RM 19.1	1	5.0	5.0	5.0	-
RM 20.75	1	5.0	5.0	5.0	-
RM 21	3	6.8	10.5	5.0	3.2
RM 21.1	2	5.0	5.0	5.0	0.0
RM 23	2	5.0	5.0	5.0	0.0
RM 31	2	5.0	5.0	5.0	0.0
RM 40	1	5.0	5.0	5.0	-
Slikok Creek	1	5.0	5.0	5.0	-
RM 19	1	5.0	5.0	5.0	-
Total	**21**	**8.2**			

[14] When reported observed value was not detected, one half the limit of quantitation (0.5*LOQ, or 0.5*10 = 5.0 µg/L) was used for reporting purposes.

Table C. 4. Zinc (Zn), both dissolved and total, and corresponding hardness (mg/L) observed during the 2022 monitoring season. The acute freshwater criteria for zinc are also provided. Non-detects are presented as zeros. November samples were cross verified at the State of Alaska Environmental Health Lab (EH Lab) and are designated as such.

RM	Hardness (mg/L)	Zinc Dissolved (µg/L)	Zinc Total (µg/L)	Acute Criteria	Result Condition	Note
Event 9 - April 2022						
Field Blank	0	0	0	-	-	-
5	3880.0	46.9	30.9	2600.6	Below Acute Criteria	Hardness suggests marine water intrusion
21	37.9	0	0	51.5	Below Acute Criteria	-
21.1	38.8	0	0	52.5	Below Acute Criteria	-
31	42.3	0	0	56.5	Below Acute Criteria	-
70	53.1	0	0	68.5	Below Acute Criteria	-
Event 10 - May 2022						
Field Blank	0	138	0	-	Reject all May 2022, questionable blank -	
5	52.3	107	0	67.7	Reject, total zinc non-detect	
10.1	39.8	77.4	0	53.7	Reject, total zinc non-detect, RPD>10% (83%)	
12.75	39.0	105	0	52.8	Reject, total zinc non-detect	
19	36.4	148	0	49.8	Reject, total zinc non-detect	
19.1	37.5	117	0	51.0	Reject, total zinc non-detect, RPD>10% (105%)	
20.75	38.8	57.7	0	52.5	Reject, total zinc non-detect, RPD>10% (71%)	
21	38.2	128	0	51.8	Reject, total zinc non-detect	
21.1	37.6	130	0	51.2	Reject, total zinc non-detect	
23	41.4	125	0	55.5	Reject, total zinc non-detect	
31	42.9	108	0	57.2	Reject, total zinc non-detect	

RM	*Hardness (mg/L)*	*Zinc Dissolved (µg/L)*	*Zinc Total (µg/L)*	*Acute Criteria*	*Result Condition*	*Note*
40	38.3	120	0	52.0	Reject, total zinc non-detect	
70	52.2	132	0	67.6	Reject, total zinc non-detect	
76	50.5	120	0	65.7	Reject, total zinc non-detect	
82	50.6	151	0	65.8	Reject, total zinc non-detect, RPD>10% (96%)	
82.1	144.0	99.9	52.5	159.6	Reject, questionable field blank	
Event 11 - June 2022						
Field Blank	0	0	0	-	-	
5	46.2	0	15.1	60.9	Below Acute Criteria	
10.1	37.9	0	0	51.5	Below Acute Criteria	
12.75	38.0	0	0	51.6	Below Acute Criteria	
19	68.2	0	0	84.7	Below Acute Criteria	
19.1	37.2	0	0	50.7	Below Acute Criteria	
20.75	37.2	0	0	50.7	Below Acute Criteria	
21	37.6	10.5	0	51.2	Below Acute Criteria	
21.1	37.7	0	0	51.3	Below Acute Criteria	
23	38.1	0	0	51.7	Below Acute Criteria	
31	39.2	0	0	53.0	Below Acute Criteria	
40	37.2	0	0	50.7	Below Acute Criteria	
70	48.5	0	0	63.5	Reject, RPD>10% (101%)	
76	48.0	17.3	0	62.9	Below Acute Criteria	
Event 12 - July 2022						
Field Blank	0	86.8	62.3	-	Reject, questionable field blank	
5	42.3	10.5	58.2	56.5	Reject, questionable field blank, PRD>10% (60%)	
10.1	40.5	31.1	136	54.5	Reject, questionable field blank, RPD>10% (20%)	
12.75	39.8	53.8	127	53.7	Reject, questionable field blank	

RM	*Hardness (mg/L)*	*Zinc Dissolved (µg/L)*	*Zinc Total (µg/L)*	*Acute Criteria*	*Result Condition*	*Note*
19	60.0	36.2	68.4	76.0	Reject, questionable field blank	
19.1	44.8	42.0	96.8	59.3	Reject, questionable field blank	
20.75	40.0	28.5	117	53.9	Reject, questionable field blank	
21	35.8	39.4	29.3	49.1	Reject, questionable field blank	
21.1	36.6	0	0	50.0	Reject, questionable field blank	
23	40.0	50.6	89.8	53.9	Reject, questionable field blank	
31	40.8	28.6	54.3	54.8	Reject, questionable field blank	
40	39.5	50.7	45.4	53.3	Reject, questionable field blank	
70	49.7	41.2	94.4	64.8	Reject, questionable field blank	
76	49.4	0	0	64.5	Reject, questionable field blank, RPD>10% (154%)	
Event 13 - August 2022						
Field Blank	0	58.9	123	-	Reject, questionable field blank	
5	44.0	39.0	70.1	58.4	Reject, questionable field blank	
10.1	38.9	23.1	59.5	52.7	Reject, questionable field blank	
12.75	39.4	43.3	49.5	53.2	Reject, questionable field blank, RPD>10% (14%)	
19	69.7	50.3	69.9	86.3	Reject, questionable field blank	
19.1	38.8	39.2	45.9	52.5	Reject, questionable field blank	
20.75	39.0	49.3	72.4	52.8	Reject, questionable field blank	
21	38.6	45.6	62.7	52.3	Reject, questionable field blank, RPD>10% (10.1%)	
21.1	39.0	47.8	108	52.8	Reject, questionable field blank Below Acute Criteria	
23	39.7	52.8	60.8	53.6	Reject, questionable field blank, RPD>10% (52%)	
31	39.0	31.6	73	52.8	Reject, questionable field blank, RPD>10% (22%)	

RM	*Hardness (mg/L)*	*Zinc Dissolved (µg/L)*	*Zinc Total (µg/L)*	*Acute Criteria*	*Result Condition*	*Note*
40	38.0	36.6	59.6	51.6	Reject, questionable field blank	
70	48.5	51.4	65.3	63.5	Reject, questionable field blank	
76	48.4	47.1	50.3	63.4	Reject, questionable field blank	
Event 14 - September 2022						
Event Rejected - See Appendix E						
Event 15 - November 2022						
Field Blank	0	0	1.5	-	-	Samples cross verified by EH Lab
12.75	37.2	0	0	50.7	Below Acute Criteria	Samples cross verified by EH Lab
21	35.9	0	0	49.2	Below Acute Criteria	Samples cross verified by EH Lab
23	36.6	0	0	50.0	Below Acute Criteria	Samples cross verified by EH Lab
70	45.6	0	0	60.2	Below Acute Criteria	Samples cross verified by EH Lab

RPD Summary Tables

Table C. 5. Relative Percent Difference (RPD) summary for the 2022 field season of the 2021-2022 Kenai River Water Quality Monitoring project.

	PRD > 20%			RPD >10%		
Filtered, Dissolved	**False (Pass)**	**True (Fail)**	**% Pass**	**False (Pass)**	**True (Fail)**	**% Pass**
Aluminum	17	11	61%	14	14	50%
Cadmium	28		100%	28		100%
Calcium	24	4	86%	24	4	86%
Copper	22	6	79%	22	6	79%
Lead	27	1	96%	27	1	96%
Magnesium	24	4	86%	23	5	82%
Organic carbon	23	1	96%	23	1	96%
Potassium	25	3	89%	24	4	86%
Selenium	28		100%	28		100%
Sodium	23	5	82%	22	6	79%
Total dissolved solids	24	4	86%	16	12	57%
Zinc	17	11	61%	13	15	46%
Unfiltered, Total						
Calcium	28		100%	28		100%
Copper	23	5	82%	22	6	79%
Hardness, carbonate	28		100%	28		100%
Magnesium	28		100%	28		100%
Zinc	19	9	68%	18	10	64%

AquaTroll Summary Table

Table C. 6. Summary of AquaTroll performance based on the troll output file during each sample event.

Date	RM	Parameter	Comment	Action
4/19/2022	5	NA	No issues	
	21.1	NA	No issues	
	21	NA	No issues	
	31	NA	No issues	
	70	Turbidity	Failed to record	**Reject Turbidity**
5/17/2022	5	NA	No issues	
	10.1	NA	No issues	
	12.75	NA	No issues	
	19.1	NA	No issues	

	19	NA	No issues	
	20.75	NA	No issues	
	21.1	Turbidity	First min of recording elevated	No action
	21	NA	No issues	
	23	NA	No issues	
	31	NA	No issues	
	40	GPS	No GPS recording	Use site Lat/Long
	70	GPS	No GPS recording	Use site Lat/Long
	76	Turbidity, GPS	Readings not recorded for 17/156 recordings. No GPS	**Reject Turbidity**
	82.1	GPS	No GPS recording	Use site Lat/Long
	82	Turbidity	Last 3 min of recording not recorded	**Reject Turbidity**
6/13/2022	5	NA	No issues	
	10.1	NA	No issues	
	12.75	NA	No issues	
	19.1	Turbidity	8/77 readings not recorded	No action
	19	Turbidity	Large spike in reading at min 3 - **Reject**	**Reject Turbidity**
	20.75	Turbidity	54/213 readings not recorded	No action
	21.1	NA	No issues	
	21	NA	No issues	
	23	NA	No issues	
	31	NA	No issues	
	40	GPS	No GPS recording	No action
	70	GPS	No GPS recording	Use site Lat/long
	76	Turbidity	1/154 readings not recorded	No action
7/19/2022	5	GPS	No GPS for first 3 min	Use site Lat/Long
	10.1	Turbidity	2/194 readings not recorded	No action
	12.75	Turbidity, GPS	70/151 recordings not recorded. Range outside normal	**Reject Turbidity**
	19.1	Turbidity	Missing values. Range outside normal	**Reject Turbidity**
	19	GPS	GPS missing	Use site Lat/Long
	20.75	Turbidity	Missing values. Range outside normal	**Reject Turbidity**
	21.1	NA	No issues	
	21	NA	No issues	
	23	NA	No issues	
	31	NA	No issues	

	40	GPS	GPS missing	Use site Lat/Long
	70	GPS	GPS missing	Use site Lat/Long
	76	GPS	GPS missing	Use site Lat/Long
8/15/2022	5	NA	No issues	
	10.1	NA	No issues	
	12.75	Turbidity	5/199 not recorded	No action
	19.1	Turbidity	11/416 not recorded. Values outside normal range	**Reject Turbidity**
	19	NA	No issues	
	20.75	Turbidity	5 readings not recorded. Values outside normal range.	**Reject Turbidity**
	21.1	NA	No issues	
	21	NA	No issues	
	23	NA	No issues	
	31	GPS	GPS missing	Use site Lat/Long
	40	GPS	GPS missing	Use site Lat/Long
	70	GPS	GPS missing	Use site Lat/Long
	76	GPS	GPS missing	Use site Lat/Long
9/06/2022	5	NA	No issues	
	10.1	NA	No issues	
	12.75	NA	No issues	
	19.1	NA	No issues	
	19	NA	No issues	
	20.75	NA	No issues	
	21.1	NA	No issues	
	21	NA	No issues	
	23	NA	No issues	
	31	GPS	GPS missing	Use site Lat/Long
	40	NA	No issues	
	70	GPS	GPS missing	Use site Lat/Long
	76	GPS	GPS missing	Use site Lat/Long
	82.1	GPS	GPS missing	Use site Lat/Long
	82	GPS	GPS missing	Use site Lat/Long
11/03/2022	12.75	Density	Density not recorded	No action – density not entered in AWQMS
	21	NA	No issues	
	23	NA	No issues	
	70	Density	Density not recorded	No action – density not entered in AWQMS

Appendix D: Relative Percent Difference Forward by ADEC

Forward: Precision and Relative Percent Difference in the 2017-2019 Multi-Agency Baseline Monitoring Dataset

Alaska Department of Environmental Conservation

August 2022

In late 2019 the Alaska Department of Environmental Conservation (ADEC) evaluated a subset of water quality data from the Kenai River for inclusion in the 2020 Integrated Report. The subset of data was sourced from the Kenai River Multi-Agency Baseline Monitoring program (hereafter referred to as Baseline), managed by the Kenai Watershed Forum. The data covered a period from 2107 to 2019 and included dissolved metals (As, Cd, Cr, Cu, Pb, and Zn), total metals (Ca, Mg, and Fe), nutrients (N and P), and pathogens from 13 sites along the Kenai River and 9 sites in tributaries.

Quality control thresholds were outlined for the Baseline program in a series of Quality Assurance Project Plans (QAPPs). Starting in the 2012 QAPP[15], a minimum of 10% of the field samples were required to have a paired duplicate (QA) sample. These QA samples would be collected during both the spring and summer sampling events. Also, the replicate sample(s) would be rotated among the 7 monitoring teams (see pg. 31, KWF 2012). Precision was to be evaluated by calculating the relative percent difference (RPD) between a routine sample and its QA sample. The RPD was not to exceed 20% for dissolved metals (pg. 14-18, of KWF 2012). RPD is defined as follows:

$$RPD = \frac{(A - B)}{(A + B)/2} * 100$$

Where A is the routine sample and B is the duplicate, or QA sample (KWF 2012).

A standard quality assurance evaluation of the Baseline data revealed that dissolved zinc and copper data did not meet the quality control thresholds set for the project. Between 2007 and 2009, 67% (6 of 9) of the paired QA samples for dissolved zinc exceeded the 20% RPD (Table 1), and 56% (5 of 9) exceeded for copper. It was also noted that the number of QA samples was insufficient (<10% of samples) to evaluate dissolved metals in the Kenai River mainstem for multiple years because a significant number of QA samples were collected at tributary sites and were not representative of the mainstem.

Dissolved cadmium, chromium, arsenic, and lead data from the 2017-2019 Baseline dataset were accepted for inclusion in the IR by ADEC. The RPD percent failure for cadmium and chromium results were 0% and 10% respectively. Arsenic and lead results both had RPD failures of 30%, however the observed values were an order of magnitude less than the applicable

[15] The 2012 and 2019 QAPP were applied to the 2017-2019 dataset provided.

water quality criteria (18 AAC 70) and were therefore accepted. The cadmium, chromium, arsenic, and lead data will be uploaded to the EPA Water Quality Exchange (WQX).

Based on the frequency of RPD exceedance in the 2017-2019 data, it was determined that dissolved zinc and copper results from the 2017-2019 dataset could not be included in the 2020 IR. This decision was made after the ADEC QA officer reviewed the data, and the ADEC WQSAR Program Manager discussed the data issues with the Region 10 EPA lead.

Table D.1. Relative percent difference (RPD) for routine samples and their paired duplicate sample for the Kenai River Multi-Agency Baseline Monitoring Program from 2017-2020. Non-detects (ND) are indicated. One half of the lab provided method detection limit was substituted for ND's for RPD calculations. RPDs greater than 20 percent failed to meet data quality objectives.

DATE	RM	Name	Type	Zn (ug/l) Routine	Zn (ug/l) Duplicate	RPD	>20
4/25/2017	0	No Name Creek	Tributary	82	110	29%	Yes
7/25/2017	1.5	City Dock	Mainstem	39	44	12%	No
7/25/2017	36	Moose River	Tributary	15	46	102%	Yes
4/24/2018	1.5	City Dock	Mainstem	51	76	39%	Yes
4/24/2018	19	Slikok Creek	Tributary	60	95	45%	Yes
7/31/2018	0	No Name Creek	Tributary	157	123	24%	Yes
4/30/2019	1.5	City Dock	Mainstem	89.9	110	20%	No
4/30/2019	19	Slikok Creek	Tributary	74.4	ND	192%	Yes
7/30/2019	0	No Name Creek	Tributary	5.53	5.31	4%	No
% Of paired samples with RPD >20%							**67%**

In 2021 ADEC initiated a two-year ambient water quality monitoring project on the Kenai River. The primary objective of this project was to evaluate dissolved zinc and copper levels on the Kenai River mainstem. The secondary objective was to incorporate additional quality assurance procedures to evaluate sampling methods for potential sources of contamination. The ADEC monitoring project incorporated 'clean hands, dirty hands' (EPA 1996) methods, field blanks, more frequent QA samples (4 per sampling event, i.e., >20% frequency), and the inclusion of total zinc and copper analysis. This project is ongoing, and a final report is expected in 2023. A 2021 field report is available on the ADEC website (see ADEC 2021).

References

ADEC. 2021 Kenai River Water Quality Monitoring. Prepared by S. Apsens and J. Petitt. Alaska Department of Environmental Conservation, Division of Water, Soldotna, AK. 36 pg.

EPA. 1996. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division, Washington D.C. 39 pg.

KWF. 2012. Quality Assurance Project Plan: Kenai River Watershed Monitoring Program. 2nd edition. Prepared for the State of Alaska, Department of Environmental Conservation, Division of Water. 56 pg.

KWF. 2019. Quality Assurance Project Plan: Kenai River Watershed Monitoring Program. Version 2. Prepared for the State of Alaska, Department of Environmental Conservation, Division of Water. 70 pg.

Appendix E: September 2022 Quality Assurance Issue Summary

Introduction

The following section describes the rationale for rejecting water quality data collected during the September 2022 (event 14) sampling event. Water chemistry data from the September 2022 sampling event were not included in the analysis for the 2021-2022 Kenai River Waterbody Report.

Data Review

Copper and Zinc

Numerous quality assurance issues were noted after a routine in-season review of the laboratory reported dissolved and total copper results for the November 2022 (event 14) sampling event. The reported dissolved copper results were an order of magnitude different than the project average (avg. dissolved 1.6 µg/l, avg. total 1.86 µg/l, see Appendix C) (Table F.1). Also, no copper was detected in the corresponding total samples (Table F.2). Finally, 249 µg/l dissolved copper was detected in the associated field blank.

The reported results were indicative of possible sample contamination. The DEC Quality Assurance Officer was notified, and the lab project manager was contacted as well. DEC requested that the aliquots be sent to the State of Alaska Environmental Health Lab (EH) for an inter-lab sample split comparison using the same or equivalent methods.

Conclusion and Corrective Action

DEC ultimately decided to reject the water chemistry data collected during the September (Event 14) sampling event. This decision was based on multiple factors including the strong evidence of sample contamination. Though the copper results were the focus of the initial data QA investigation, it soon became clear that the zinc data were also unreliable. Only zinc and copper (dissolved and total) underwent multiple analyses due to costs. Other parameters (e.g., aluminum, cadmium, chromium, lead) were also rejected due to the overall uncertainty associated with the sample analysis for this event.

An additional field sampling event was scheduled to meet the data objectives for this project. This event occurred in November 2022. A subset of the project sites was sampled due to the presence of snow and poor weather conditions. The resulting water samples were sent to the contract laboratory for analysis and the aliquots were sent to EH for an intra-laboratory comparison. The resulting RPDs between the contract laboratory results and the EH results were acceptable. The November 2022 results were accepted and the data objectives for this project were achieved.

Recommendations Moving Forward

- All data should be reviewed shortly after receipt so that appropriate actions can be taken if necessary. This is important as laboratories are only required to hold aliquots for a limited period post initial analysis (e.g., two weeks).
- The inclusion of field blanks was key in identifying when and if potential sample contamination occurred. Projects analyzing water samples for copper and zinc, especially dissolved copper and zinc, should always include at least one field blank.

Appendix F: 2022 In Situ Field Measurements Summary

The following provides a summary of in situ measurements observed over the 2022 monitoring season. All tables and graphs exclude results rejected due to failing to meet quality assurance requirements (Appendix C).

Table F. 1. Average (Avg.) values for in situ parameters at each monitoring location during the 2022 season.

River Mile	Avg. Dissolved oxygen (DO) (mg/L)	Avg. pH	Avg. Salinity (PSU)	Avg. Specific conductance (µS/cm)	Avg. Temperature, water (C°)	Avg. Total Dissolved Solids (PPT)	Avg. Turbidity (NTU)
5	10.5	7.71	2.926	4986.0	10.2	3.240	186.82
10.1	10.6	7.78	0.034	75.8	10.3	0.049	30.37
12.75	10.8	7.82	0.033	73.7	9.1	0.048	101.49
19	10.1	7.39	0.052	113.1	10.0	0.073	7.01
19.1	10.7	7.78	0.030	67.2	10.3	0.043	21.95
20.75	10.7	7.53	0.030	67.7	10.2	0.043	78.21
21	11.3	7.31	0.034	76.0	8.5	0.049	35.74
21.1	11.3	7.56	0.034	75.8	9.2	0.049	23.64
23	10.8	7.45	0.035	77.2	9.6	0.050	25.86
31	11.0	7.51	0.035	78.5	9.1	0.051	21.47
40	10.8	7.45	0.033	73.6	10.7	0.047	18.91
70	11.4	7.72	0.044	97.0	7.6	0.063	5.70
76	11.0	7.61	0.043	93.1	9.4	0.060	2.73
82	11.7	7.44	0.043	93.3	7.8	0.061	5.40
82.1	11.8	7.63	0.043	95.5	7.9	0.062	2.63
Overall Avg.	10.9	7.58	0.259	458.8	9.4	0.298	37.86

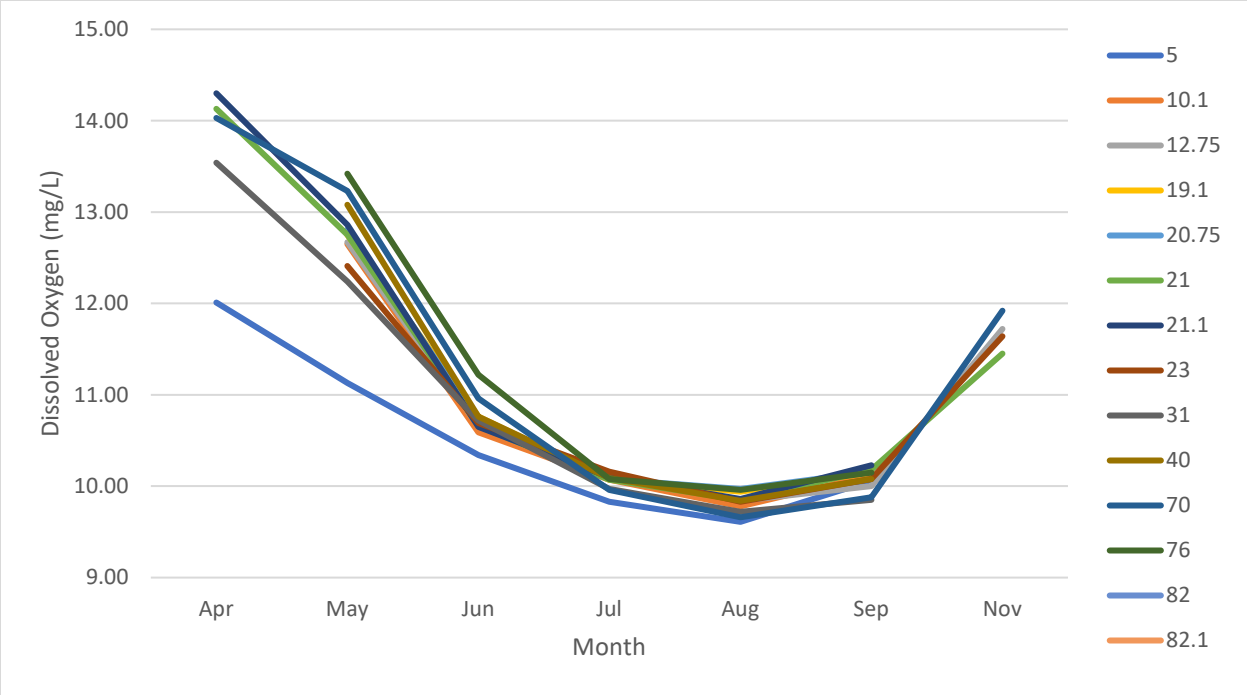

Figure F. 1. Dissolved oxygen (mg/L) observed over the 2022 monitoring season.

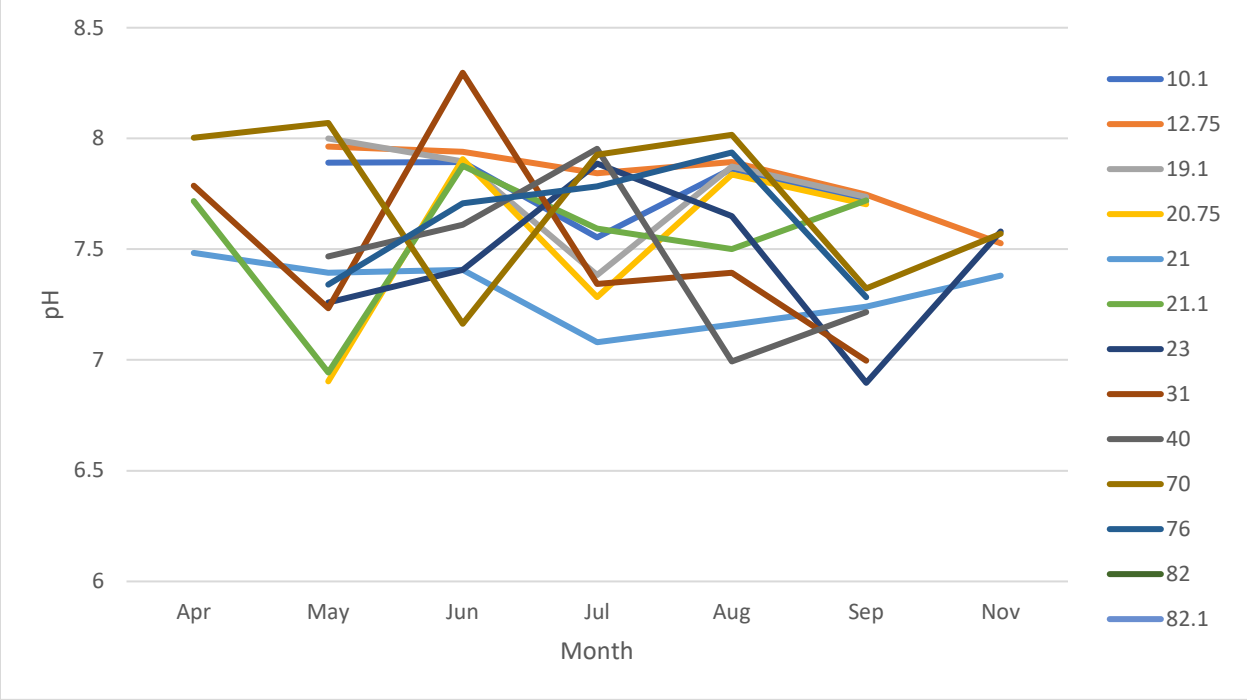

Figure F. 2. pH observed over the 2022 monitoring season.

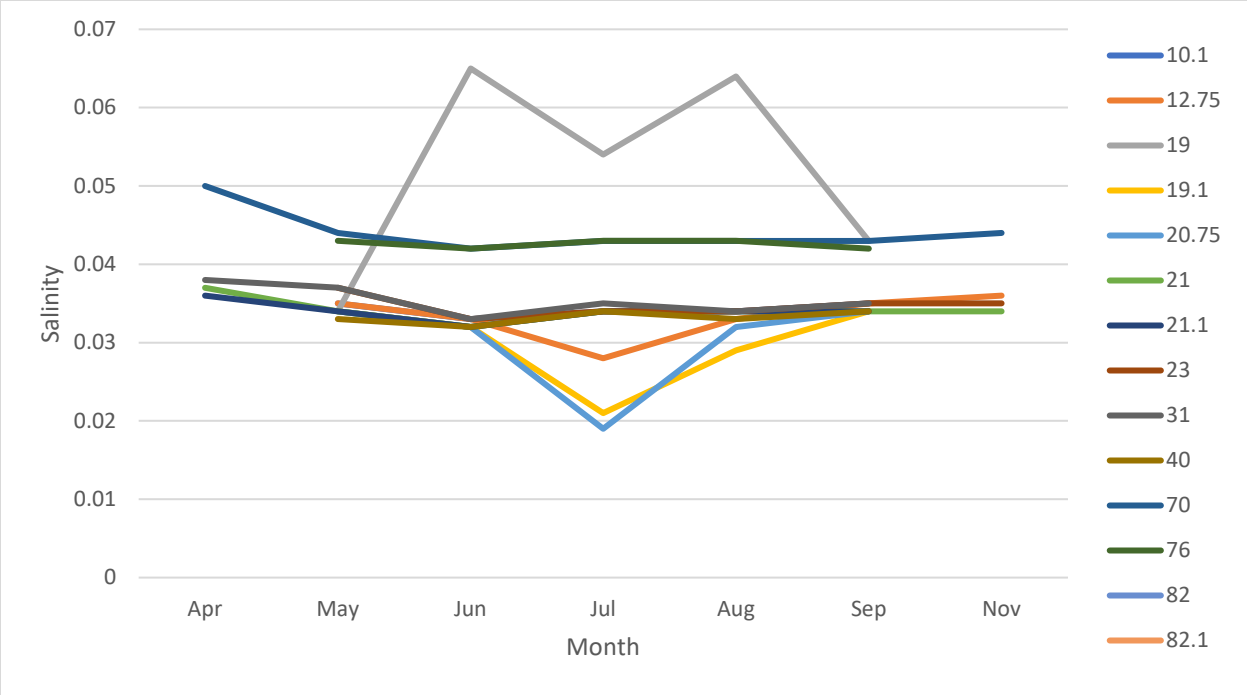

Figure F. 3. Salinity (PSU) observed over the 2022 monitoring season. Note that salinity observations from river mile 5 (Warren Ames Bridge) are excluded (observed maximum of 17.07 PSU).

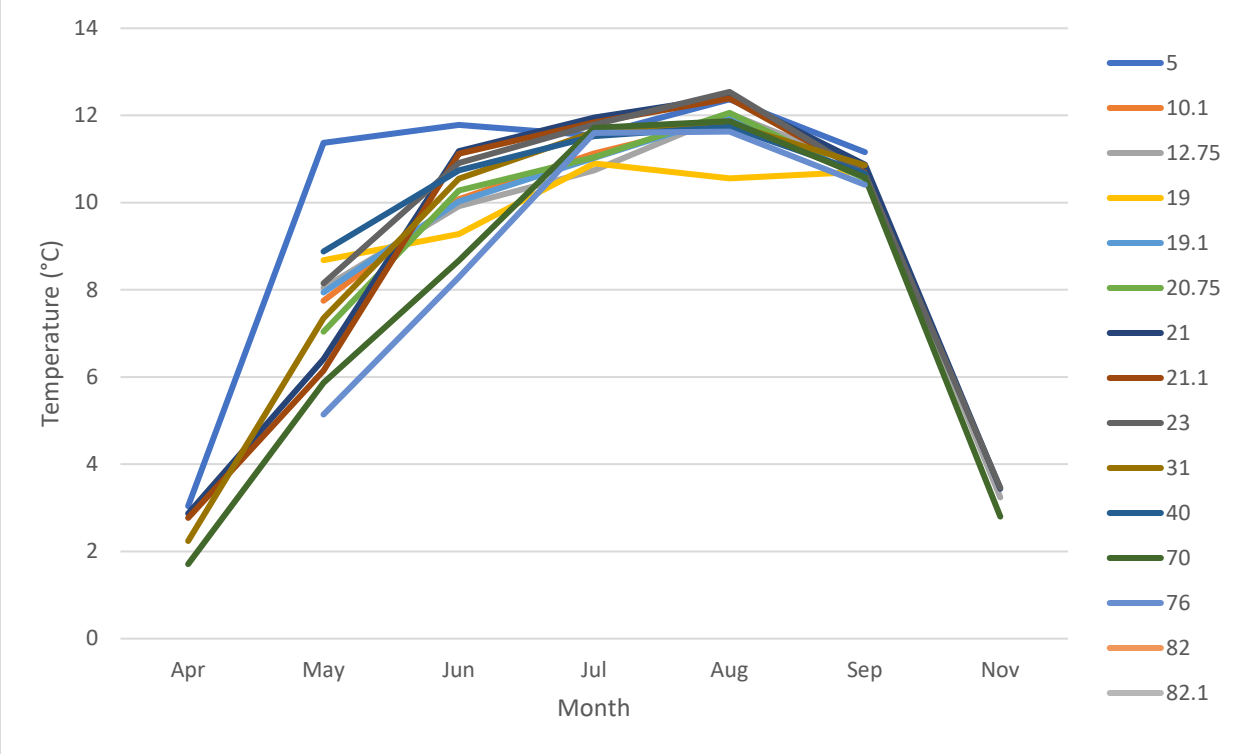

Figure F. 4. Water temperature (°C) observed over the 2022 monitoring season.

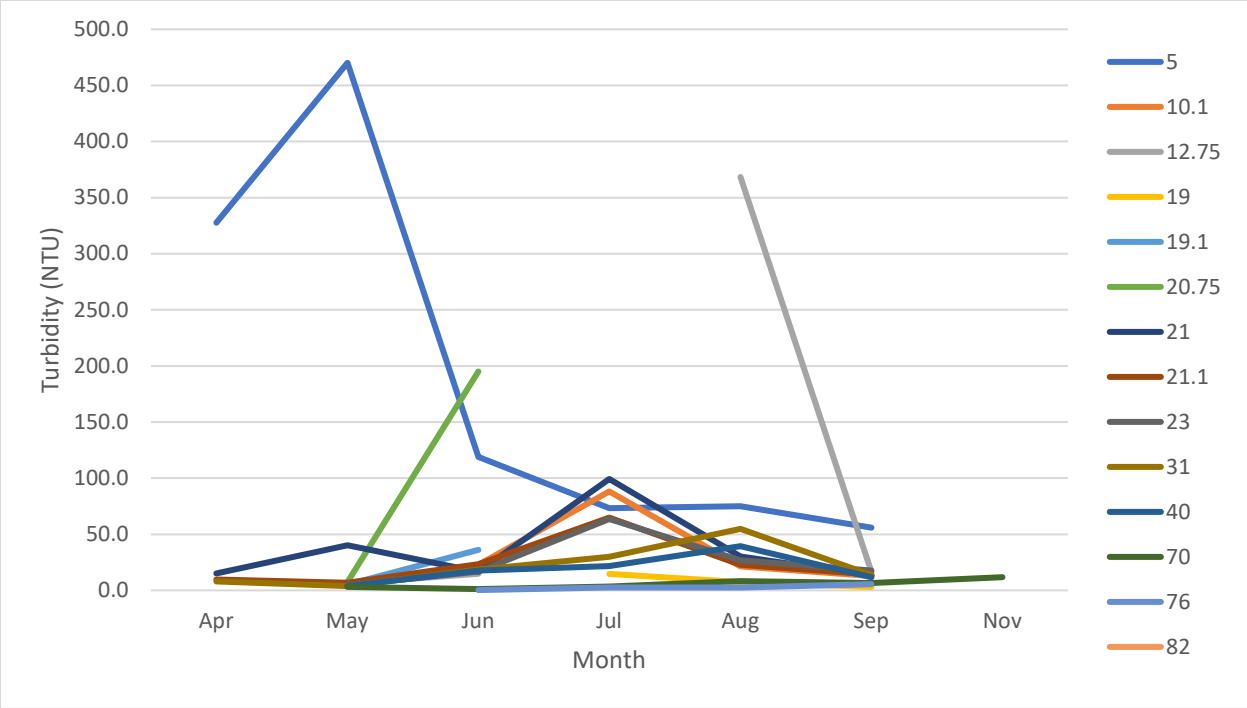

Figure F. 5. Turbidity (NTU) observed over the 2022 monitoring season.

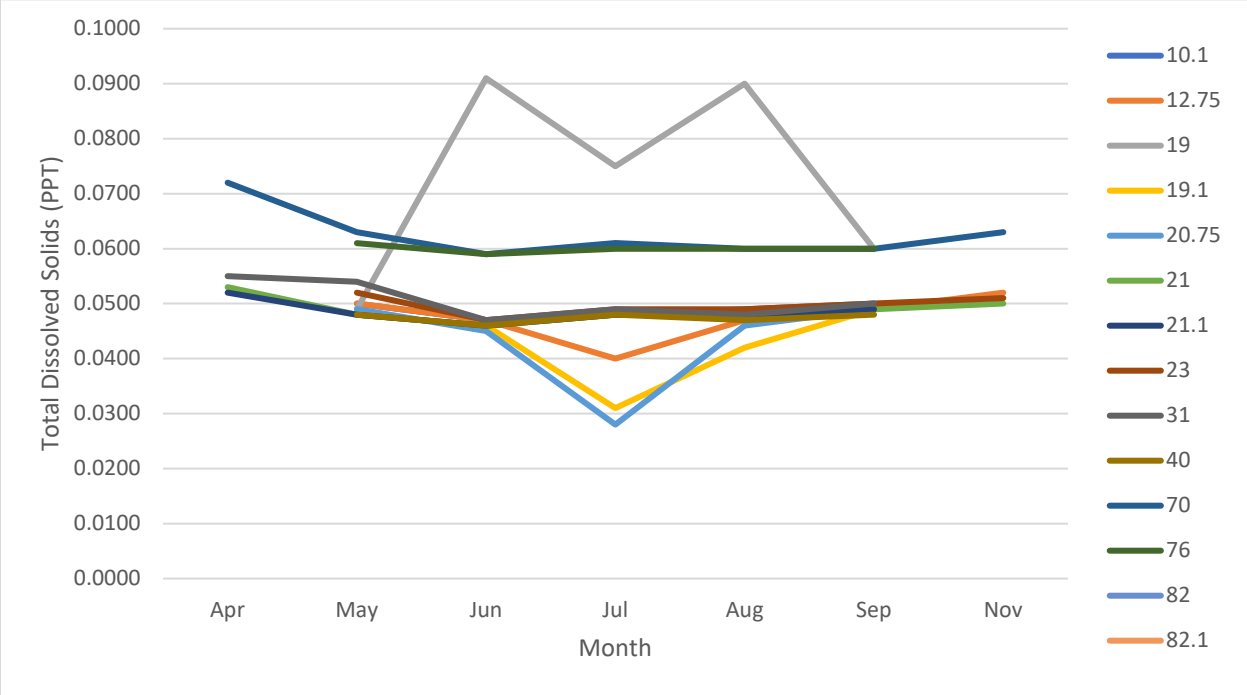

Figure F. 6. Total dissolved solids (PPT) observed over the 2022 monitoring season. Results from river mile 5 (Warren Ames Bridge) are excluded (observed maximum of 18.77 PPT).