Technical Report No. 19-13

Eklutna River Aquatic Habitat Monitoring, 2019

by

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and

Ron Benkert

January 2020

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

Symbols and Abbreviations

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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	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
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: Deconstructed Lower Eklutna River 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 to complete the final two years of USACE required monitoring.

We conducted two sampling events during 2019, visiting four previously 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 dam site. At each of the three lower sites, a suite of variables including channel geometry, substrate composition, and water quality were recorded. Continuous water temperature monitoring sites were established at two of these three locations. At the one site upstream from the dam site, only water quality variables were recorded in addition to the establishment of a third continuous temperature monitoring location.

At the two monitoring sites upstream from the Thunder Bird Creek confluence, channel geometry measurements indicated aggradation occurred following dam deconstruction. Dominant substrates generally transitioned from silt/sand and cobble prior to dam deconstruction to mostly medium gravel dominance with the D_{50} particle size generally increasing, and D_{84} particle size generally decreasing. Water quality at these two sites were generally within expected ranges; however, pH was consistently high, ranging from 8.44 to 8.70.

All recorded variables from the monitoring site downstream from the Thunder Bird Creek confluence generally remained unchanged.

At the water quality sampling location upstream from the sediment plug, all variables were found to be within expected range. Interestingly, pH was again high; however, it tracked closely to measurements taken at each of the other monitoring sites.

INTRODUCTION

The Eklutna River flows approximately 32 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 two miles upstream from Cook Inlet. The Eklutna River was obstructed by dams for nearly a century. The first obstruction constructed in 1929 was a concrete dam designed for hydroelectric generation. It was located in the vertical-walled canyon roughly 4.8 km (3 miles) upstream from the Glenn Highway and Cook Inlet and less than a mile and a half upstream from the Thunder Bird Creek confluence. The second dam was constructed in 1955 at the outlet of Eklutna Lake to facilitate power generation and store potable water for Anchorage and the surrounding areas. Fish passage was completely blocked by the lower dam. 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. This has resulted in a relatively flat hydrograph with discharges of between 8 and 24 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.

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 accounts, some species potentially migrated upstream into Eklutna Lake (Mark Lamoreaux, Biologist, NVE, Personal Communication). A population of landlocked sockeye salmon still inhabits the lake. 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 fishes inhabit the lower river below the confluence with Thunder Bird Creek, although in 2007 juvenile Chinook and coho salmon were documented about 0.8 km (0.5 miles) above the confluence of Thunder Bird Creek. Fish sampling effort conducted by the ADF&G Habitat Section in 2019 documented spawning chum salmon below the Thunder Bird Creek confluence and found juvenile Chinook and coho salmon upstream to the base of a naturally occurring bedrock constriction barrier one mile upstream of Thunder Bird Creek.

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. This included the collection of data describing channel geometry, substrate composition, and water quality prior to and after dam removal.

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. 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 to continue the existing environmental studies program through completion and to produce the remaining requisite annual and final reports. This 2019 interim report represents a summary of data collected from 2017 prior to dam removal through September 2019. A final report will be produced in February of 2021 presenting all USACE required data and analyses following the completion of all contractual obligations from data collected through autumn of 2020.

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) (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 to the south and the other dominated by ground water and non-glacial surface runoff to the north. 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 plan 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. Discharges through this section remain relatively stable throughout the year. 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 lower most monitoring site is within this river section.

Fish Distribution Within the Study Area

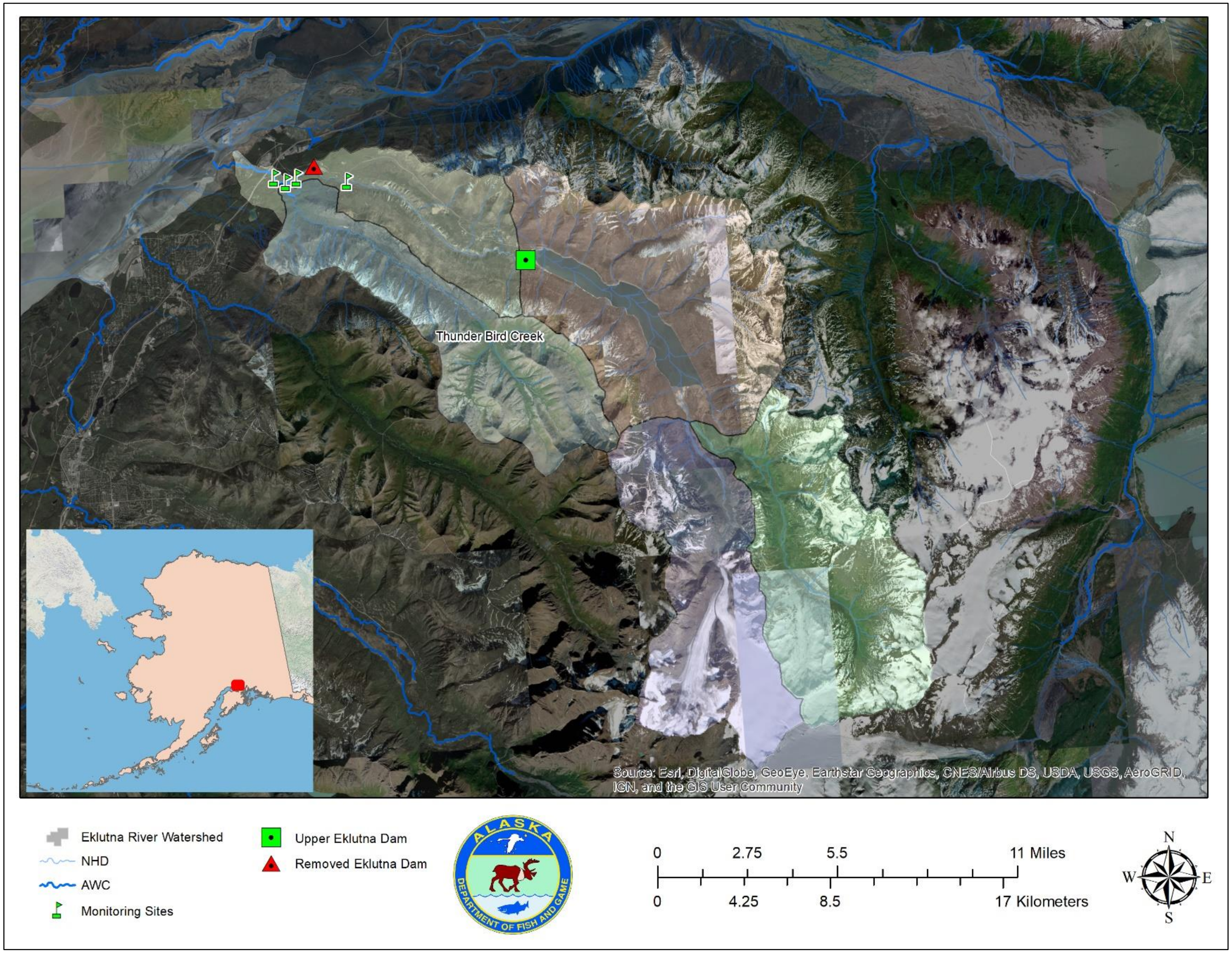
The Eklutna River is documented in the Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Anadromous Waters Catalog [AWC]) (Alaska Department of Fish and Game, 2018)) to support all five species of Pacific salmon; however, the current upstream extent of AWC documented habitat extends less than 4.8 km (3 miles) upstream from Cook Inlet and less than 0.8 km (0.5 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*), and slimy sculpin (*Cottus cognatus*).

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 attempts. Concurrently, visual observations were made of any adult salmon visible in the turbid water. A total of 57 juvenile coho salmon, 58 juvenile Chinook salmon, and 26 Dolly Varden were captured ranging upstream to a natural fish passage barrier located 1.6 km (1 mile) upstream from Thunder Bird Creek. Additionally, one adult stream resident Dolly Varden was captured upstream from the fish barrier indicating suitable fish habitat may exist above the barrier throughout the year. Finally, three distinct chum salmon spawning areas were documented downstream from Thunder Bird Creek. Observations from this sampling effort have been nominated for inclusion in the AWC and are anticipated to be adopted into the catalog by June 2020.

Eklutna Lake is known to support resident sockeye salmon (*Oncorhynchus nerka*) (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 an historic population of anadromous sockeye salmon in Eklutna Lake.

Thunder Bird Creek is documented in the AWC to support Chinook salmon (*Oncorhynchus tshawytscha*) as well as a suite of resident fish species similar to the Eklutna River. Thunder Bird Falls, a large waterfall, is located about 1.6 km (1 mile) upstream on Thunder Bird Creek and marks the upstream extend of salmon habitat.

Figure 1.– Eklutna River Watershed Map.



OBJECTIVES

The objective of this monitoring project is to fulfill several Clean Water Act 404 permit conditions issued to Eklutna, Inc. by the USACE. These conditions include documenting changes to physical habitat in the middle and lower Eklutna River in response to the deconstruction of the lower Eklutna River hydroelectric dam completed during fall of 2018. To achieve the objective, the following tasks need to be completed:

Task 1: Select monitoring sites. This included three representative monitoring sites downstream from the deconstructed 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. An additional water quality-only monitoring site upstream from the sediment plug above the deconstructed dam site also was chosen.

Task 2: Conduct cross-sectional surveys at an established location within each of the full monitoring site locations biannually through 2020.

Task 3: Characterize substrate composition within each of the full monitoring sites using standardized techniques biannually through 2020.

Task 4: Monitor water quality variables weekly at one location upstream and one location downstream of the sediment plug for the first year following dam removal. Thereafter, monitor water quality variables at one location upstream from the sediment plug, as well as at each monitoring site during regularly scheduled biannual field visits.

Task 5: Record continuous water temperature readings at the water quality only site upstream from the sediment plug, and one location upstream and one location downstream of the Thunder Bird Creek confluence.

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

METHODS

Monitoring Sites

The complete suite of monitoring locations are shown in Figure 2.

Prior to the completion of dam removal, three monitoring sites were established in the Eklutna River (Table 1). Two monitoring sites were selected upstream from the Thunder Bird Creek confluence and one monitoring site was selected downstream of the confluence. 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 plug upstream from the dam site. This monitoring site was established solely to record water quality parameters biannually in conjunction with other monitoring events. Additionally, three continuous temperature monitoring sites were established as shown below. Each site will be visited biannually through 2020.

Table 1.– Eklutna River monitoring locations.

Site	Latitude	Longitude	Comments
WQ Site	61.444	-149.302	Water Quality only site located upstream from sediment plug
Eklutna 6	61.4471	-149.348	Full monitoring site includes continuous temperature monitoring
Eklutna 8	61.4454	-149.359	Full monitoring site without continuous temperature monitoring
Eklutna 10	61.4477	-149.369	Full monitoring site includes continuous temperature monitoring

Figure 2.– Eklutna River Monitoring Site Map

Fieldwork Dates and Collection Effort

All sampling dates and collection effort are listed in Table 2 below.

In May 2017, baseline geomorphic and substrate composition data were collected following break-up. Following dam removal in autumn of 2018, the first round of post-dam-removal data were collected in October prior to freeze-up; however, neither the upstream WQ monitoring site nor the continuous temperature monitoring sites were yet established. In 2019, all monitoring sites were established and visited. All data were collected during two distinct field events, the first in May following break-up and the second in September prior to freeze-up.

Table 2.– Sampling dates and collection effort.

Date	Site	Channel Geometry	Substrate Composition	Water Quality[b]	Continuous Temperature[c]
5/17/2017	WQ Site[a]	-	-	-	-
	Eklutna 6	X	X	-	-
	Eklutna 8	X	X	-	-
	Eklutna 10	X	X	-	-
10/11/2018	WQ Site[a]	-	-	-	-
	Eklutna 6	X	X	X	-
	Eklutna 8	X	X	X	-
	Eklutna 10	X	X	X	-
6/13/2019	WQ Site	-	-	X	X
	Eklutna 6	X	X	X	X
	Eklutna 8	X	X	X	-
	Eklutna 10	X	X	X	X
9/25/2019	WQ Site	-	-	X	X
	Eklutna 6	X	X	X	X
	Eklutna 8	X	X	X	-
	Eklutna 10	X	X	X	X

[a] Upstream WQ-only site not established until June 2019
[B] Water quality variables not recorded until 2018
[C] Continuous temperature monitoring locations not established until 2019

Channel Geometry

Physical changes to channel geometry were assessed by conducting biannual cross-sectional surveys at previously established locations within each of the three monitoring sites described above. Each of the three 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 were recorded. In addition to these incremental measurements, the following typical geomorphic features also were measured:

- left and right top of bank
- left and right bottom of bank
- ordinary high water line (OHW)
- thalweg
- edge of water (both banks)
- bankfull elevation (both banks)
- channel irregularities or unique channel features

Graphical representations of channel profiles collected during each event at each survey location are provided in Appendix A.

Substrate Composition

Composition of stream substrate particles play an important role in supporting fish populations. For example, boulders support resting and feeding behavior and provide refuge from predators by providing eddies and resting 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 also can reduce spawning habitat quality for salmonids.

Prior to dam deconstruction, we observed substrate conditions upstream from the Thunder Bird Creek confluence were not conducive to supporting productive fish habitats. 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 diminished flow and a reduction in stream energy needed to transport substrate other than fine particles through the system. This embedding and armoring of surface bed materials commonly occurs below dams because of the interruption of bedload movement. With an estimated 230,000 cy of sediment (HDR, 2016) impounded behind the lower dam (referred to here as the sediment plug), a key objective of this study is to document the transport of this newly available sediment down the system following dam deconstruction and assess how this changes the relative proportion of particle classes and fish habitat.

Substrate composition was characterized at each monitoring site using the Wolman Pebble Count methodology (Wolman 1954, cited in USFS 2001) where by 20 substrate particles were randomly selected, 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 were 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 changes.

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

Water Quality

Water quality parameters including water temperature, dissolved oxygen, pH, and conductivity were measured using a YSI Pro Plus multiparameter meter. Turbidity was measured using a Hach 2100Q. Continuous water temperature readings were collected using Tidbit MX Temp 400 loggers set to record temperature measurements every hour during the monitoring season.

Water quality parameters were not recorded prior to dam deconstruction. Water temperature, dissolved oxygen, pH, and conductivity were recorded at each site downstream from the dam deconstruction site beginning in October 2018. Turbidity was added for all subsequent sampling events.

The water quality only monitoring site was added in 2019. All water quality parameters listed above were recorded at this location during each visit in 2019.

The continuous water temperature loggers were installed in 2019 at the water quality only site as well as at Eklutna 6 and Eklutna 10. These loggers were removed for the winter following the final sampling event of 2019.

Quality Assurance Plan

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

DATA ANALYSIS

The purpose of this 2019 interim report is to describe the monitoring project and present field data in raw form along with text summaries and graphical representations, but with limited analysis. A more robust analytical effort will be implemented prior to submittal of the final project report in February 2021, and will include an analysis of secondary effects resulting from dam removal observed across the entire monitoring timeline. Results from each sampling event will be compared with one another and with assumptions used for the sediment transport analysis, including at minimum:

- channel geometry
- substrate composition
- water quality parameters

RESULTS AND DISCUSSION

As a result of this monitoring project, a suite of geomorphic and water quality variables were measured prior to and following dam deconstruction. Measured variables have been assessed to describe how channel geometry and substrate composition changed.

At the two monitoring sites upstream from the Thunder Bird Creek confluence (*Eklutna 6* and *Eklutna 8*), channel geometry measurements indicate that aggradation occurred following dam deconstruction. Substrate compositions generally transitioned from silt/sand and cobble dominant to mostly medium gravel dominant with the D_{50} generally increasing, and the D_{84} generally decreasing. Water quality at these two sites were generally within expected ranges, however pH was consistently found to be high, ranging from 8.44 to 8.70.

All recorded variables from the monitoring site downstream of the Thunder Bird Creek confluence (*Eklutna 10*) generally remained unchanged.

At the water quality sampling location upstream of the sediment plug, all variables were found to be within expected range although pH was high, but tracked closely to measurements taken at each of the other monitoring sites.

Appendix A provides graphical summaries of all data collected at *Eklutna 6 (*Appendix A1), *Eklutna 8* (Appendix A2), and *Eklutna 10* (Appendix A3). Substrate composition (D_{50} and D_{84}) is displayed for all sampling events at each monitoring site in Appendix A4. All water quality variables collected at each monitoring site are presented in Appendix A5. Graphs displaying all continuous water temperature data collected at *Eklutna 6*, *Eklutna 10*, and the *WQ Site* are displayed in Appendix 6 through Appendix 8 respectively.

EKLUTNA 6

<u>Visit #1:</u> Monitoring site *Eklutna 6* was established by ADF&G–Habitat and NOAA personnel on 5/17/2017 about 0.6 miles downstream from the dam deconstruction site. During this initial visit, the channel geometry transect was established and measured, and substrate composition recorded. Water quality variables were not recorded.

Substrate composition was generally dominated by fine sands and large cobbles with a D_{50} of fine gravel and a D_{84} of coarse cobble.

<u>Visit #2:</u> On 10/11/2018, *Eklutna 6* was visited following the completion of dam deconstruction. During this visit, ADF&G–Habitat and NVE personnel resurveyed the channel geometry transect, recorded substrate composition, and collected a suite of water quality variables including instantaneous temperature, dissolved oxygen, and conductivity; turbidity and pH were not measured.

Compared to the previous visit, the channel aggraded by about ½ foot with mobilized sediment. Substrate composition transitioned to silt and medium-gravel dominant with a decrease in relative abundance of sand and cobble. The D_{50} particle size increased from fine to medium gravel while the D_{84} decreased from large cobble to very coarse gravel. Water quality parameters generally were within expected ranges, except dissolved oxygen readings were abnormally high. This anomaly was likely the result of a faulty sensor.

<u>Visit #3:</u> *Eklutna 6* was visited on 6/13/2019 by ADF&G–Habitat personnel. During this visit channel geometry was surveyed, and substrate composition and water quality recorded. Turbidity

and pH were added to the suite of water quality variables recorded, and a Tidbit MX Temp 400 continuous water temperature monitor was established about 50 meters upstream from the channel geometry transect.

We found that the channel had begun to down-cut into the previously aggraded material by about ¼ foot. Substrate composition became increasingly dominated by silts and coarse gravel, with the D_{50} increasing further to coarse gravel and the D_{84} decreasing slightly. Embeddedness was noted to have decreased from prior sampling events. Water quality variables generally were non-noteworthy; however, pH was recorded at 8.7 which is high. The dissolved oxygen level was recorded to be within expected range (approximately 100% saturation).

Visit #4: On 9/25/2019, *Eklutna 6* was again visited by ADF&G–Habitat personnel. During this visit, all data types collected during the June 2019 visit were recorded. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

The channel had again begun to aggrade nearly to the level observed during the October 2018 visit. Substrate composition was dominated by silts and fine cobble, while the D_{50} increased to very coarse gravel and the D_{84} increased to small cobble. Substrate embeddedness was noted to have continued to decrease from previous sampling events. Water quality variables were not noteworthy, but pH was high at 8.44.

EKLUTNA 8

Visit #1: Monitoring site *Eklutna 8* was established on 5/17/2017, about 1.6 km (1 mile) downstream from the dam deconstruction site. During the initial visit, the channel geometry transect was established and measured and substrate composition recorded. Water quality variables were not recorded.

Substrate composition generally was dominated by silts, fine gravel, and coarse cobble with a D_{50} of fine gravel and a D_{84} of large cobble.

Visit #2: *Eklutna 8* was revisited on 10/11/2018, following the completion of dam deconstruction. During this visit, ADF&G–Habitat and NVE personnel resurveyed the channel geometry transect, recorded substrate composition, and collected a suite of water quality variables including instantaneous temperature, dissolved oxygen, and conductivity; turbidity and pH was not measured.

Compared to the previous visit, the channel aggraded by nearly one foot with mobilized sediment. Substrate composition transitioned to primarily medium-gravel dominant with a decrease in relative abundance of silts, sand and cobble. The D_{50} particle size increased slightly while the D_{84} decreased substantially from large cobble to medium gravel. Water quality variables generally were within expected ranges; however, dissolved oxygen readings were abnormally high. This was likely the result of a faulty sensor.

Visit #3: *Eklutna 8* was again visited on 6/13/2019 by ADF&G–Habitat personnel. During this visit, channel geometry was surveyed, and substrate composition and water quality recorded. Turbidity was added to the suite of water quality variables recorded. Continuous water temperature was not monitored at this site.

The channel continued to aggrade. Substrate composition remained similar to the previous visit, although theD_{50} increased to medium gravel and the D_{84} increased slightly to coarse gravel. Water quality parameters were similar to those previously recorded.

Visit #4: On 9/25/2019, *Eklutna 8* was visited by ADF&G–Habitat personnel. During this visit, all data parameters collected during the previous visit were recorded.

The channel aggraded further. Substrate composition was similar to the previous two visits with the D_{50} and the D_{84} remaining virtually unchanged. Water quality variables were similar to previous recordings.

EKLUTNA 10

Visit #1: Monitoring site *Eklutna 10* was established on 5/17/2017, about 0.8 km (0.5miles) downstream from the Thunder Bird Creek confluence. During the initial visit, the channel geometry transect was established and measured, and substrate composition recorded. Water quality variables were not recorded.

Substrate composition was generally dominated by medium gravels through coarse cobble with a D_{50} of coarse gravel and a D_{84} of large cobble.

Visit #2: *Eklutna 10* was revisited on 10/11/2018 following the completion of dam deconstruction. During this visit, ADF&G–Habitat and NVE personnel resurveyed the channel geometry transect and collected a suite of water quality variables including instantaneous temperature, dissolved oxygen, and conductivity. Turbidity and pH were not measured. Substrate composition was not recorded during this event due to weather conditions.

Channel geometry remained very similar to the previous visit. Substrate composition was not recorded due to unsuitable stream conditions. Water quality variables were generally within expected ranges, except that dissolved oxygen readings were abnormally high. This was likely the result of a faulty sensor.

Visit #3: *Eklutna 10* was again visited on 6/13/2019 by ADF&G–Habitat personnel. During this visit, channel geometry was surveyed and substrate composition and water quality recorded. Turbidity and pH were added to the suite of water quality variables recorded and a Tidbit MX Temp 400 continuous water temperature monitor was established about 20 meters downstream from the channel geometry transect.

Channel geometry was virtually unchanged from previous surveys. Substrate composition was similar to previous samples although the D_{50} increased slightly to very coarse gravel while the D_{84} remained virtually unchanged. Water quality variables were generally similar to previous visits; turbidity, as expected, decreased substantially from monitoring locations upstream from Thunder Bird Creek because of clear water input from Thunder Bird Creek.

Visit #4: On 9/25/2019, *Eklutna 8* was again visited by ADF&G–Habitat personnel. During this visit, all data collected during the June 2019 visit were recorded. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

We found channel geometry essentially unchanged. Similarly, substrate composition remained largely unchanged despite a slight decrease in the D_{84} to small cobble. Water quality variables were similar to previous visits.

WATER QUALITY (WQ) SITE

Visit #1: On 6/21/2019, ADF&G–Habitat personnel established a water quality monitoring site upstream from the sediment plug. During this visit, we measured instantaneous water quality variables including temperature, dissolved oxygen, pH, conductivity, and turbidity. Additionally, we installed a Tidbit MX Temp 400 continuous water temperature monitor.

All water quality variables were similar to those found at downstream locations.

Visit #2: On 9/25/2019 ADF&G–Habitat revisited this water quality monitoring site and found all measured variables were within expected ranges and similar to those recorded at downstream monitoring sites. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

CONCLUSION

The ADF&G-Habitat will continue to observe and document changes to the Eklutna River channel resulting from the deconstruction of the lower dam through the termination of this current monitoring program in the fall of 2020. Establishment of the monitoring sites and continued monitoring may provide valuable information for future actions within the Eklutna River basin. Currently negotiations are being conducted per the 1991 sales agreement between the utilities and the State of Alaska to develop a mitigation plan for the effects of project operations on the Eklutna River. The current monitoring effort could be extended to assist in the evaluation of the success of any mitigation developed as the result of these negotiations.

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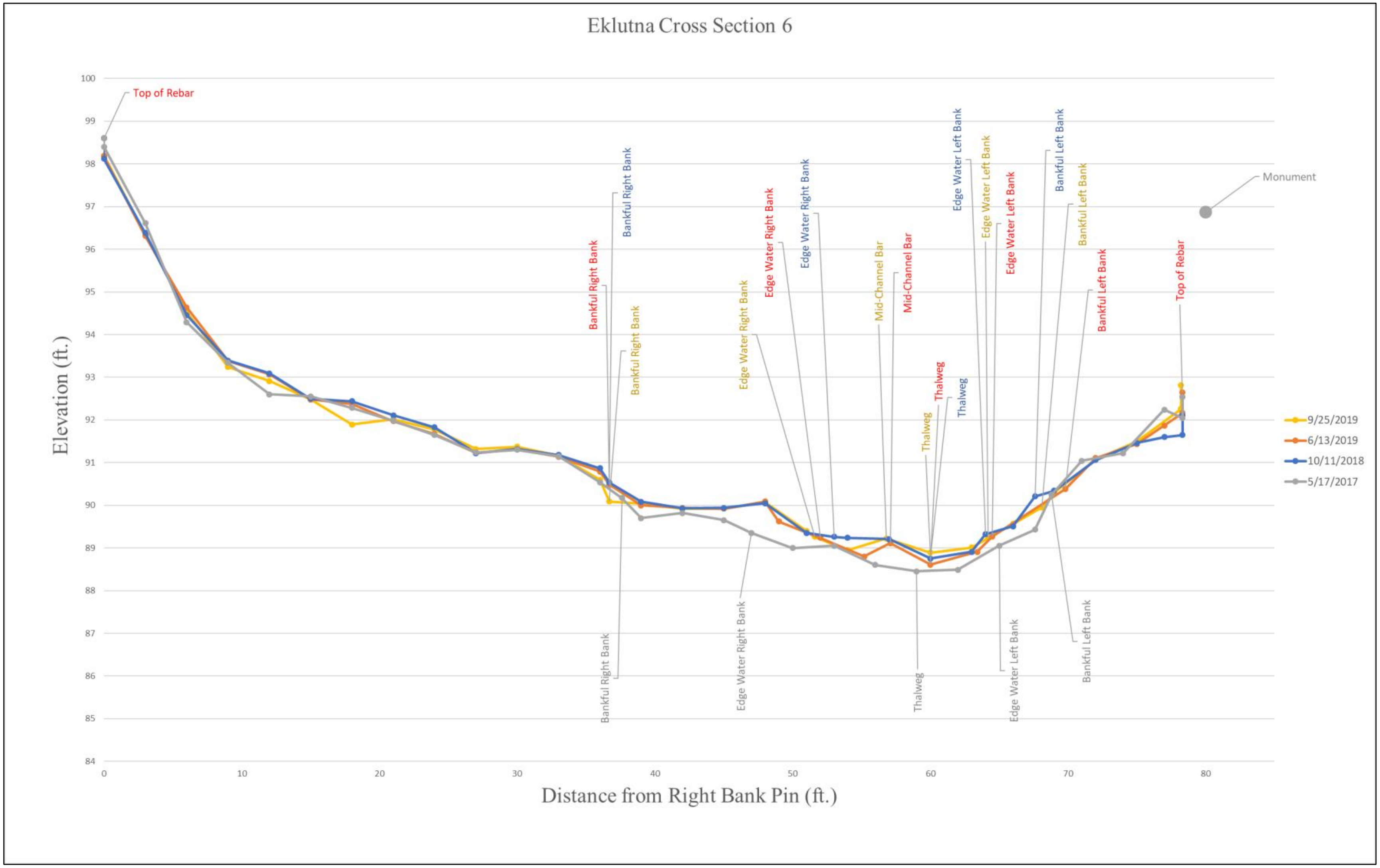
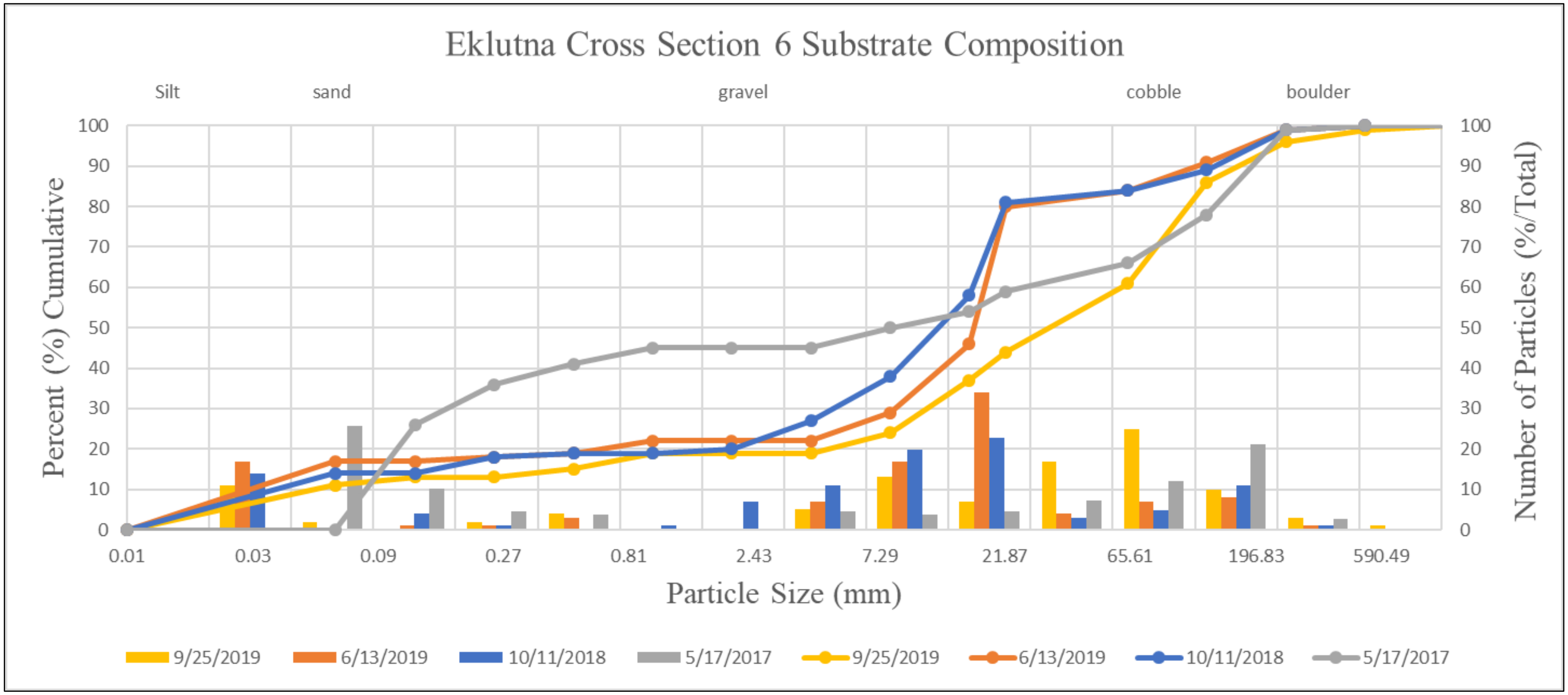
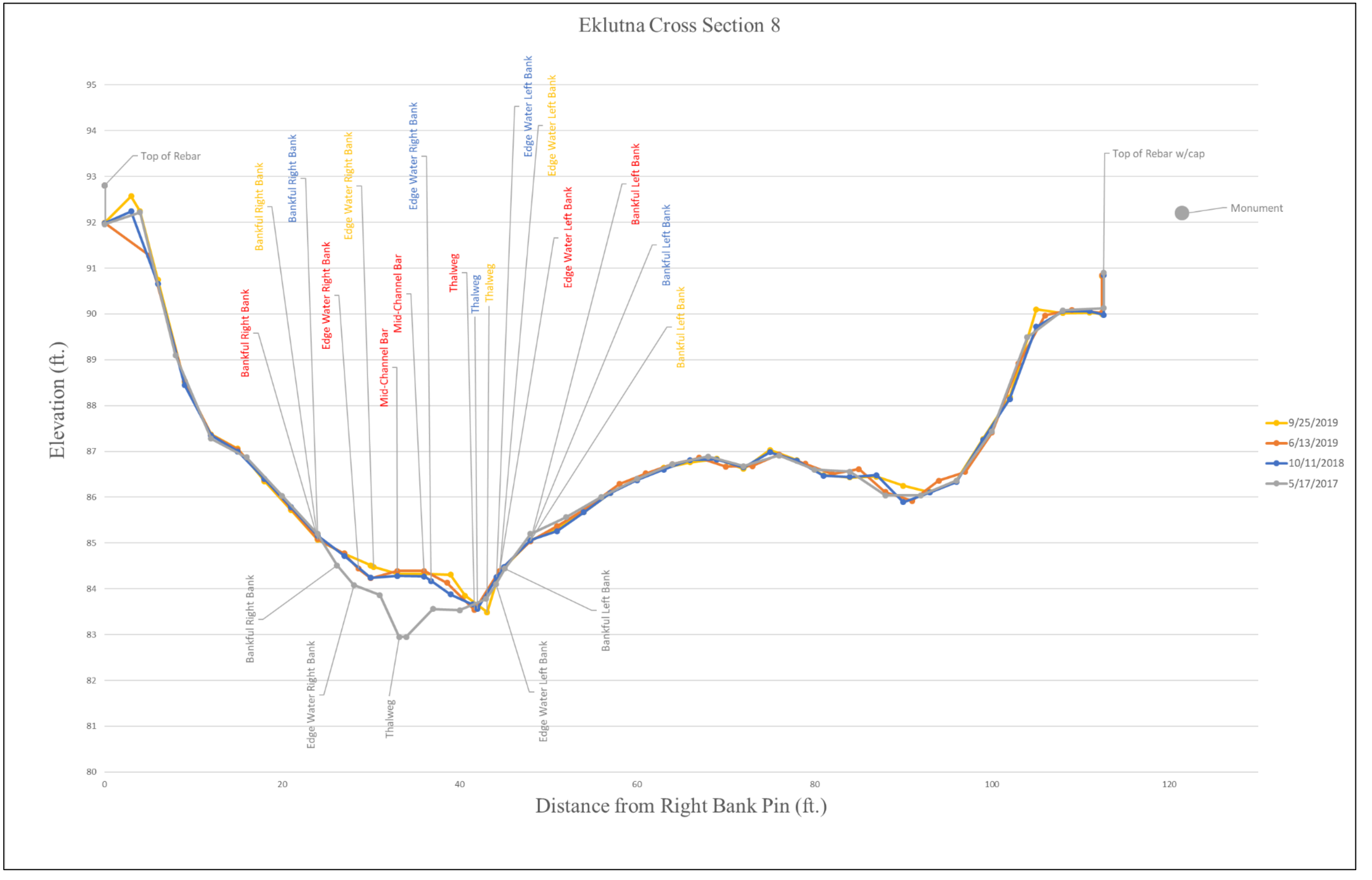
APPENDIX A: GRAPHICAL SUMMARIES OF FIELD DATA

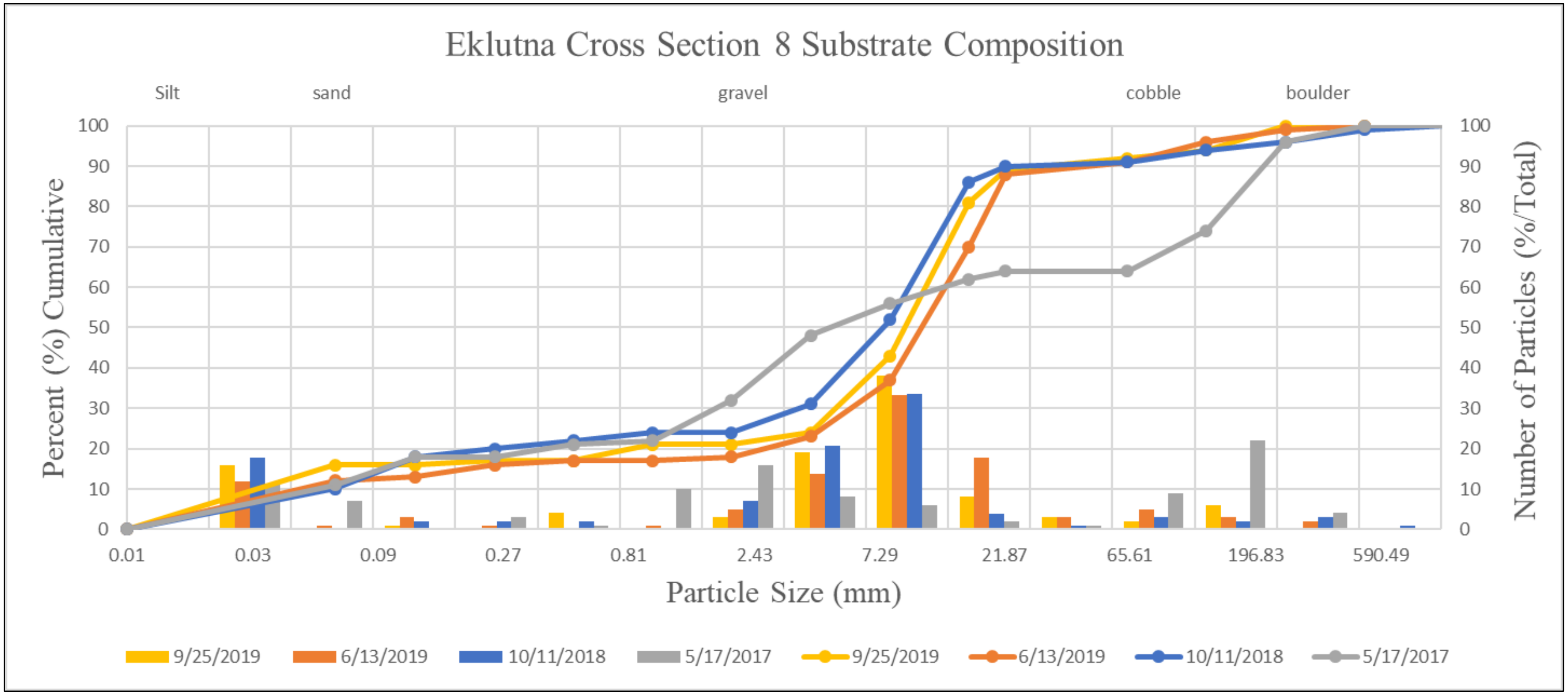
Appendix A1.–Eklutna 6 Channel Geometry and Substrate Composition.



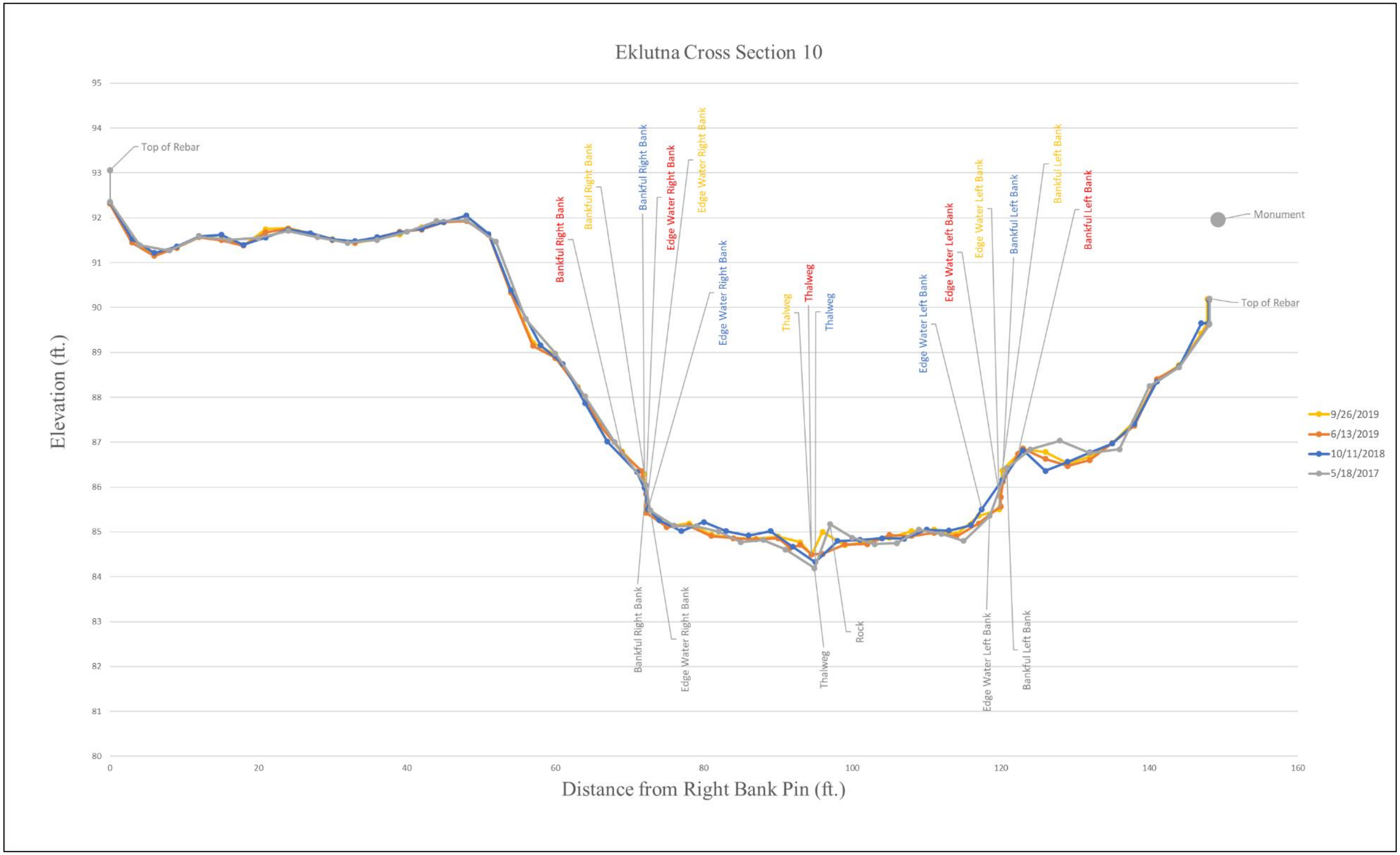

Eklutna Cross Section 6 Substrate Composition
Silt
sand
gravel
cobble
boulder
Percent (%) Cumulative
Number of Particles (%/Total)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.03
0.09
0.27
0.81
2.43
7.29
21.87
65.61
196.83
590.49
Particle Size (mm)
9/25/2019
6/13/2019
10/11/2018
5/17/2017

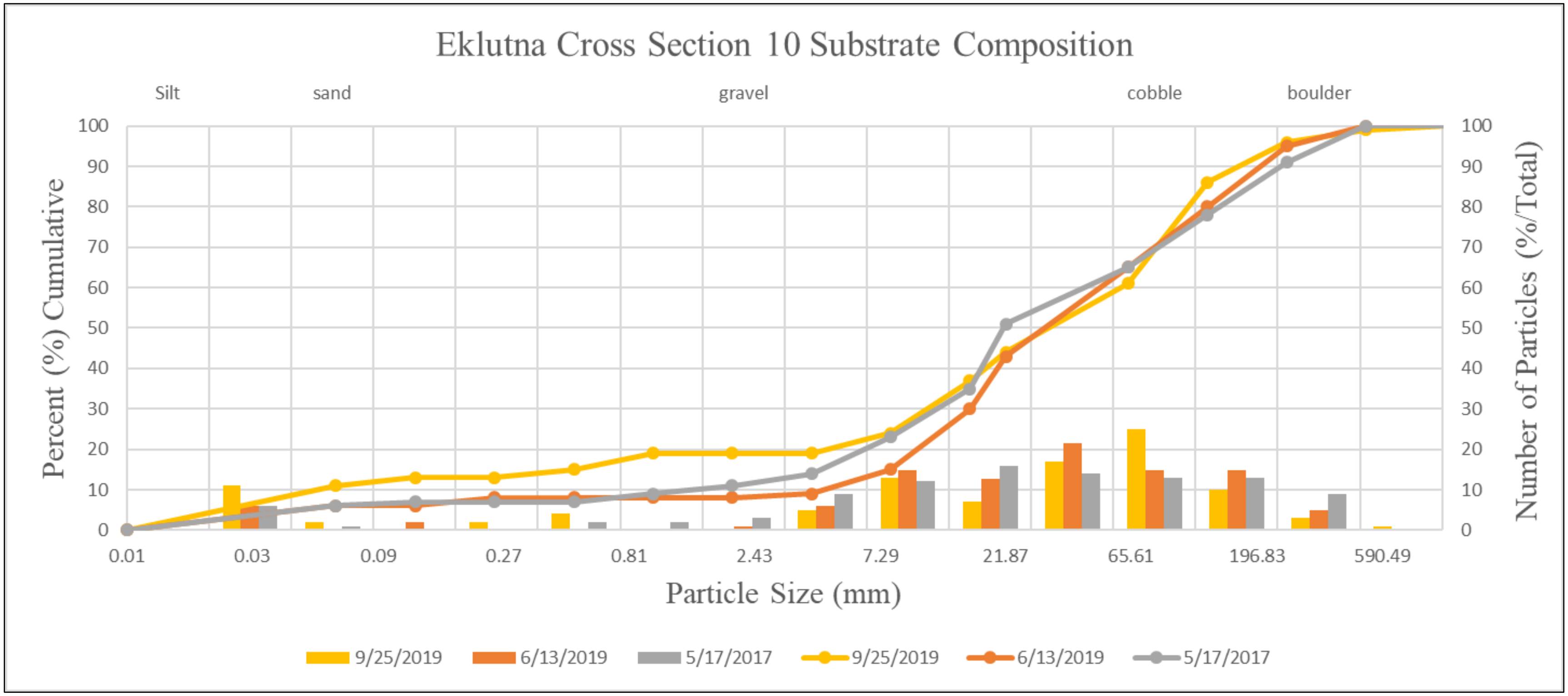
Appendix A2.–Eklutna 8 Channel Geometry and Substrate Composition.




Eklutna Cross Section 8 Substrate Composition
Silt
sand
gravel
cobble
boulder
Percent (%) Cumulative
Number of Particles (%/Total)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.03
0.09
0.27
0.81
2.43
7.29
21.87
65.61
196.83
590.49
Particle Size (mm)
9/25/2019
6/13/2019
10/11/2018
5/17/2017
9/25/2019
6/13/2019
10/11/2018
5/17/2017

Appendix A3.–Eklutna 10 Channel Geometry and Substrate Composition.





Eklutna Cross Section 10 Substrate Composition
Silt
sand
gravel
cobble
boulder
Percent (%) Cumulative
Number of Particles (%/Total)
100
90
80
70
60
50
40
30
20
10
0
0.01
0.03
0.09
0.27
0.81
2.43
7.29
21.87
65.61
196.83
590.49
Particle Size (mm)
9/25/2019
6/13/2019
5/17/2017
9/25/2019
6/13/2019
5/17/2017

Appendix A4.–Substrate Composition Table.

	Cross Section 6		Cross Section 8		Cross Section 10	
Date	D_{50}	D_{84}	D_{50}	D_{84}	D_{50}	D_{84}
5/17/2017	Fine Gravel	Large Cobble	Fine Gravel	Large Cobble	Coarse Gravel	Large Cobble
10/11/2018	Medium Gravel	Very Coarse Gravel	Fine Gravel	Medium Gravel	-	-
6/13/2019	Coarse Gravel	Very Coarse Gravel	Medium Gravel	Coarse Gravel	Very Coarse Gravel	Large Cobble
9/25/2019	Very Coarse Gravel	Small Cobble	Medium Gravel	Coarse Gravel	Very Coarse Gravel	Small Cobble

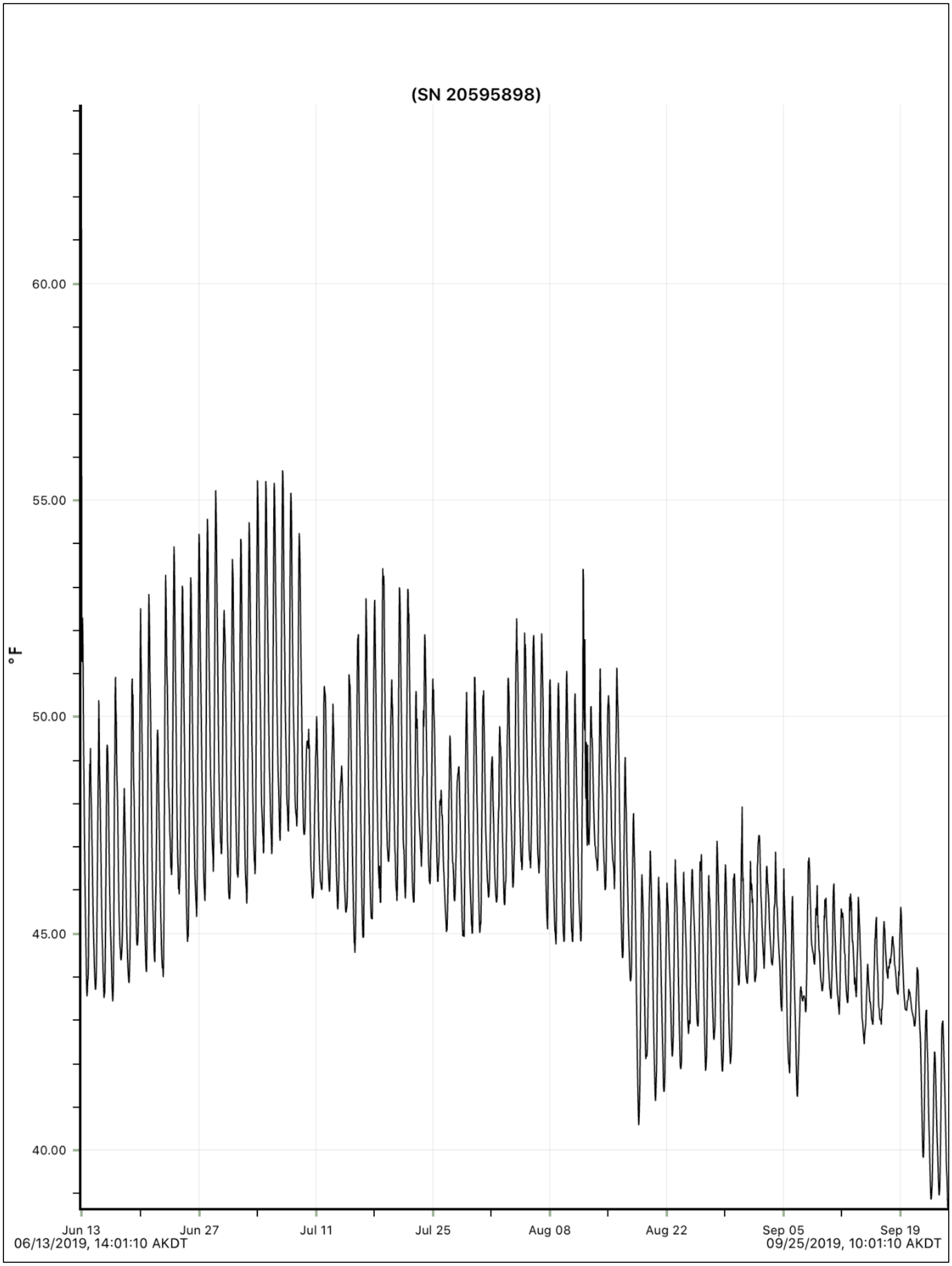
Note: Size ranges for substrate classifications: Fine Gravel = 4–8 mm; Medium Gravel = 8–16 mm; Coarse Gravel = 16–32 mm; Very Coarse Gravel = 32–64 mm; Small Cobble = 64–128 mm; Large Cobble = 128–256 mm.

Appendix A5.–Water Quality Variables.

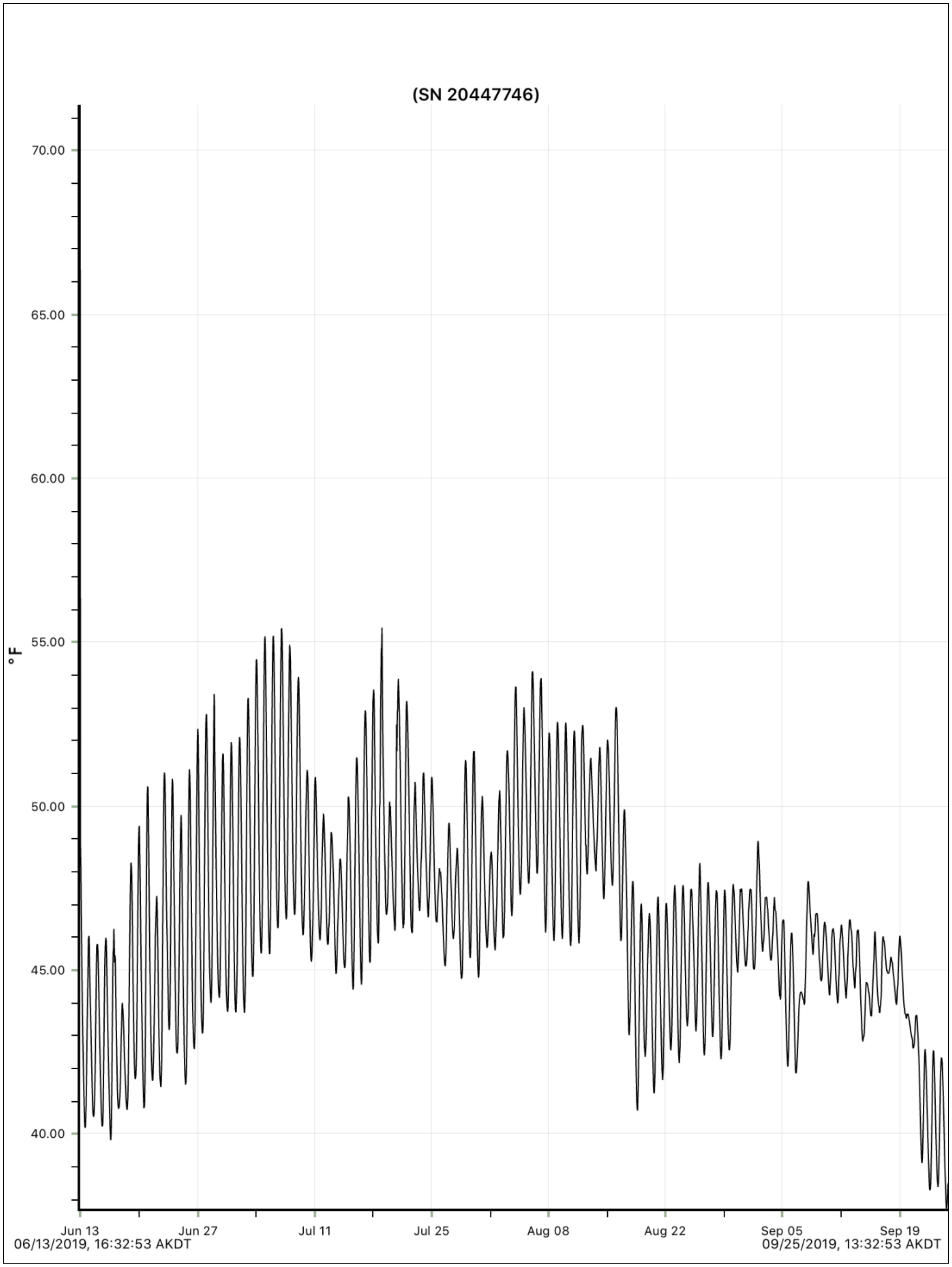
	Eklutna 6			Eklutna 8			Eklutna 10			WQ Site	
Water Quality Variable	**10/11/2018 ***	**6/13/2019**	**9/25/2019**	**10/11/2018 ***	**6/13/2019**	**9/25/2019**	**10/11/2018 ***	**6/13/2019**	**9/25/2019**	**6/13/2019**	**9/25/2019**
Temperature	4.7	11.2	3.9	4.9	11.6	4.3	4.6	9.7	3.7	2.5	3.4
Dissolved Oxygen (mg/L)	17.52	11.28	12.69	18.2	11.1	12.53	17.2	11.75	12.71	10.46	13.65
Dissolved Oxygen (% Saturation)	136.4	102.8	97	142.4	102.6	96.3	133.6	103.6	96.3	98	102.6
Conductivity	245	279	248	205	302	246	255	255	277	304	231.6
pH	~	8.7	8.44	~	8.52	8.58	~	8.36	8.53	8.35	8.51
Turbidity	~	78	54	~	118	56	~	18	13	48	29

* Variables collected with a different water quality meter and DO variables were questionable.

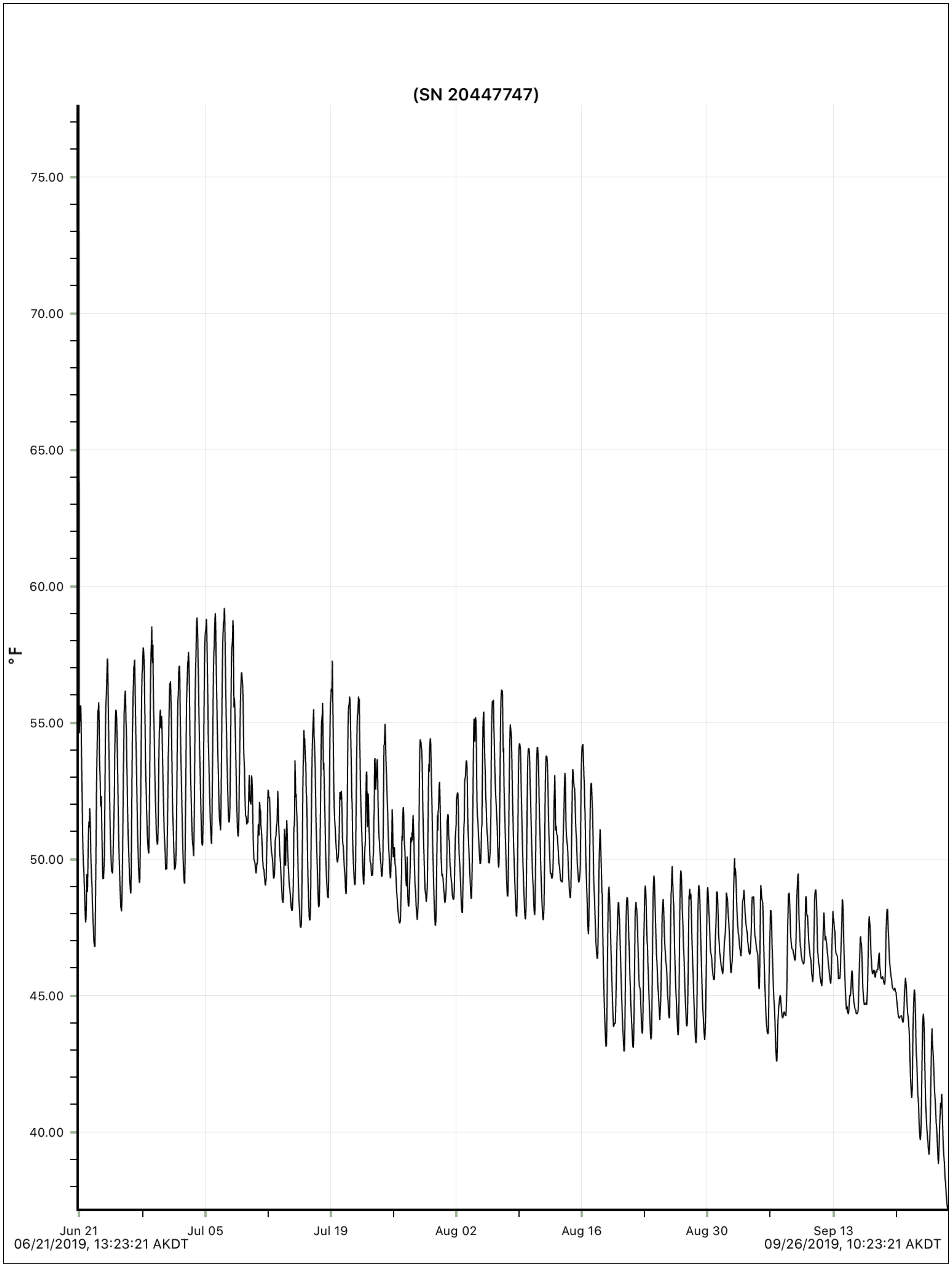
Appendix A6.–Eklutna 6 Continuous Temperature Data.



Appendix A7.–Eklutna 10 Continuous Temperature Data.



Appendix A8.–WQ Site Continuous Temperature Data.



APPENDIX B: EKLUTNA SITE PHOTOS

Appendix B1.–Eklutna 6 Site Photos

Eklutna 6–May 2017

Eklutna 6–October 2018

Eklutna 6–June 2019

Eklutna 6–September 2019

Appendix B2.–Eklutna 8 Site Photos

Eklutna 8–May 2017

Eklutna 8–October 2018

Eklutna 8–June 2019

Eklutna 8–September 2019

Appendix B3.–Eklutna 10 Site Photos

Eklutna 10–May 2017

Eklutna 10–October 2018

Eklutna 10–September 2019