Technical Report No. 24-02

Eklutna River Aquatic Habitat Monitoring – 2021-2023

by

Ron Benkert and Josh Brekken

January 2024

Alaska Department of Fish and Game **Habitat Section**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by the Divisions of Habitat, Sport Fish, and Commercial Fisheries. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figures or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)	
fork length	FL
mideye-to-fork	MEF
mideye-to-tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	$>$
greater than or equal to	$\geq$
harvest per unit effort	HPUE
less than	$<$
less than or equal to	$\leq$
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not detected	N
no data	ND
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Cover photo credit: Lower Eklutna River Just Upstream from the Deconstructed Dam

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Thank you all for your contribution.

EXECUTIVE SUMMARY

In collaboration with the Conservation Fund, Eklutna, Inc. completed deconstruction of the 60-foot high lower Eklutna River Dam in 2018. The deconstruction project was permitted, in part by the United States Army Corps of Engineers (USACE) which required Eklutna Inc. to collect a suite of pre- and post-project geomorphic and water quality data. These data were necessary to evaluate secondary effects of dam removal and sediment mobilization on the physical characteristics of the lower river for three years following dam removal. During Autumn of 2017, baseline data were collected describing channel geometry, substrate composition, and water quality at three monitoring locations downstream from the dam site. Year 1 (2018) of this monitoring project was completed by Eklutna Inc. in collaboration with the National Oceanographic and Atmospheric Administration (NOAA), the Native Village of Eklutna, and the Alaska Department of Fish and Game (ADF&G)–Habitat. In 2019, Eklutna Inc. contracted with the ADF&G–Habitat Section to complete the final two years of USACE required monitoring.

In 2021 ADF&G entered into an agreement with Trout Unlimited to continue the Eklutna River monitoring program for an additional three years. An additional monitoring location upstream of the old dam site, previously established in 2017, was added to the monitoring program for a total of four sites.

We conducted one sampling event each year in 2021, 2022, and 2023, visiting the four established monitoring locations. Two of these monitoring locations were downstream from the deconstructed dam site but upstream from the Thunder Bird Creek confluence; one site was downstream from Thunder Bird Creek; and one site was above the sediment plug upstream from the old dam site. At each of the sites, a suite of variables including channel geometry, substrate composition, and water quality were recorded.

At the monitoring site located above the deconstructed lower dam (Eklutna 2U) scouring of the bed was observed compared to the 2017 survey conducted prior to the lower dam deconstruction. There was a slight change in the channel dimensions at this location after the controlled flow releases in 2021. Between 2021 and 2023 there was a slight decrease in the D_{50} particle size after an increase in 2022 while the D_{84} particle size remained categorized as very coarse gravel. Particle sizes and channel dimensions were similar between 2022 and 2023. Water quality at this site were generally un-noteworthy, however pH was consistently high, ranging from 8.10 to 8.62. At monitoring site Eklutna 6 (site just below the deconstructed dam site), the channel aggraded nearly two feet in over half the channel between 2017 and 2023. More sand and gravel sized particles were observed in 2023 as compared to 2017. There was a slight increase in D_{50} substrate size but a slight decrease in D_{84} substrate composition. This is likely the result of the removal of the lower dam and controlled flow releases in the fall of 2021. No changes of note were observed between 2022 and 2023. Water quality at this site was generally un-noteworthy; however, pH was consistently high, ranging from 8.10 to 8.70.

At monitoring site Eklutna 8 (located just upstream from Thunder Bird Creek), the channel has aggraded over a foot between 2017 and 2023. Additional minor changes occurred after the controlled release. At this location it appears that both bed aggradation and subsequent scouring occurred. The overall channel substrate size increased with more gravel and cobbles present in the 2022 and 2023 surveys. Water quality at this site was generally un-noteworthy, but pH was elevated, ranging from 8.09 to 8.56.

All recorded variables from the monitoring site downstream from the Thunder Bird Creek confluence (Eklutna 10) generally remained stable throughout the monitored period. This is likely due to Thunder Bird Creek providing additional flow into this reach that leads to more dynamic bedload transport at the site. The pH levels were elevated however, ranging from 7.95 to 8.68.

INTRODUCTION

The Eklutna River flows approximately 32 kilometers [km (20 miles)] from the Eklutna Glacier in the Chugach Mountains through Eklutna Lake and into Cook Inlet near the Native Village of Eklutna (NVE) (Figure 1). Thunder Bird Creek is the only major tributary to the Eklutna River and joins it about 3.2 km (2 miles) upstream from Cook Inlet. The Eklutna River has been obstructed by dams for nearly a century. The first obstruction constructed in 1929 was a concrete dam (lower dam) designed for hydroelectric generation. It was located in the vertical-walled canyon roughly 5.6 km (3.5 miles) upstream from Cook Inlet. The second dam (upper dam) was constructed in 1955 at the outlet of Eklutna Lake (17.7 km (11-mile) from Cook Inlet) to facilitate power generation and store potable water for Anchorage and the surrounding areas. Fish passage was completely blocked by both dams. Over the ensuing decades following the completion of the upper Eklutna River dam, the allocation of flow down the river was dramatically curtailed and maintenance of a natural hydrograph ceased. Now, the majority of flow in the lower Eklutna River is sourced from Thunder Bird Creek. The Eklutna River upstream from the confluence of Thunder Bird Creek is typically supplied only by groundwater and hillside seeps, although on rare occasions Eklutna Lake has overtopped the upper dam conveying brief pulses of lake water down the system. Some reaches of the river downstream from the upper dam are intermittently dry. This has resulted in a relatively flat hydrograph with discharges rarely exceeding 10 cubic-feet-per-second (cfs) throughout the year, this is less than one-tenth of the typical minimum annual discharge measured prior to the completion of the upper dam.

In 2018, Eklutna Inc. completed deconstruction of the 18.2 m (60-foot) high lower Eklutna River dam. It was anticipated that up to 230,000 cubic yards (cy) of sediment could be mobilized down the Eklutna River following dam removal (HDR, 2016), potentially resulting in numerous changes to downstream habitats and fish communities. The project was permitted in part by the United States Army Corps of Engineers (USACE), which required Eklutna Inc. to collect a suite of pre- and post-project geomorphic and water quality data necessary to evaluate the impacts of dam removal and sediment mobilization on the physical characteristics of the lower river over a three-year period (2018-2020). This included the collection of data describing channel geometry, substrate composition, and water quality prior to and following dam removal.

Historically, the Eklutna River was an important subsistence fishery for the Eklutna people and supported populations of all five species of Pacific salmon. According to traditional ecological knowledge (TEK) accounts, some species potentially migrated upstream into Eklutna Lake (Mark Lamoreaux, Biologist, NVE, Personal Communication). A population of landlocked sockeye salmon (*Oncorhynchus nerka*) inhabits the lake today. Although all five species of salmon still occur in the Eklutna River, their populations are substantially depressed from their former abundance due predominantly to dam-related impacts (Mark Lamoreaux, Biologist, NVE, Personal Communication). Currently the majority of anadromous fish inhabit the lower river below the confluence with Thunder Bird Creek, although in 2007 juvenile Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) were documented about 0.8 km (0.5 miles) above the confluence of Thunder Bird Creek. Subsequent fish sampling effort conducted by the ADF&G Habitat Section in 2019 and 2020 documented spawning chum salmon (*Oncorhynchus keta*) below the Thunder Bird Creek confluence and found juvenile Chinook salmon rearing upstream to the base of a naturally occurring bedrock constriction barrier 1.6 km (1 mile) upstream of Thunder Bird Creek. Juvenile coho salmon have subsequently been found nearly 1.6 km (1 mile) upstream from the deconstructed dam site, and adult coho, chum, and Chinook salmon have been found migrating upstream from the Thunder Bird Creek confluence.

In 2017, in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and NVE, the ADF&G–Habitat Section began collecting the environmental data specified by the USACE to satisfy permit conditions. Baseline data were collected in May 2017 describing channel geometry and substrate composition prior to dam removal. The 2017 data was used to assess the magnitude and duration of sediment mobilization and impacts to the the river channel downstream of the lower dam site. These measurements were replicated with the inclusion of water quality following dam removal in October 2018. Eklutna Inc. synthesized and reported the findings of these datasets to the USACE in October 2018 to satisfy annual reporting requirements.

In 2019, Eklutna Inc. contracted with the ADF&G–Habitat Section to continue the existing environmental studies program through its completion in 2020 and to produce the remaining requisite annual and final reports.

In 2021, Trout Unlimited contracted with the ADF&G-Habitat Section to continue with this program for another three years, through 2023. This report is the culmination of these studies.

STUDY AREA AND SETTING

The Eklutna River watershed is a glacially influenced system originating in the Chugach Mountains about 48.2 km (30 miles) northeast of Anchorage, Alaska, and drains an area of about 450 square kilometers [(sq km) 174 sq miles] (Figure 1). This watershed is comprised of the 17.7 km (11-mile) long Eklutna River—which historically drained Eklutna Lake—two major tributaries of Eklutna Lake, and Thunder Bird Creek. Thunder Bird Creek is the only substantial tributary downstream of the lake. It joins the lower Eklutna River at about 3.2 km (2 miles) upstream from Cook Inlet and contributes the bulk of the flow conveyed through the lower Eklutna River.

For the purposes of this report, we have divided the system into three components: the upper river (including Eklutna Lake); the middle river between the lake outlet and the Thunder Bird Creek confluence; and the lower river between Thunder Bird Creek and Cook Inlet.

The upper watershed is comprised predominantly of two major tributaries: one conveying meltwater from the Eklutna Glacier and the other dominated by ground water and non-glacial surface runoff. These two dominant tributaries flow roughly 16 km (10 miles) through broad glacial valleys before draining into the narrow, 11.2 km (7-mile) long Eklutna Lake. Eklutna Lake is a natural lake, however a dam was constructed in 1955 at its outlet to manage water levels to supply potable water and generate hydroelectric power for delivery to Anchorage and the surrounding communities. The completion of this dam resulted in the near total elimination of surface flow draining from Eklutna Lake into the middle reaches of the Eklutna River. This dramatically changed the natural hydrograph from the lake outlet to Cook Inlet.

The middle Eklutna River watershed stretches approximately 14.4 km (9 miles) from the lake outlet to the confluence of Thunder Bird Creek, the largest tributary within the system. This section transitions from a relatively broad glacial moraine/outwash valley with meandering channel plain and moderate habitat complexity into a constricted canyon with little channel sinuosity and minimal lateral habitats. About 12.9 km (8 miles) downstream from the lake, the lower Eklutna River dam was deconstructed in 2018. This dam was constructed in 1929 for hydroelectric power generation, which resulted in the complete blockage of fish passage. Due to the upper dam, which rarely releases any lake water into the middle river, this section of river no longer conveys continuous flow; rather, it is fed solely by spatially and temporally intermittent ground water contributions and lateral run-off resulting in a flat hydrograph. Three of our four monitoring sites are located within this section.

The lower Eklutna River, stretching roughly 3.2 km (2 miles) from its confluence with Thunder Bird Creek to Cook Inlet, is dominated by non-glacial Thunder Bird Creek flow. Because Thunder Bird Creek is the dominant contributor of flow, water clarity throughout the lower river section is typically much greater than the relatively turbid waters conveyed through the upper and middle river sections. In general, this section transitions from a moderately incised broad canyon reach into a meandering braided floodplain channel prior to joining Cook Inlet near the NVE townsite. Additionally, this section of river flows under both the Old Glenn Highway, the Glenn Highway, and the Alaska Railroad corridor. Our lowest monitoring site is within this river section.

In the fall of 2021, after the 2021 transect survey, controlled flow releases from the Eklutna Lake dam (upper dam) were conducted by opening the dam's spillway gate. Starting on the morning of September 13, approximately 150 cfs of lake water was released downstream of the dam to the middle and lower Eklutna River. This continued through September 24 when the spillway gate was partially closed and released flows were reduced to about 75 cfs. Then again on September 29 the gate was further closed to reduce the flows to about 25 cfs which continued until October 6 when the gate was completely closed.

FISH DISTRIBUTION WITHIN THE STUDY AREA

The Eklutna River is documented in the Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Anadromous Waters Catalog [AWC]) (Alaska Department of Fish and Game, 2022) to support all five species of Pacific salmon; however, the current upstream extent of AWC documented habitat extends about 7.3 km (4.5 miles) upstream from Cook Inlet and about 4 km (2.5 miles) upstream of the confluence of Thunder Bird Creek. Additionally, this river is known to support a suite of resident fish species including Dolly Varden (*Salvelinus malma*), rainbow trout (*Oncorhynchus mykiss*), threespine stickleback (*Gasterosteus aculeatus*), slimy sculpin (*Cottus cognatus*), and non-native Alaska blackfish (*Dallia pectoralis*).

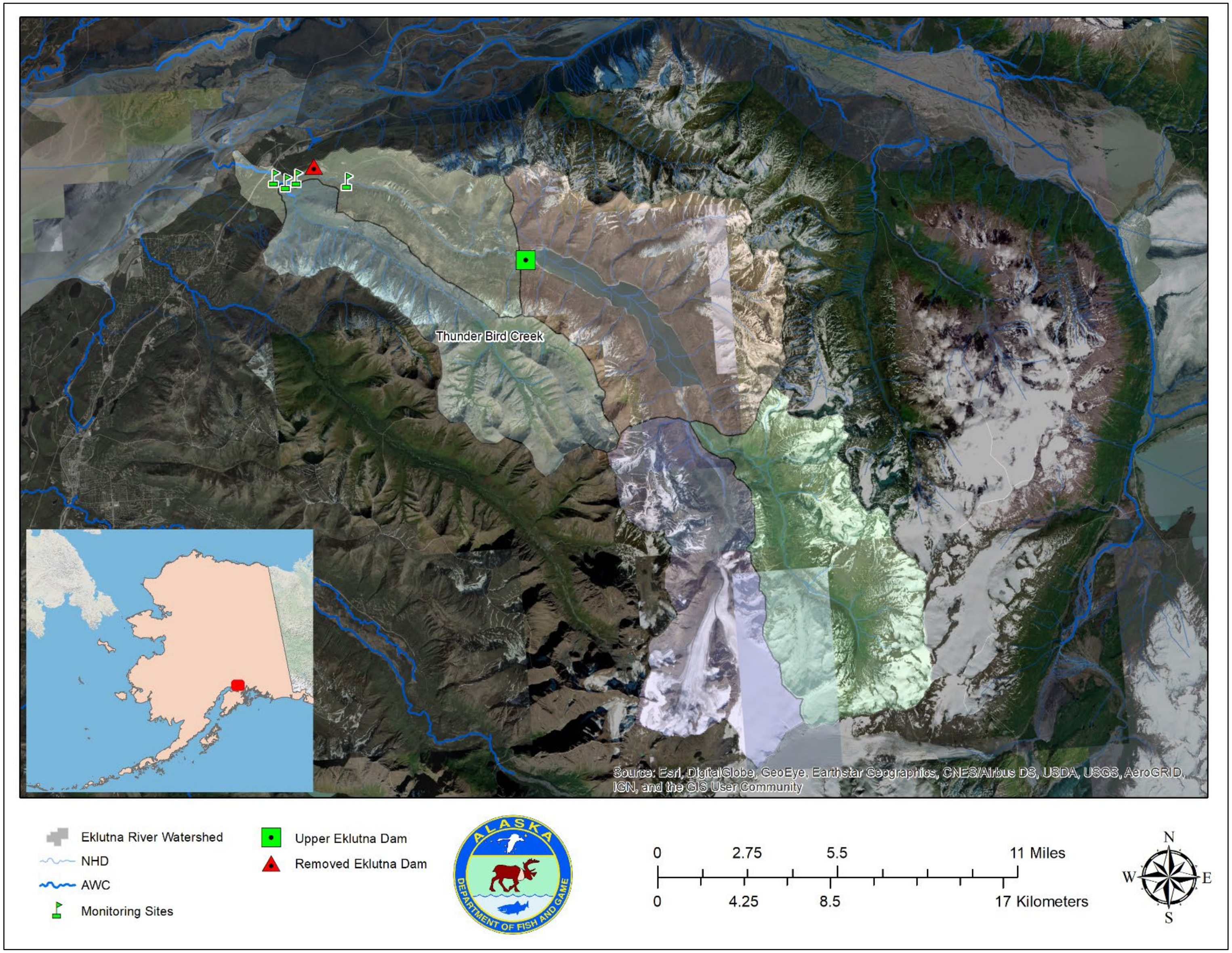
In 2019, the ADF&G–Habitat Section conducted a fish sampling effort from the Old Glenn Highway bridge upstream to the dam deconstruction site. During a single day of sampling, 10 baited minnow traps were set along with many opportunistic dip net sweeps. Concurrently, visual observations were made of any adult salmon in the turbid water. A total of 57 juvenile coho salmon, 58 juvenile Chinook salmon, and 26 Dolly Varden were captured upstream to a natural fish passage barrier located 1.6 km (1 mile) upstream from Thunder Bird Creek. Three distinct chum salmon spawning areas were documented downstream from Thunder Bird Creek in 2019, 2021, and 2022. Observations from this sampling effort were adopted into the Anadromous Waters Catalog.

In spring of 2020, ADF&G-Habitat hiked up the Eklutna River channel from the Old Glenn Highway bridge to a beaver pond located approximately 1.6 km (1-mile) upstream from the lower dam deconstruction site. During the effort, ADF&G partially deconstructed the natural constriction barrier which allowed the channel to adjust to a configuration that was anticipated to support some flow-dependent fish passage. Additionally, a robust, healthy population of stream resident Dolly Varden were found distributed throughout the river upstream from the sediment wedge. During a subsequent Autumn fish collection effort several juvenile coho salmon were found rearing above the former constriction barrier and upstream nearly 1.6 km (1 mile) from the deconstructed dam site. This confirmed that juvenile salmon are now able to migrate throughout most of the system . Additionally, two adult coho salmon and two adult Chinook salmon were documented approximately 0.6 km (half mile) upstream from Thunder Bird Creek. In September 2021, using a backpack electrofisher, ADF&G staff documented dozens of Dolly Varden upstream of the canyon indicating suitable fish habitat exists above the former lower dam site.

Eklutna Lake is known to support resident sockeye salmon (also known as kokanee salmon), Dolly Varden, and rainbow trout. The origin of the kokanee salmon in Eklutna Lake is not conclusively known; however, NVE biologist Mark Lamoreaux has stated that traditional ecological knowledge of the area indicates anadromous sockeye salmon migrated into the lake to spawn prior to the construction of the lower Eklutna River Dam in 1929 (Mark Lamoreaux, Biologist, NVE, Personal Communication). Loso et al. (2015) implemented a nitrogen isotope analysis of Eklutna Lake substrates resulting in non-conclusive findings for the presence of a historic population of anadromous sockeye salmon in Eklutna Lake.

Thunder Bird Creek is documented in the AWC to support Chinook and coho salmon as well as a suite of resident fish species. Thunder Bird Falls, a large waterfall (~100 feet), is located about 0.4 km (0.25 miles) upstream from the mouth of Thunder Bird Creek and marks the upstream extent of salmon distribution.

Figure 1.– Eklutna River Watershed Map.



OBJECTIVES

The objective of this monitoring project is to continue to monitor the Eklutna River channel to assess and document conditions as the result of the 2018 dam deconstruction. These conditions include documenting changes to physical habitat in the middle and lower Eklutna River. To achieve the objective, the following tasks were completed:

Task 1: Select monitoring sites. This included one site upstream from the deconstructed dam and three monitoring sites downstream from the old dam site, (including two sites located in the canyon upstream from the confluence of Thunder Bird Creek, and one site located downstream from the confluence).

Task 2: Conduct cross-sectional surveys at an established location within each of the full monitoring site locations annually through 2023.

Task 3: Characterize substrate composition within each of the full monitoring sites using standardized techniques annually through 2023.

Task 4: Monitor water quality variables at each monitoring site during regularly scheduled annual field visits.

Task 5: Record continuous water temperature readings at the monitoring site upstream from the sediment plug, and one location upstream and one location downstream of the Thunder Bird Creek confluence. Temperature monitors were installed in 2022 and 2023.

Monitored variables include: channel geometry; substrate composition; and water quality variables including temperature (C°), dissolved oxygen (mg/L), pH, turbidity (NTU), and conductivity (µS/cm).

METHODS

MONITORING SITES

Prior to the completion of dam removal, three monitoring sites were established in the Eklutna River (Table 1, Sites 6, 8, and 10). Two monitoring sites were selected upstream from the Thunder Bird Creek confluence (Sites 6 and 8) and one monitoring site was selected downstream of the confluence (Site 10). Each monitoring site was selected at a location representative of proximal upstream and downstream conditions.

Only channel geometry and substrate composition were recorded during the initial 2017 sample event to represent pre-removal conditions. In October 2018, each monitoring site was revisited and sampled for the first time following the completion of dam removal.

In 2019, an additional monitoring location was established above the sediment wedge upstream from the dam site (Site 2U). This monitoring site was initially established solely to record water quality parameters in conjunction with other monitoring events and was added as the fourth monitoring site for this project with full channel geometry monitoring in 2021. Additionally, continuous temperature monitoring was established at three of the sites as shown in Table 1. The complete suite of monitoring locations is shown in Figure 2.

Table 1.– Eklutna River monitoring locations.

Site	Latitude	Longitude	Comments
Eklutna 2U	61.4483	-149.3281	Full monitoring site includes continuous temperature monitoring. Located upstream of former lower dam and sediment wedge.
Eklutna 6	61.447	-149.348	Full monitoring site includes continuous temperature monitoring. Located downstream of former lower dam and upstream of Thunderbird Creek.
Eklutna 8	61.445	-149.359	Full monitoring site without continuous temperature monitoring. Located downstream of former lower dam and upstream of Thunderbird Creek.
Eklutna 10	61.448	-149.369	Full monitoring site includes continuous temperature monitoring. Located downstream of Thunderbird Creek.

All four monitoring four sites were surveyed in 2021, 2022, and 2023. Temperature data loggers were deployed at three of the sites in 2022 and 2023 from May through October.

Figure 2.– Eklutna River Monitoring Site Map

Channel Geometry

Physical changes to channel geometry were assessed from 2021 through 2023 by conducting cross-sectional surveys at previously established locations within each of the four monitoring sites described above. 2017 data are also included to allow comparison of pre-dam removal channel geometry to post-dam removal. Each of the four survey sites were established and marked on the river-left bank canyon wall with a 2 1/2-inch diameter brass temporary benchmark (TBM). Each end of the survey transect was marked by a 2-foot-long rebar pin driven into the ground and fitted with an orange safety cap. Cross-sectional channel geometry was measured by standard surveying methods using a surveyor's auto level, stadia rod, and fiberglass field tape measuring in tenths of feet. To match existing datasets, measurements were recorded approximately every three feet along the cross-section to ensure a minimum of 20 geomorphic data points. In addition to these incremental measurements, the following typical geomorphic features were measured:

- top of bank (both banks)
- bottom of bank (both banks)
- thalweg
- edge of water (both banks)
- bankfull elevation (both banks)
- channel irregularities or unique channel features

Graphical representations of channel cross sectional profiles collected in 2017 and during 2021 through 2023 are provided in Appendix A.

Substrate Composition

Composition of stream substrate particles plays an important role in supporting fish. For example, boulders support resting and feeding behavior and provide refuge from predators by providing eddies and pools. Gravel substrates are especially important for many spawning fishes as gravels provide habitat for egg incubation and survival of newly hatched alevin. Fine substrates, like sand and silt, may support feeding or spawning fishes of certain species but if present in high proportions can reduce spawning and incubation habitat quality for salmonids.

Prior to dam deconstruction, we observed substrate conditions upstream from the Thunder Bird Creek confluence that were not conducive to providing habitat for endemic fish. The substrate was comprised almost entirely of fine and very coarse particles with very limited distribution of gravel. Additionally, larger substrates were embedded and immobile. These conditions were likely the result of a flat hydrograph, diminished flow, and insufficient stream energy necessary to transport substrate other than fine particles through the system. This embedding and armoring of bed surface materials commonly occurs below dams due to interrupted bedload movement. With an estimated 230,000 cy of sediment (HDR, 2016) impounded behind the lower dam (referred to here as the sediment wedge), a key objective of this study is to document the transport of this newly available sediment down the system following dam deconstruction and document changes in relative proportion of particle classes and by extension facilitate assessment of changes in fish habitat.

An important classification of streambed particle size is to record the median size of all recorded particles (D_{50}) in which half of the particles median diameters are larger and half are smaller. Similarly, the D_{84} particle size is used to highlight the particle size classification of which 84% of measured particles are equal to or smaller in median diameter. Additionally, the D_{84} classification has been shown to be one predictor of channel roughness and discharge (Rosgen, 2007).

Collectively these values are simply standardized index values used to compare substrate composition among sites and through time and can be used for various other hydrologic and hydraulic analyses.

Substrate composition was characterized at each monitoring site using the Wolman Pebble Count methodology (Wolman 1954, cited in USFS 2001) whereby 20 substrate particles were randomly selected from the bed surface, measured, and tallied along each of five transects spanning from edge-water to edge-water straddling the cross-section survey line. Measured particles were then categorized in accordance with methods described by Rosgen (1994). The resulting data yield a representative size distribution of channel substrate particles.

The distribution of particle sizes was graphed for each sample event at each cross section (Appendix A) to display number of particles (% total) of each size class as well as a running cumulative percent. These graphical representations allow us to inspect the following:

1. relative proportion of fine particles (< 6 mm) to the more desirable gravels;
2. changes in the median particle size (D_{50});
3. the occurrence of coarser particles (D_{84}); and
4. how the dominant substrate class changed over time.

These variables can be used during future analyses to assess potential improvements in substrate quality for supporting the endemic fish community.

Water Quality

Water quality parameters including water temperature, dissolved oxygen, pH, and conductivity were measured at each transect site in 2021, 2022, and 2023 using a YSI Pro Plus multiparameter meter. Turbidity was measured both years at each transect site using a Hach 2100Q.

HOBO Tidbit temperature loggers were deployed at three of the transect sites (Eklutna 2U, 6, and 10) from late May through early October in 2022 and 2023. The loggers were attached to rebar stakes in scour pools behind large boulders and set to record the water temperature every hour.

Quality Assurance Plan

Field data were recorded on datasheets or in pre-formatted waterproof survey field books. Data were checked for accuracy and completeness by a team member other than the recorder prior to site departure. Data were entered and managed in Microsoft Excel. Data quality control (QC) was ensured by implementing three levels of data quality review:

- QC1: Data were reviewed prior to leaving each site.
- QC2: All data were checked following database entry to identify entry errors.
- QC3: During data analysis, data were inspected for outliers or inconsistencies.

DATA ANALYSIS

The purpose of this monitoring report is to describe the monitoring project and present field data in raw form along with text summaries and graphical representations, but with only minor qualitative analysis. Data collected during this monitoring effort may be used for future analysis.

RESULTS AND DISCUSSION

Water quality data and cross-sectional surveys were conducted in the summer of 2021, after dam removal, but before water was released from the upper dam spillway as part of the Fish and Wildlife Program Development. Controlled releases from the Eklutna Lake dam occurred in the fall of 2021 to assist with habitat modeling assessments (see Table 3). These flows mobilized a significant portion of the sediment wedge as well as other channel substrates causing both scour and aggradation.

Table 2.– Eklutna River controlled flow releases (approximate).

Date	Flow (cfs)	Duration (days)
September 13, 2021	150	11
September 24, 2021	75	5
September 29, 2021	25	7
October 6, 2021	0	-

Measurements were collected at the four monitoring sites in 2017 prior to the lower dam removal and both before (2021) and after the controlled releases (2022 and 2023) to document changes resulting from the dam removal and flow releases. Appendix A provides graphical summaries of cross-sectional data and substrate composition at each monitoring site as well as a table depicting substrate classification (D_{50} and D_{84}).

All water quality variables collected at each monitoring site are presented and graphs displaying continuous water temperature data are displayed in Appendix B (continuous water temperature measurements were not collected in 2021). Water quality measurements were collected opportunistically each year during site visits (collected on different dates each year). Water quality values were mostly consistent between the three years with a couple of noticeable trends. Turbidity measurements spiked in 2022 after the controlled water releases mobilized fine sediments that had accumulated in the channel during low flow conditions (Figure 3). This was especially evident at Sites 6 and 8 which are downstream of the sediment wedge, but upstream of the confluence with Thunderbird Creek. Turbidity measurements moderated in 2023 relative to 2022 but were still above 2021 measurements. To a lesser degree, pH measurements also spiked in 2022, but results in 2023 were similar to 2021 (pre-release; Figure 4). These increases in 2022 were likely caused by the mobilization of material from the sediment wedge and activated side channels due to the controlled water releases from the dam. Conductivity and dissolved oxygen levels were similar for all three years (Appendix A).

Based on hourly readings from the Hobo temperature loggers, water temperatures averaged the highest at Site 6 and the lowest at Site 10 below Thunderbird Creek. The average water temperature at Site 2 was cooler than Site 6 but warmer than Site 10. This trend was also captured with the opportunistic monitoring conducted with a hand-held water quality sensor.

Figure 3.– Water Quality – Turbidity Measurements at Monitoring Sites

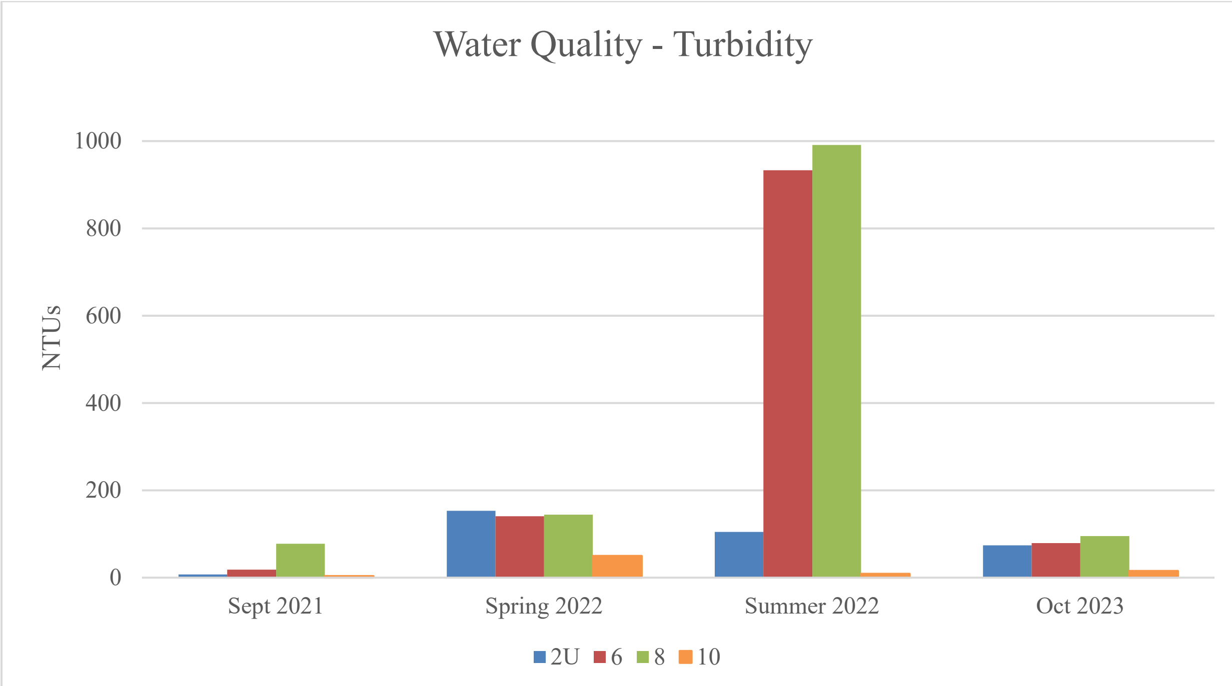
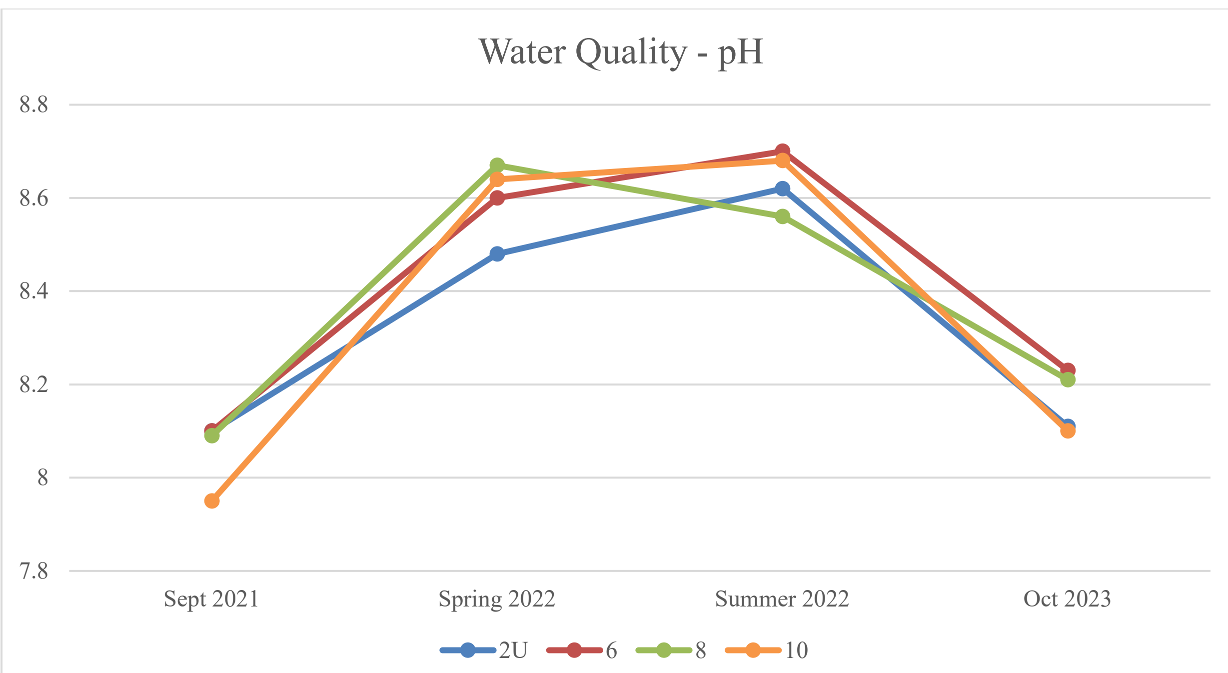


Figure 4.– Water Quality – pH Measurements at Monitoring Sites



EKLUTNA 2U

Some scour occurred at the monitoring site (2U) upstream from the remaining sediment wedge (former dam impoundment). The main flow channel widened at this site with the bankfull elevation and width slightly decreasing. Overall channel depth (at thalweg) was relatively unchanged. Some aggradation occurred on the streambanks and in a minor side channel that was dry during the surveys. Changes to the channel at this cross section occurred mostly between 2017 and 2018 when the lower dam was removed and during and/or post controlled flow releases in late 2021.

Less silt and more gravel sized particles were present in the channel substrate after the controlled flow releases and the channel overall substrate size increased slightly. The D_{50} values increased from fine gravel (2-8 mm) to coarse gravel (16-32 mm) after the controlled releases but decreased to coarse sand (1-2 mm) between 2022 and 2023 after returning to a continuous low-flow regime. D_{84} values increased from coarse gravel to very coarse gravel (32-64 mm) after the controlled release and throughout the monitoring period.

Based on the continuous temperature monitoring, water temperatures at this site tended to be cooler than Eklutna 6 (downstream of the dam), but warmer than Eklutna 10 (downstream of Thunderbird Creek). The highest daily mean temperature was 8.38 °C on July 4 and the coldest daily mean temperature was 3.40 °C on October 12 in 2022. In 2023, the highest daily mean temperature was 8.14 °C on July 13 and the coldest daily mean temperature was 2.14 °C on October 4. The average temperature was 6.85 °C in 2022 and 6.48 °C in 2023.

EKLUTNA 6

This cross section showed the most changes after the lower dam removal in 2018 and after the controlled flow releases. Significant aggradation occurred in the main channel at this monitoring location downstream of the former dam site. About two feet of material aggraded in the main flow channel which caused the bankfull width to decrease and the bankfull elevation to increase. The aggradation pushed the channel to the left bank (looking downstream) and created a side channel on the right bank. Very little changed at this cross section between 2022 and 2023 after returning to a continuous low-flow regime.

Less sand and more gravel sized particles were present after the controlled flow releases with an overall slight increase in substrate size. The D_{50} values increased from medium gravel (8-16 mm) to coarse gravel. The D84 value decreased from large cobble (128-256 mm) in 2017 to coarse to very coarse gravel between 2021 and 2023, with a slight increase in D84 particle size between 2021 and 2023.

Water temperatures at this site were consistently the warmest compared to the other two temperature monitoring sites, especially early in the season. The highest daily mean temperature was 9.17 °C on June 30 and the coldest daily mean temperature was 2.69 °C on October 12 in 2022. In 2023, the highest daily mean temperature was 9.03 °C on August 2 and the coldest daily mean temperature was 1.99 °C on October 4. The average temperature was 7.20 °C in 2022 and 7.02 °C in 2023.

EKLUTNA 8

The channel cross-section at monitoring site 8 showed about a foot of aggradation between pre- and post-lower dam removal with minor changes observed after the controlled flow releases. Aggradation occurred at the site which increased both the bankfull width (+3.7 feet) and the bankfull elevation (+0.2 feet) between 2021 and 2023. The channel thalweg elevation increased but remained in the same location. Minor aggradation occurred between 2022 and 2023 at this cross section after returning to a continuous low-flow regime.

Prior to the lower dam removal the D_{50} values were lower (fine gravel) and D_{84} values higher (large cobble) compared to post dam removal values. From 2021 to 2023 the overall channel substrate increased with more gravels present after the controlled flow releases. The number of silt sized particles increased temporarily after the controlled flow releases. The D_{50} values increased from fine gravel to very coarse gravel but the D_{84} decreased from large cobble to very coarse gravel.

Continuous water temperatures were not recorded at this site but based on water temperature data collected during site visits, the water temperature regime at this site is similar to that of monitoring site 6, which runs a little warmer than both the site below Thunderbird Creek and the site above the former dam.

EKLUTNA 10

The channel cross section at this monitoring location showed very minor changes throughout the monitoring period. There was some aggradation and minor scour after the controlled flow releases, but the bankfull elevation, bankfull width, and thalweg remained relatively unchanged. The aggregation on the left bank scoured out, returning to pre-controlled flow release conditions, between 2022 and 2023.

Slightly more large gravel and cobble substrate was present after the controlled flow releases and the overall channel substrate size increased slightly. The D_{50} values increased from coarse gravel to very coarse gravel and the D_{84} values fluctuated between small cobble and large cobble.

Water temperatures at this site were consistently the coolest compared to the other two temperature monitoring sites, especially early in the season. This is likely due to the influence of Thunder Bird Creek. The highest daily mean temperature was 8.14 °C on August 3 and the coldest daily mean temperature was 2.09 °C on October 12 in 2022. In 2023, the highest daily mean temperature was 9.25 °C on August 3 and the coldest daily mean temperature was 1.5 °C on October 4. The average temperature was 6.12 °C in 2022 and 6.23 °C in 2023.

CONCLUSION

The ADF&G-Habitat Section plans to continue to observe and document changes to the Eklutna River as well as continuing to conduct fish sampling in the middle and upper river. Data collected during this study and potential future monitoring may provide valuable information guiding or assessing future actions within the Eklutna River basin. Currently negotiations are being conducted per the 1991 sale agreement between the utilities and the State of Alaska to develop a Fish and Wildlife Plan to mitigate the effects of project operations on the Eklutna River. The current monitoring effort may be extended to assist in the evaluation of the success of any mitigation efforts developed as the result of studies and flow adjustments resulting from these negotiations.

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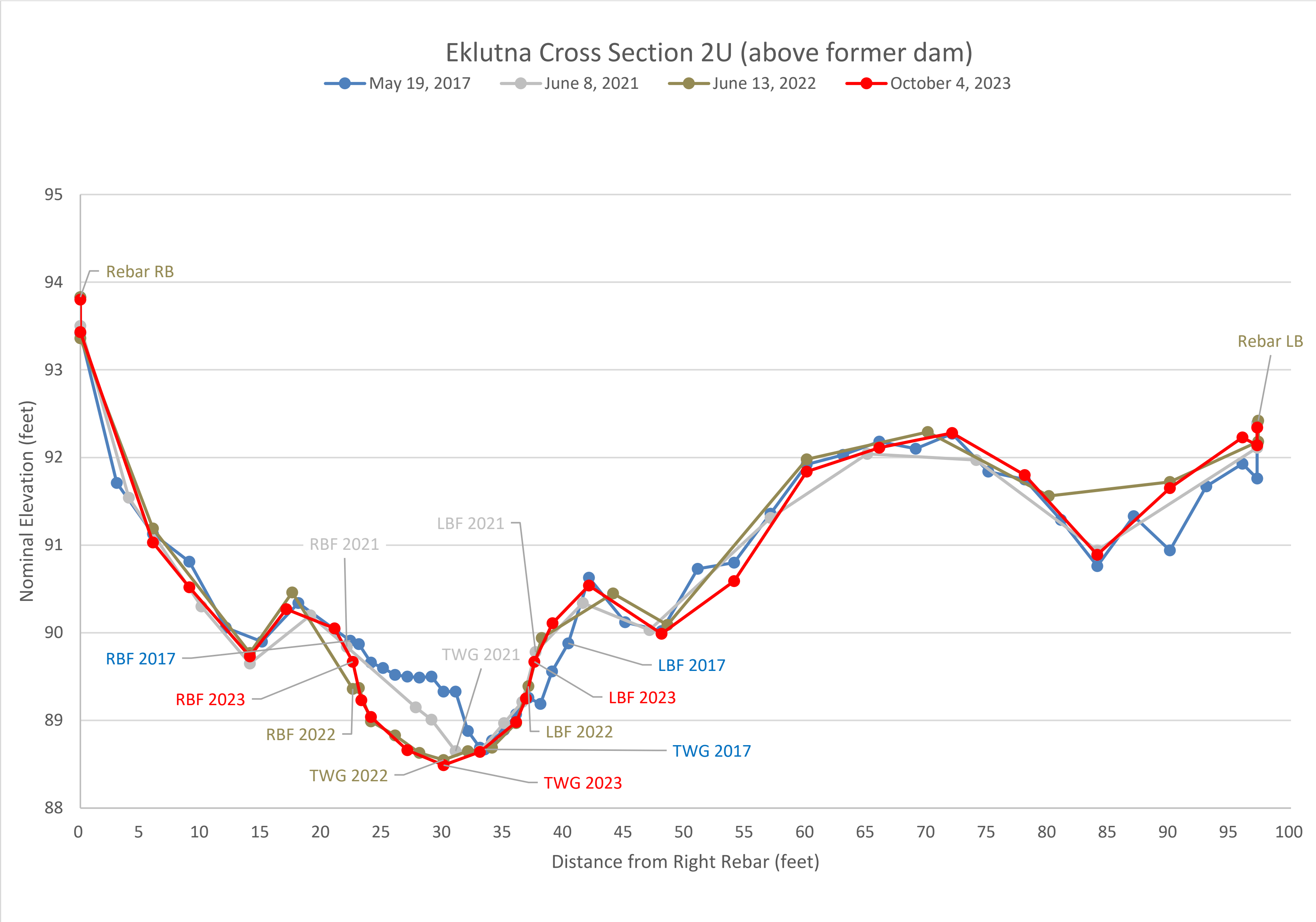
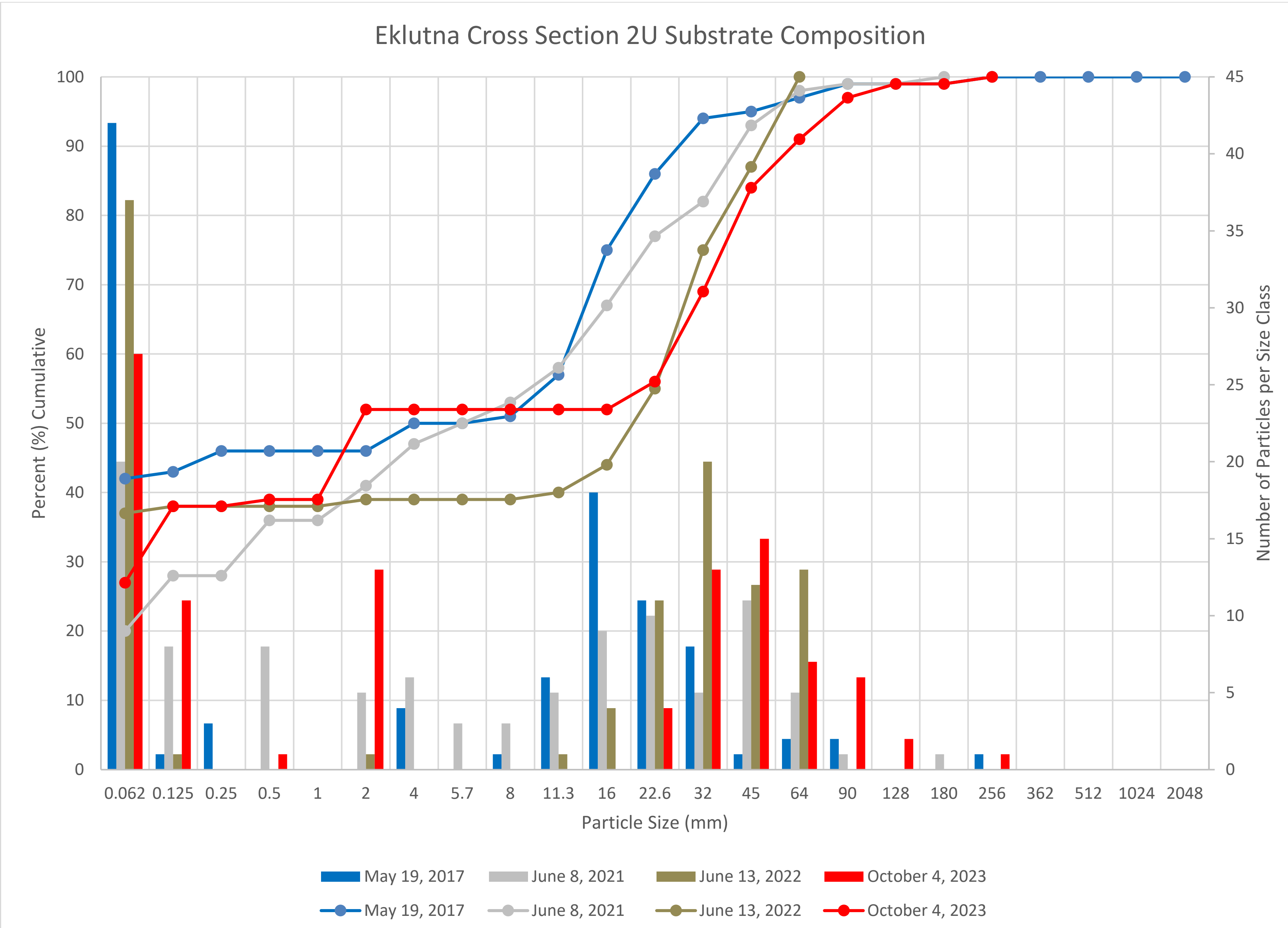
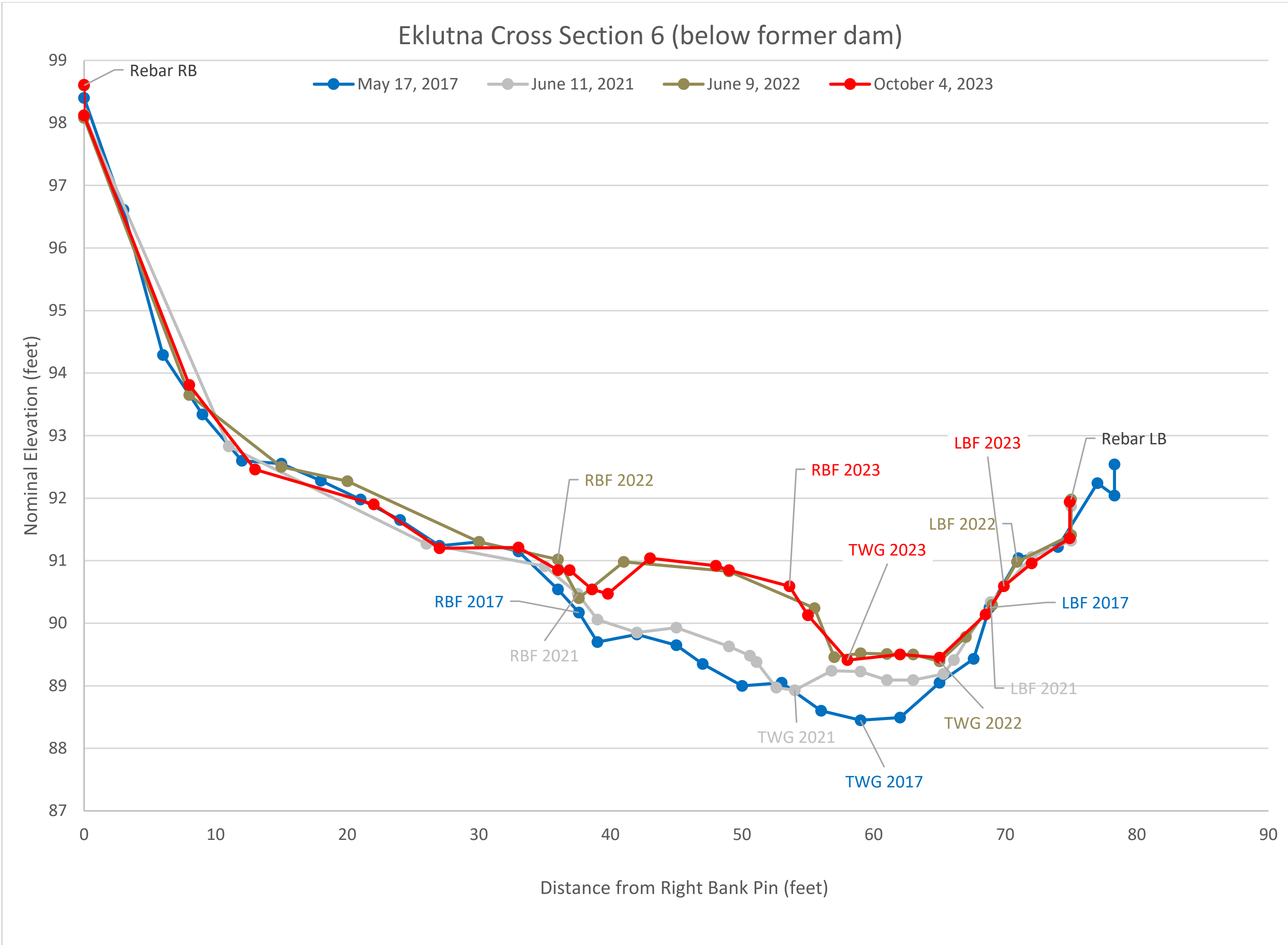
APPENDIX A: CROSS SECTION PROFILES AND SUBSTRATE COMPOSITION FIELD DATA



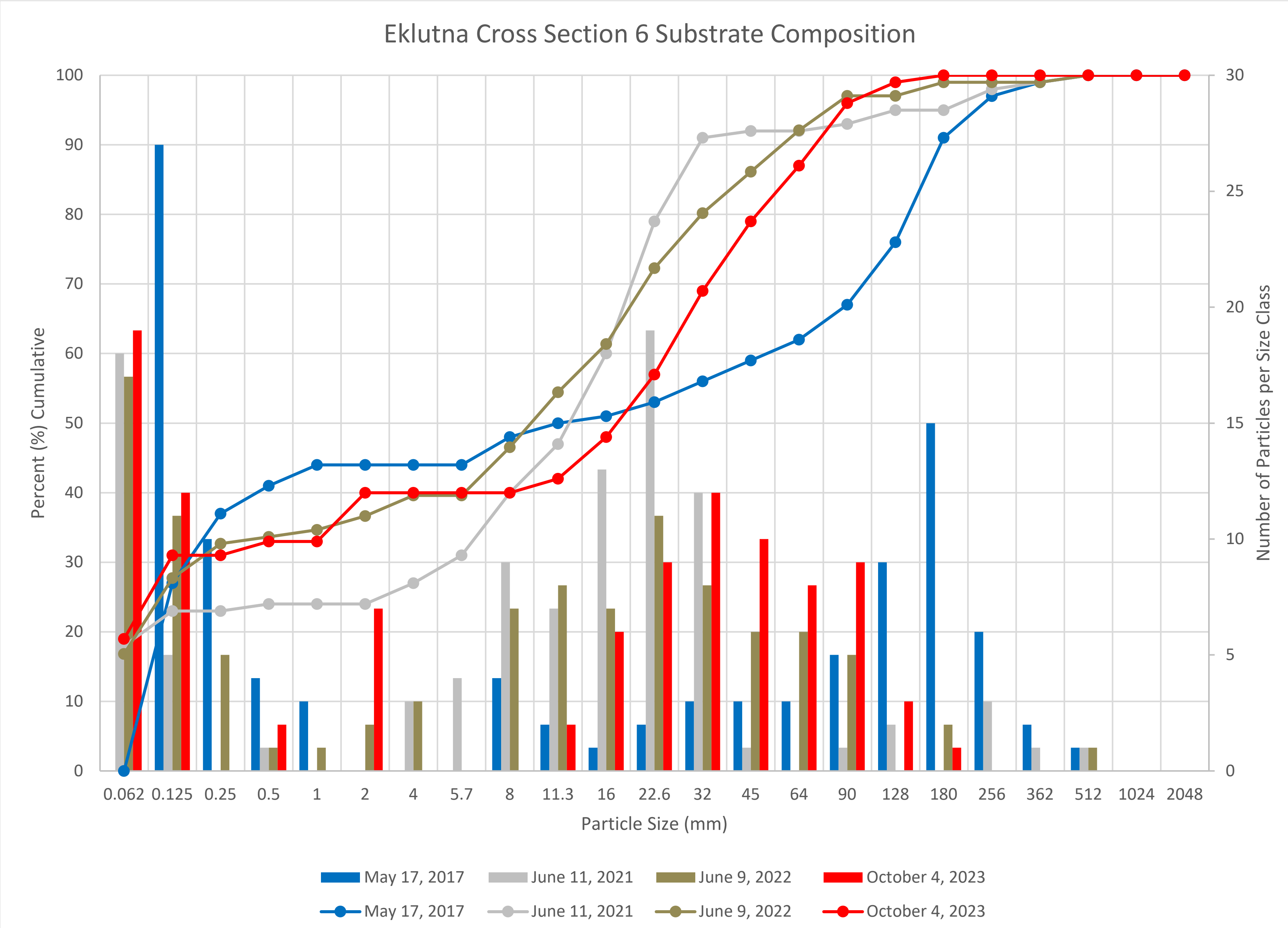
Eklutna Cross Section 2U (above former dam)
May 19, 2017
June 8, 2021
June 13, 2022
October 4, 2023
Nominal Elevation (feet)
Distance from Right Rebar (feet)
Rebar RB
Rebar LB
RBF 2021
LBF 2021
RBF 2017
RBF 2023
RBF 2022
TWG 2021
TWG 2022
TWG 2023
TWG 2017
LBF 2017
LBF 2023
LBF 2022
95
94
93
92
91
90
89
88
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

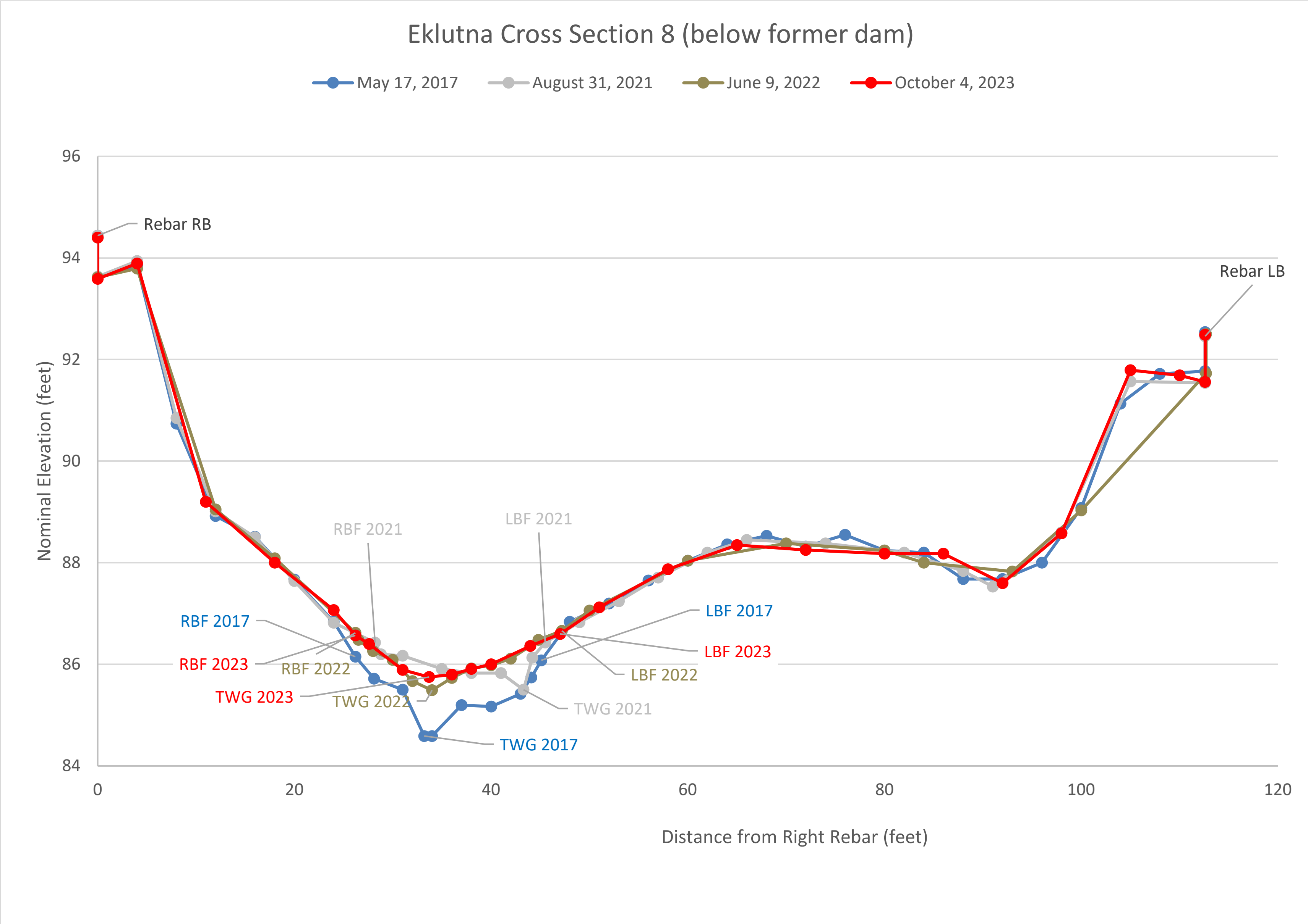


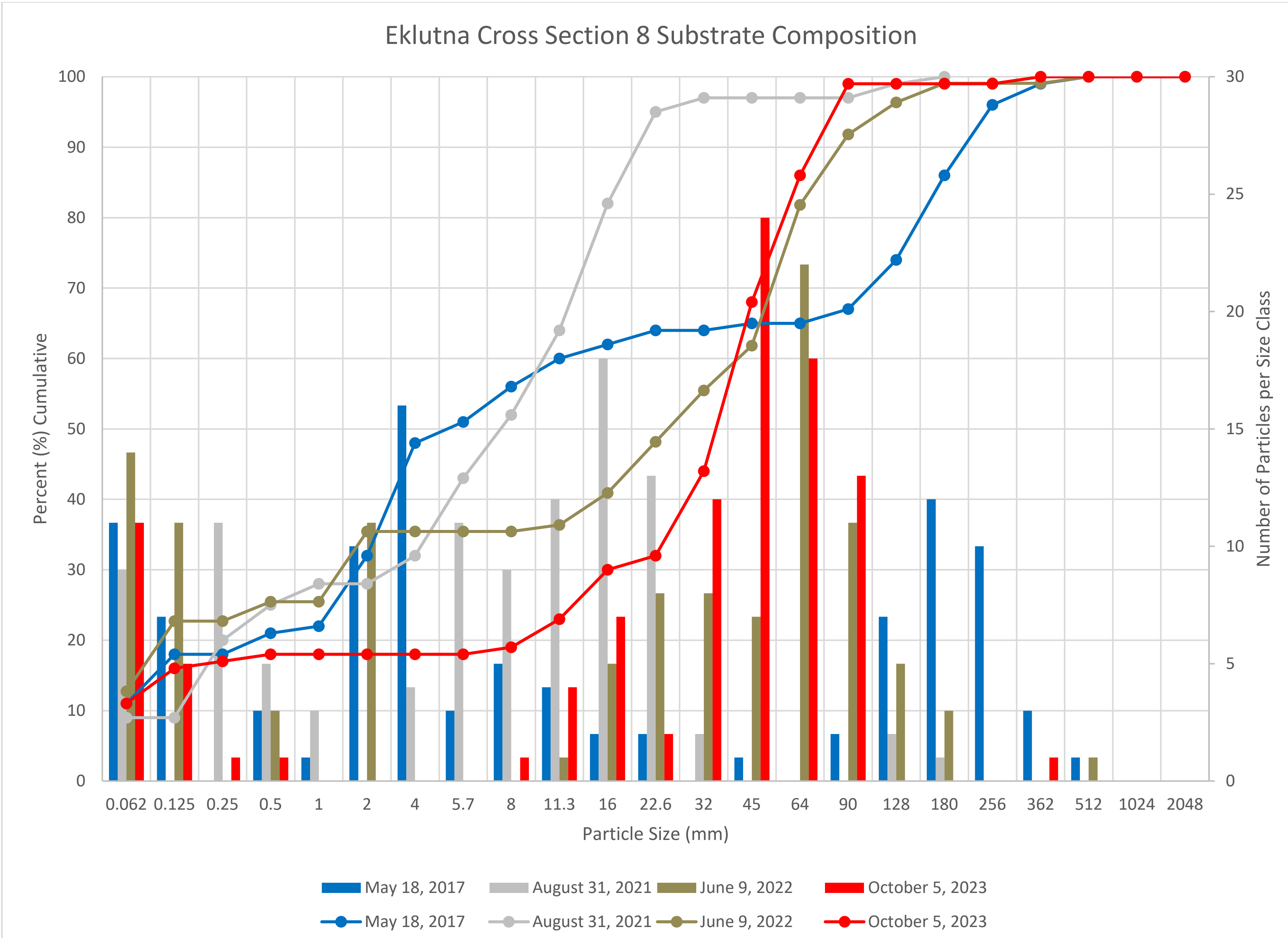
Eklutna Cross Section 2U Substrate Composition
Percent (%) Cumulative
Number of Particles per Size Class
Particle Size (mm)
0 10 20 30 40 50 60 70 80 90 100
0 5 10 15 20 25 30 35 40 45
0.062 0.125 0.25 0.5 1 2 4 5.7 8 11.3 16 22.6 32 45 64 90 128 180 256 362 512 1024 2048
May 19, 2017
June 8, 2021
June 13, 2022
October 4, 2023
May 19, 2017
June 8, 2021
June 13, 2022
October 4, 2023

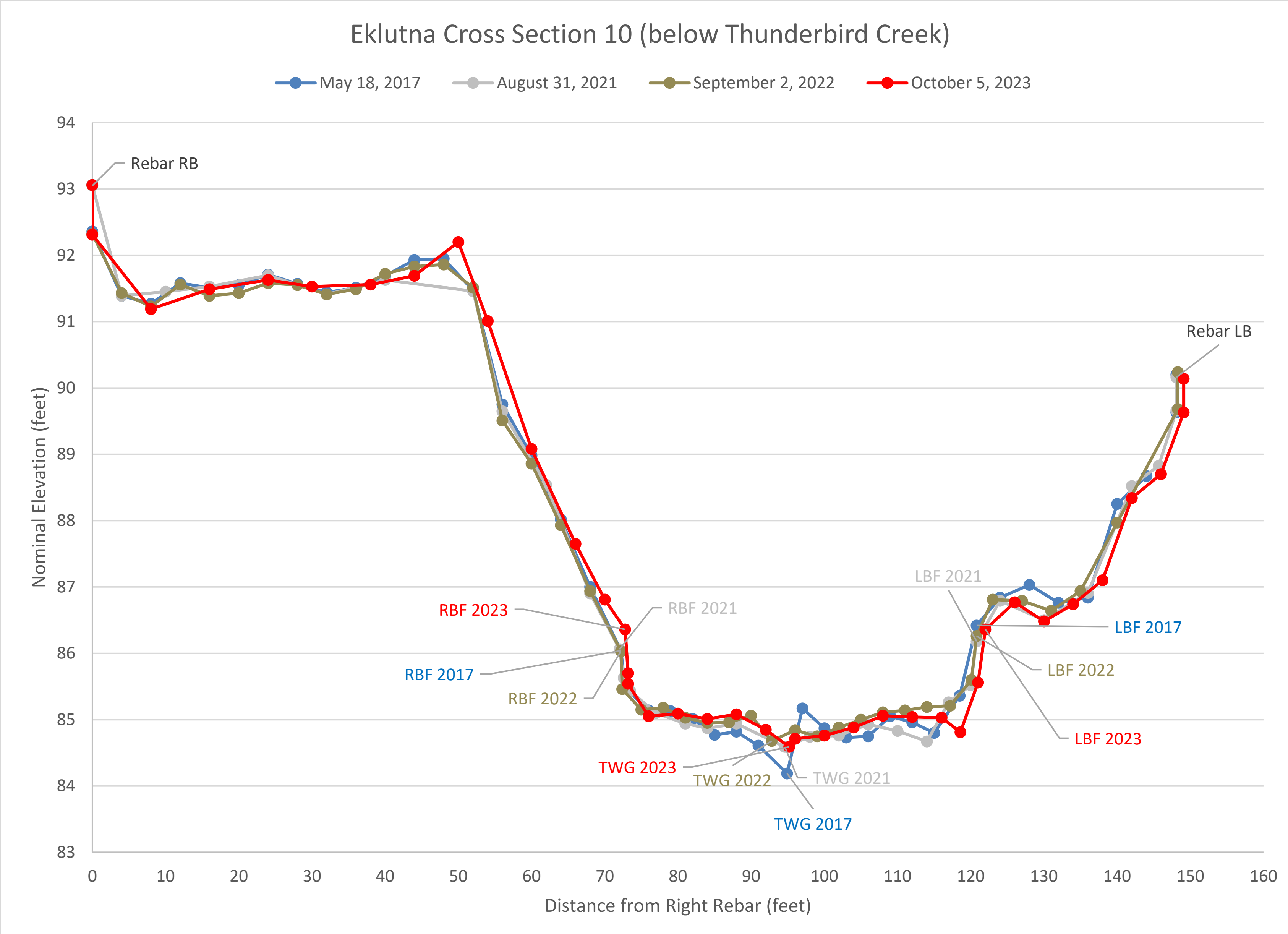


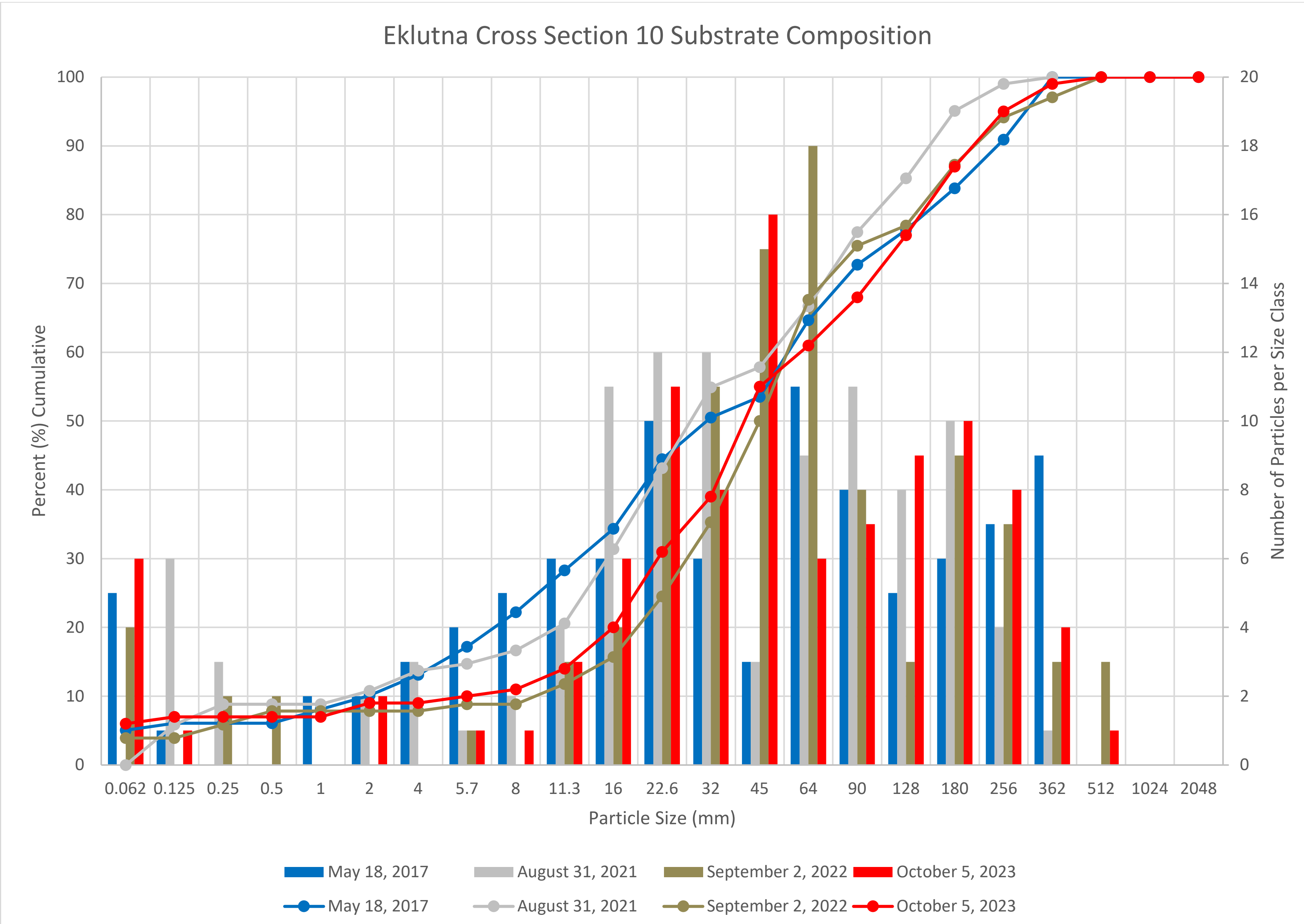
Eklutna Cross Section 6 (below former dam)
May 17, 2017
June 11, 2021
June 9, 2022
October 4, 2023
Rebar RB
Rebar LB
RBF 2022
RBF 2023
LBF 2023
LBF 2022
TWG 2023
RBF 2017
LBF 2017
RBF 2021
LBF 2021
TWG 2022
TWG 2021
TWG 2017
Nominal Elevation (feet)
Distance from Right Bank Pin (feet)
99
98
97
96
95
94
93
92
91
90
89
88
87
0
10
20
30
40
50
60
70
80
90


Eklutna Cross Section 6 Substrate Composition
Percent (%) Cumulative
Number of Particles per Size Class
Particle Size (mm)
0.062 0.125 0.25 0.5 1 2 4 5.7 8 11.3 16 22.6 32 45 64 90 128 180 256 362 512 1024 2048
May 17, 2017
June 11, 2021
June 9, 2022
October 4, 2023


Eklutna Cross Section 8 (below former dam)
May 17, 2017
August 31, 2021
June 9, 2022
October 4, 2023
Nominal Elevation (feet)
Distance from Right Rebar (feet)
96
94
92
90
88
86
84
0
20
40
60
80
100
120
Rebar RB
Rebar LB
RBF 2021
LBF 2021
RBF 2017
LBF 2017
RBF 2023
LBF 2023
RBF 2022
LBF 2022
TWG 2023
TWG 2022
TWG 2021
TWG 2017


Eklutna Cross Section 8 Substrate Composition
Percent (%) Cumulative
Number of Particles per Size Class
Particle Size (mm)
0.062 0.125 0.25 0.5 1 2 4 5.7 8 11.3 16 22.6 32 45 64 90 128 180 256 362 512 1024 2048
May 18, 2017
August 31, 2021
June 9, 2022
October 5, 2023


Eklutna Cross Section 10 (below Thunderbird Creek)
May 18, 2017
August 31, 2021
September 2, 2022
October 5, 2023
Rebar RB
Rebar LB
RBF 2023
RBF 2021
RBF 2017
RBF 2022
LBF 2021
LBF 2017
LBF 2022
LBF 2023
TWG 2023
TWG 2022
TWG 2021
TWG 2017
Nominal Elevation (feet)
Distance from Right Rebar (feet)
94
93
92
91
90
89
88
87
86
85
84
83
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160



Eklutna Cross Section 10 Substrate Composition
Percent (%) Cumulative
Number of Particles per Size Class
Particle Size (mm)
0.062
0.125
0.25
0.5
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
May 18, 2017
August 31, 2021
September 2, 2022
October 5, 2023

Substrate Composition Table

Year	Cross Section 2U		Cross Section 6		Cross Section 8		Cross Section 10	
	D50	D84	D50	D84	D50	D84	D50	D84
2017	Fine Gravel	Coarse Gravel	Medium Gravel	Large Cobble	Fine Gravel	Large Cobble	Coarse Gravel	Large Cobble
2021	Fine Gravel	Very Coarse Gravel	Medium Gravel	Coarse Gravel	Fine Gravel	Coarse Gravel	Coarse Gravel	Small Cobble
2022	Coarse Gravel	Very Coarse Gravel	Medium Gravel	Very Coarse Gravel	Coarse Gravel	Small Cobble	Very Coarse Gravel	Large Cobble
2023	Coarse Sand	Very Coarse Gravel	Coarse Gravel	Very Course Gravel	Very Coarse Gravel	Very Coarse Gravel	Very Coarse Gravel	Large Cobble

Note: Size ranges for substrate classifications: Coarse Sand = 1-2 mm; Fine Gravel = 2-8 mm; Medium Gravel = 8-16 mm; Coarse Gravel = 16-32 mm; Very Coarse Gravel = 32-64 mm; Small Cobble = 64-128 mm; Large Cobble = 128-256 mm

APPENDIX B: WATER QUALITY FIELD DATA

Water Quality Variables Tables

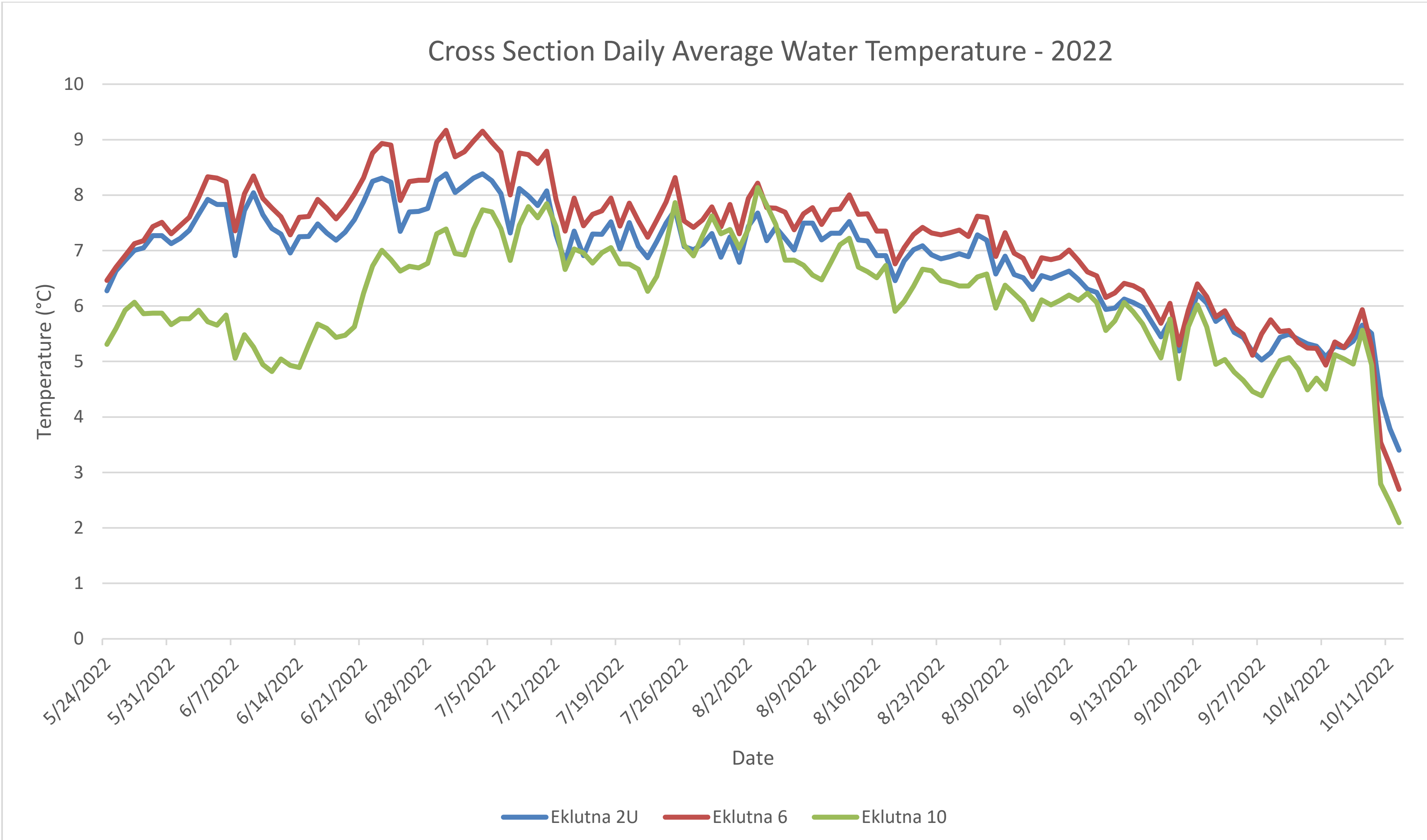
Site	Date	Temperature (°C)	Average Temperature (°C)[1]	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTUs)
	Upstream of former dam and sediment wedge						
2U	9/3/21	6.10	6.86 (2022) 6.48 (2023)	279.3	14.71	8.10	7.3
	5/23/22[2]	8.26		262.0	14.86	8.48	153.1
	6/13/22[3]	7.96		279.0	14.10	8.62	104.6
	10/4/23	2.35		252.0	13.01	8.11	74.1
	Downstream of former dam and upstream of Thunderbird Creek confluence						
6	9/3/21	6.40	7.20 (2022) 7.02 (2023)	283.5	13.83	8.10	18.5
	5/23/22[2]	8.46		261.0	14.97	8.60	140.5
	6/9/22[3]	8.57		261.0	16.88	8.70	933.1
	10/4/23	2.49		253.0	12.81	8.23	79.1
8	9/3/21	6.50	Not Collected	282.8	13.87	8.09	17.7
	5/23/22[2]	7.88		254.0	14.76	8.67	144.2
	6/9/22[3]	8.06		259.0	12.50	8.56	991.3
	10/4/23	2.51		253.0	13.23	8.21	95.6
	Downstream of Thunderbird Creek confluence						
10	9/3/21	6.20	6.13 (2022) 6.24 (2023)	316.2	13.99	7.95	3.9
	5/23/22[2]	6.30		236.0	14.00	8.64	49.9
	9/2/22	5.12		299.0	13.22	8.68	8.8
	10/4/23	1.70		313.0	13.40	8.10	15.6

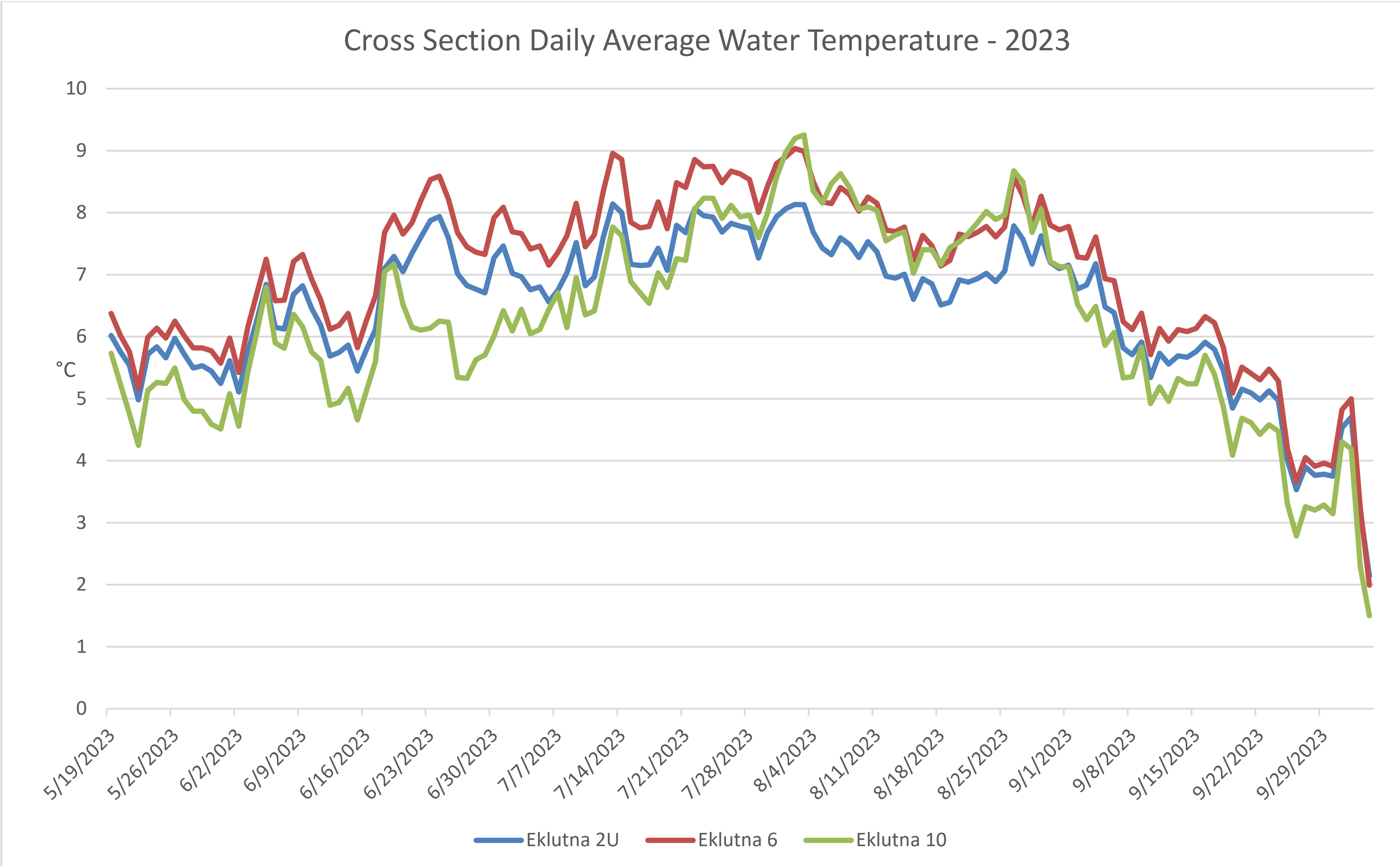
1 – Average Temperature was calculated from hourly readings by HOBO Tidbit Temperature Loggers in place from late May to early October.
2 – Water levels relatively high in mainstem Eklutna River and Thunderbird.
3 – Thunderbird Creek running exceptionally high – difficult to cross and not able to survey Creek.

Site	Year	Average Temperature (°C)[1]						
		Late May through Early Oct.	Late May	June	July	August	September	Early October
2U	2022	6.86	6.96	7.63	7.50	7.08	5.90	4.97
	2023	6.48	5.61	6.57	7.41	7.24	5.40	5.03
6	2022	7.20	7.15	8.07	8.05	7.48	6.14	4.79
	2023	7.02	5.90	7.09	8.13	7.98	5.76	5.34
10	2022	6.13	5.93	5.88	7.16	6.71	5.49	4.29
	2023	6.24	4.98	5.79	7.15	7.97	4.92	4.51

1 = Average Temperature is calculated from hourly readings by HOBO Tidbit Temperature Loggers in place from late May to early October.

Daily Average Temperature Graphs




Cross Section Daily Average Water Temperature - 2023
10
9
8
7
6
°C
5
4
3
2
1
0
5/19/2023
5/26/2023
6/2/2023
6/9/2023
6/16/2023
6/23/2023
6/30/2023
7/7/2023
7/14/2023
7/21/2023
7/28/2023
8/4/2023
8/11/2023
8/18/2023
8/25/2023
9/1/2023
9/8/2023
9/15/2023
9/22/2023
9/29/2023
Eklutna 2U
Eklutna 6
Eklutna 10

APPENDIX C: EKLUTNA SITE PHOTOS

Eklutna 2U looking upstream – June 8, 2021

Eklutna 2U looking upstream – June 13, 2022

Eklutna 2U looking upstream – October 4, 2023

Eklutna 2U looking downstream – June 8, 2021

Eklutna 2U looking downstream – June 13, 2022

Eklutna 2U looking downstream – October 4, 2023

Eklutna 6 looking upstream – June 11, 2021

Eklutna 6 looking upstream – June 9, 2022

Eklutna 6 looking upstream – October 4, 2023

Eklutna 6 looking downstream – June 11, 2021

Eklutna 6 looking downstream – June 9, 2022

Eklutna 6 looking downstream – October 4, 2023

Eklutna 8 looking upstream – August 31, 2021

Eklutna 8 looking upstream – June 9, 2022

Eklutna 8 looking upstream – October 4, 2023

Eklutna 8 looking downstream – August 31, 2021

Eklutna 8 looking downstream – June 9, 2022

Eklutna 8 looking downstream – October 4, 2023

Eklutna 10 looking upstream – August 31, 2021

Eklutna 10 looking upstream – September 2, 2022


Eklutna 10 looking upstream – October 4, 2023

Eklutna 10 looking downstream – August 31, 2021

Eklutna 10 looking downstream – September 2, 2022


Eklutna 10 looking downstream – October 4, 2023