Technical Report No. 21-02

Eklutna River Aquatic Habitat Monitoring, 2017 Through 2020

by

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and

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ALASKA DEPARTMENT OF FISH AND GAME

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	≥
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: 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 to complete the final two years of USACE required monitoring.

We conducted two sampling events during both 2019 and 2020, 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 bed elevations fluctuated through time but generally showed aggradation occurred following dam deconstruction. Dominant substrates generally transitioned from silt/sand and cobble prior to dam deconstruction to mostly medium to coarse 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 un-noteworthy; however, pH was consistently high, ranging from 8.28 to 8.70.

All recorded variables from the monitoring site downstream from the Thunder Bird Creek confluence generally remained stable throughout the monitored period.

At the water quality sampling location upstream from the sediment plug, all variables were generally un-noteworthy, however, pH was again high but tracked closely with measurements taken at each of the other monitoring sites.

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 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 3.2 km (2 miles) upstream from the New Glenn Highway 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 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.

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. Subsequent fish sampling effort conducted by the ADF&G Habitat Section in 2019 and 2020 documented spawning chum salmon below the Thunder Bird Creek confluence and found juvenile Chinook salmon rearing upstream to the base of a naturally occurring bedrock constriction barrier one mile upstream of Thunder Bird Creek. Juvenile coho salmon have subsequently been found nearly a mile upstream from the deconstructed dam site, and adult coho salmon have been found migrating upstream from the Thunder Bird Creek confluence.

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 following 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 Section to continue the existing environmental studies program through its completion in 2020 and to produce the remaining requisite annual and final reports. This final project technical report presents a summary of all data collected from 2017 prior to dam removal through the final monitoring event in September 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) 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 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 (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, 2019) to support all five species of Pacific salmon; however, the current upstream extent of AWC documented habitat extends less than 4.8 km (3.5 miles) upstream from Cook Inlet and less than 1.6 km (1 mile) 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*).

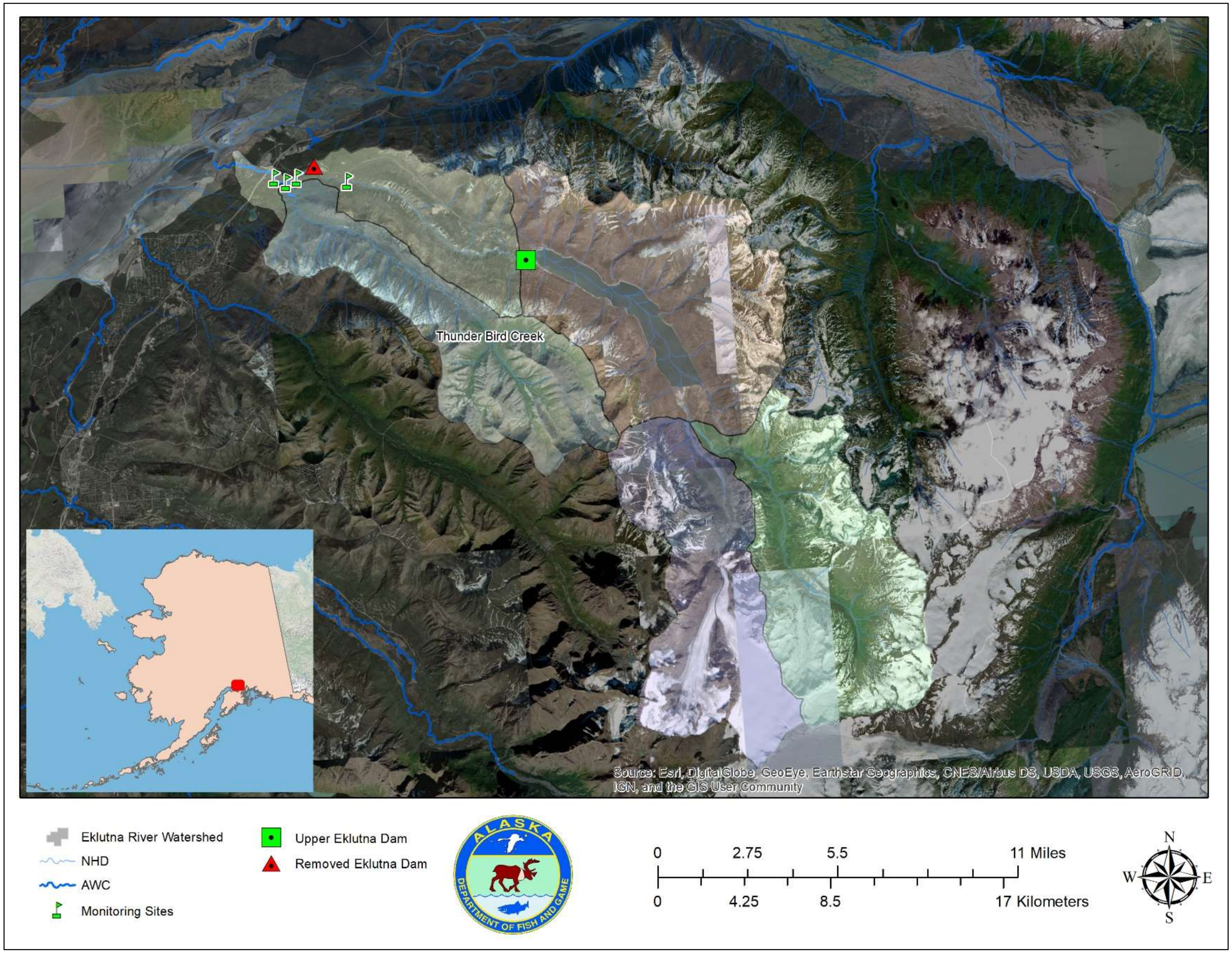
In 2019, the ADF&G–Habitat Section conducted a fish sampling effort from the Old Glenn Highway bridge upstream to the dam deconstruction site. During a single day of sampling, 10 baited minnow traps were set along with many opportunistic dip net sweeps. Concurrently, visual observations were made of 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 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 were adopted into the Anadromous Waters Catalog in June 2020.

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 mile upstream from the 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, apparently 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 mile from the deconstructed dam site. This confirmed that juvenile salmon are now able to migrate throughout most of the system during certain flow levels. Additionally, two adult coho salmon were documented approximately a half mile upstream from Thunder Bird Creek.

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 a 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. Thunder Bird Falls, a large waterfall, is located about 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 were 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 wedge 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. Each monitoring site was selected at a location representative of proximal upstream and downstream conditions.

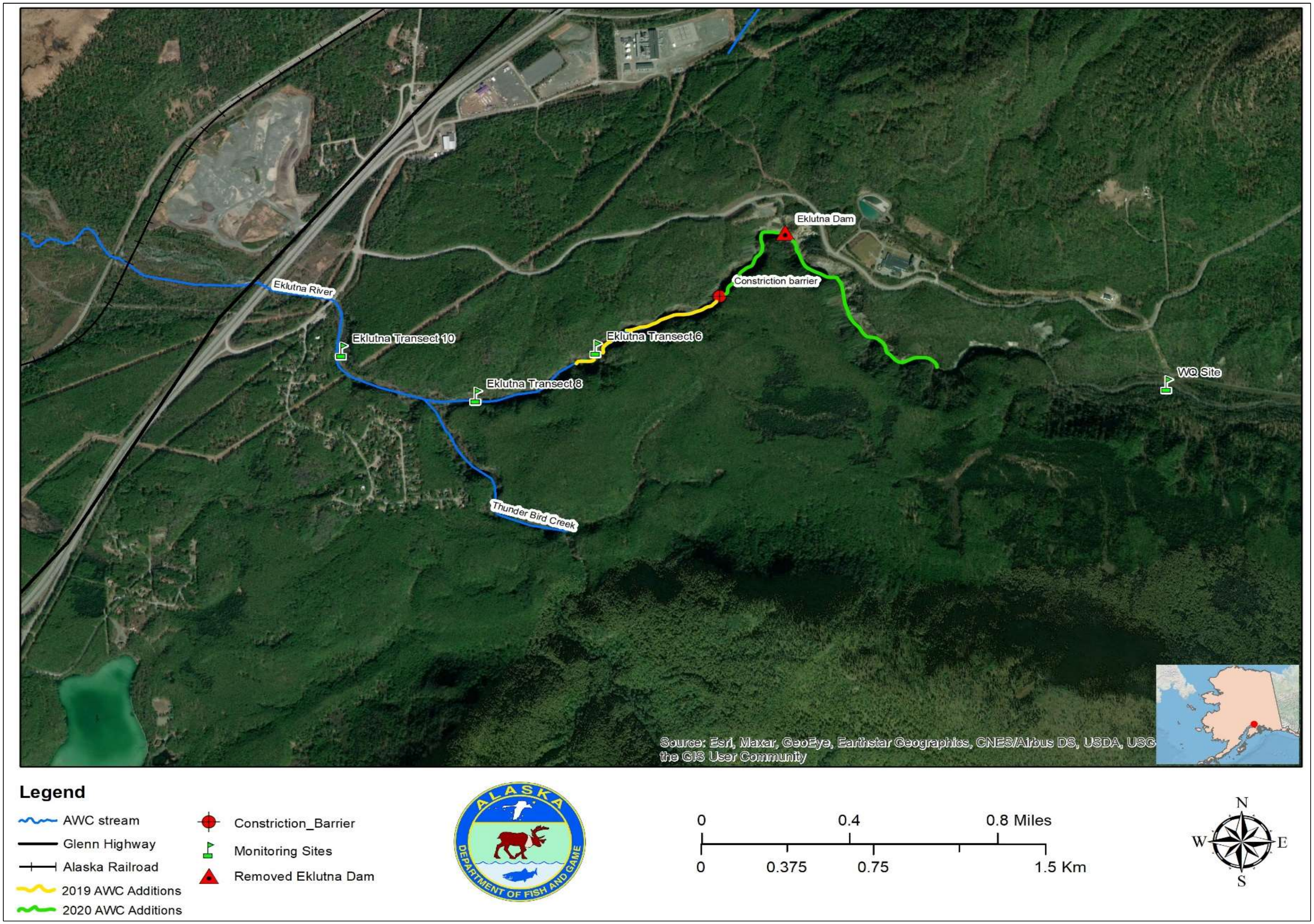
Only channel geometry and substrate composition were recorded during the initial 2017 sample event to represent pre-removal conditions. In October 2018, each monitoring site was revisited and sampled for the first time following the completion of dam removal.

In 2019, an additional monitoring location was established above the sediment wedge upstream from the dam site. 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 was 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	61.447	-149.348	Full monitoring site includes continuous temperature monitoring
Eklutna 8	61.445	-149.359	Full monitoring site without continuous temperature monitoring
Eklutna 10	61.448	-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.

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 and 2020, all monitoring sites were established and visited. All data were collected during two distinct field events each year, 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
5/28/2020	WQ Site	~	~	X	X
	Eklutna 6	X	X	X	X
	Eklutna 8	X	X	X	~
	Eklutna 10	X	X	X	X
9/23/2020	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 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 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 can reduce spawning and incubation 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 endemic fish populations. 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 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 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 changed through 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 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 during the spring 2019 visit. All water quality parameters listed above were recorded at this location during each visit in 2019 and 2020.

The continuous water temperature loggers were installed during the spring monitoring event of each sampling year at Eklutna 6 and Eklutna 10 as well as the water-quality-only monitoring site. These loggers were removed during the final monitoring event of each sample year.

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 final 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 statistical analysis.

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 change.

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. Larger substrate particles appear to have been buried by the aggrading gravels rather than mobilized downstream. Water quality variables at these two sites were generally un-noteworthy, however pH was consistently high, ranging from 8.28 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-only sampling location upstream of the sediment plug, variables were generally found to be un-noteworthy, although pH was somewhat 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 A6* through *Appendix A8* respectively.

EKLUTNA 6

<u>Visit #1:</u> Monitoring site *Eklutna 6* was established by ADF&G–Habitat Section and National Oceanographic and Atmospheric Administration (NOAA) personnel on 5/17/2017 about 1 km (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.

Visit #3: *Eklutna 6* was visited on 6/13/2019 by ADF&G–Habitat Section 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. 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 Section 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.

Visit #5: On 5/21/2020, *Eklutna 6* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was replicated from 2019 visits. The continuous temperature monitor was again installed.

The channel had generally remained stable from 2019 visits, although a mid-channel bar formed by the accumulation of fine gravels and sand likely conveyed downstream from the eroding sediment wedge. The D_{50} decreased nearly to 2017 levels from *Very Coarse Gravel* to *Medium Gravel* while the D_{84} similarly decreased from *Small Cobble* to *Coarse Gravel*. Substrate embeddedness was noted to have further decreased. Water quality variables were again not noteworthy, but pH was again high at 8.28 and due to elevated flows, turbidity was elevated at nearly 600 NTU.

Visit #6: On 9/23/2020, *Eklutna 6* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was again replicated from 2019 visits. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

The channel morphology was again similar, although D_{50} increased to previous 2019 recordings of *Coarse Gravel* and D_{84} similarly returned to *Very Coarse Gravel*. Substrate embeddedness was observed to be similar to 2019 observations. Water quality variables were again similar to previous visits although turbidity decreased to 35 NTU representing the lowest recording for this variable at this site during this study.

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 Section 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 1 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 Section 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 the D_{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 Section 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.

Visit #5: On 5/21/2020, *Eklutna 8* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was replicated from 2019 visits. The continuous temperature monitor was again installed.

The channel generally had remained stable from 2019 visits, although a mid-channel bar formed by the accumulation of fine gravels and sand likely conveyed downstream from the eroding sediment wedge. Both the D_{50} and D_{84} remained essentially consistent with 2019 measurements. Substrate embeddedness was noted to have further decreased. Water quality variables were again not noteworthy, but pH was again high at 8.3 and due to elevated flows, turbidity was elevated at nearly 500 NTU.

Visit #6: On 9/23/2020, *Eklutna 8* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was again replicated from 2019 visits. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

The channel morphology was again similar, while D_{50} and D_{84} measurements also were similar to 2019 measurements. Substrate embeddedness was observed to be similar to 2019 observations.

Water quality variables were again similar to previous visits although turbidity decreased to 26 NTU representing the lowest recording for this variable during this study.

EKLUTNA 10

Visit #1: Monitoring site *Eklutna 10* was established on 5/17/2017, about 0.8 km (0.5 miles) 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 Gravel* and *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 Section 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 not noteworthy, 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 Section 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 60 feet 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, was substantially lower than 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 Section 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.

Visit #5: On 5/21/2020, *Eklutna 10* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was replicated from 2019 visits. The continuous temperature monitor was again installed.

The channel had generally remained stable from 2019 visits. Both the D_{50} and D_{84} remained essentially consistent with 2019 measurements. Water quality variables were again not noteworthy, but turbidity was elevated at nearly 175 NTU due to increased runoff.

Visit #6: On 9/23/2020, *Eklutna 10* was visited by ADF&G–Habitat Section personnel. During this visit, all data collection was again replicated from 2019 visits. The continuous temperature monitor was removed from the site to avoid possible ice-related damage during winter months.

The channel morphology was again similar, while D_{50} and D_{84} measurements were also similar to previous measurements. Water quality variables were again similar to previous visits although turbidity decreased to 7.6 NTU representing the lowest recording for this variable during this study.

WATER QUALITY (WQ) SITE

Visit #1: On 6/21/2019, ADF&G–Habitat Section personnel established a water quality monitoring site upstream from the sediment wedge. 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 Section personnel 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.

Visit #3: On 5/21/2020, ADF&G–Habitat Section personnel recorded all previously established water quality variables and re-installed the continuous water temperature monitor.

All water quality variables were similar to those recorded during 2019 however turbidity was elevated to 251 NTU likely due to increased spring runoff.

Visit #4: On 9/24/2020 ADF&G–Habitat Section again revisited this water quality monitoring site and found all measured variables were similar to those recorded previously and those from downstream monitoring sites. Turbidity decreased from the prior recording to 9.4 NTU representing the lowest recording during this study.

CONCLUSION

The ADF&G-Habitat Section plans to continue to observe and document changes to the Eklutna River channel geometry, substrate composition, and water quality resulting from the deconstruction of the lower dam. Additionally, 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 for 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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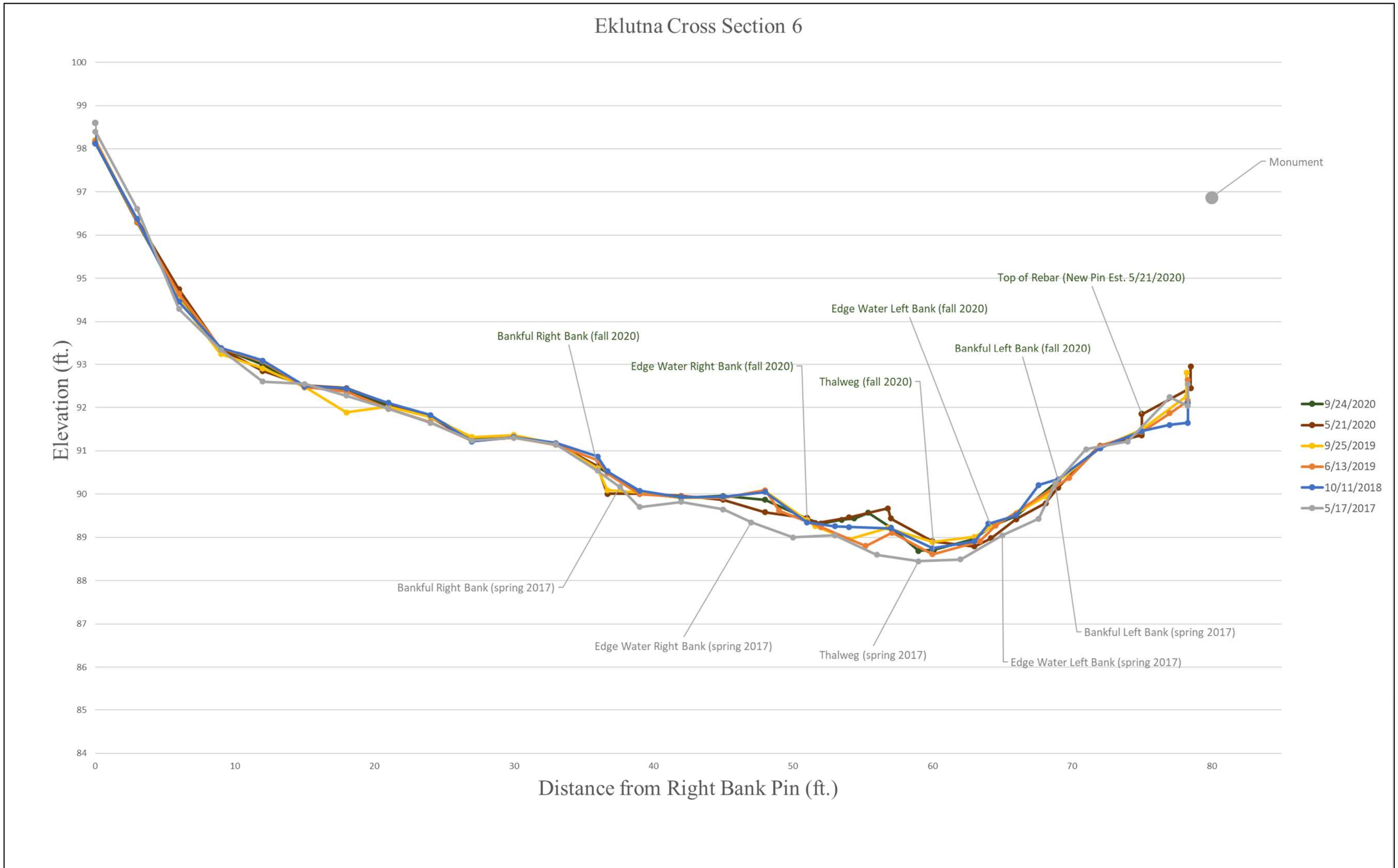
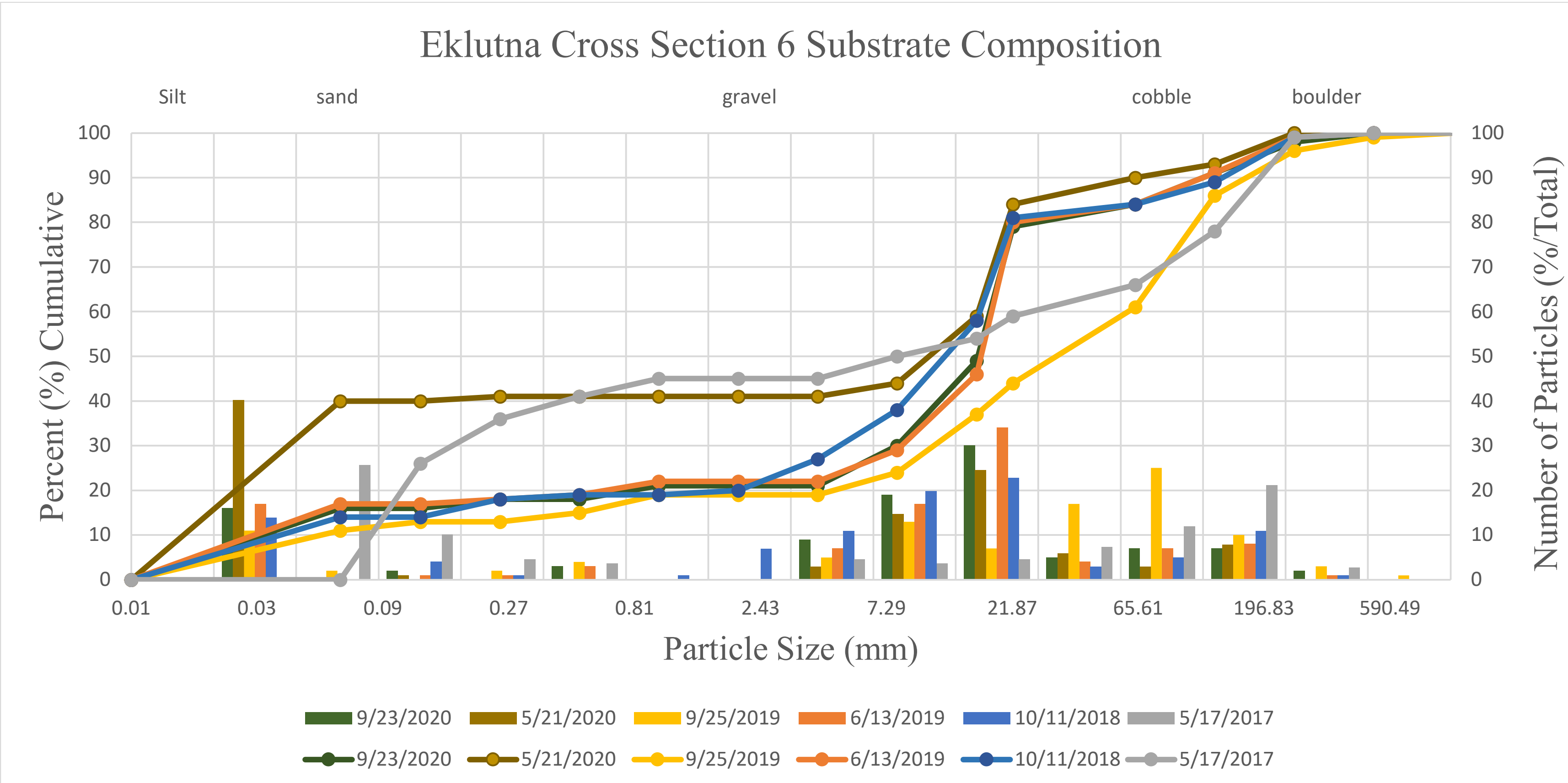
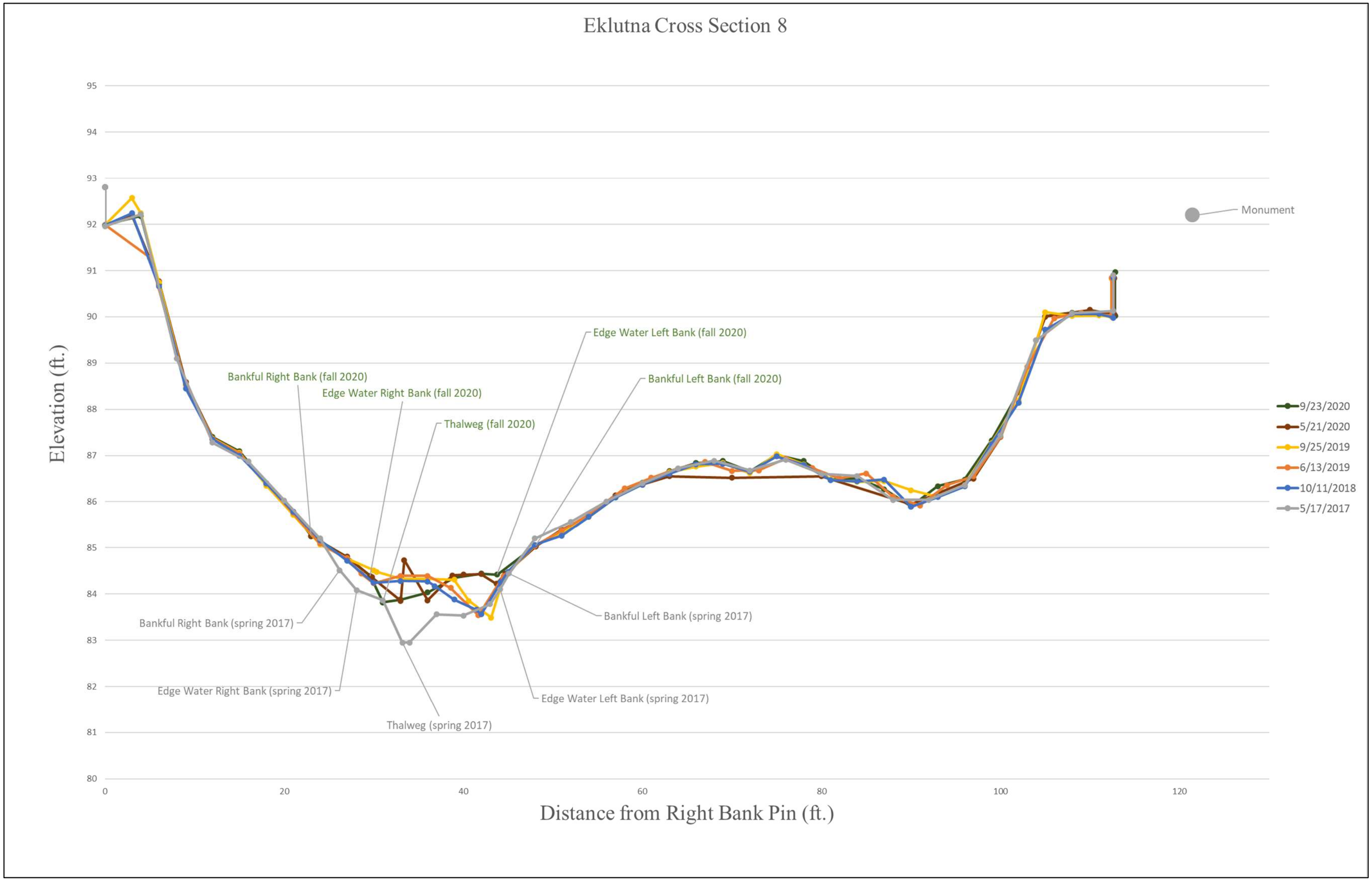
APPENDIX A: GRAPHICAL SUMMARIES OF FIELD DATA

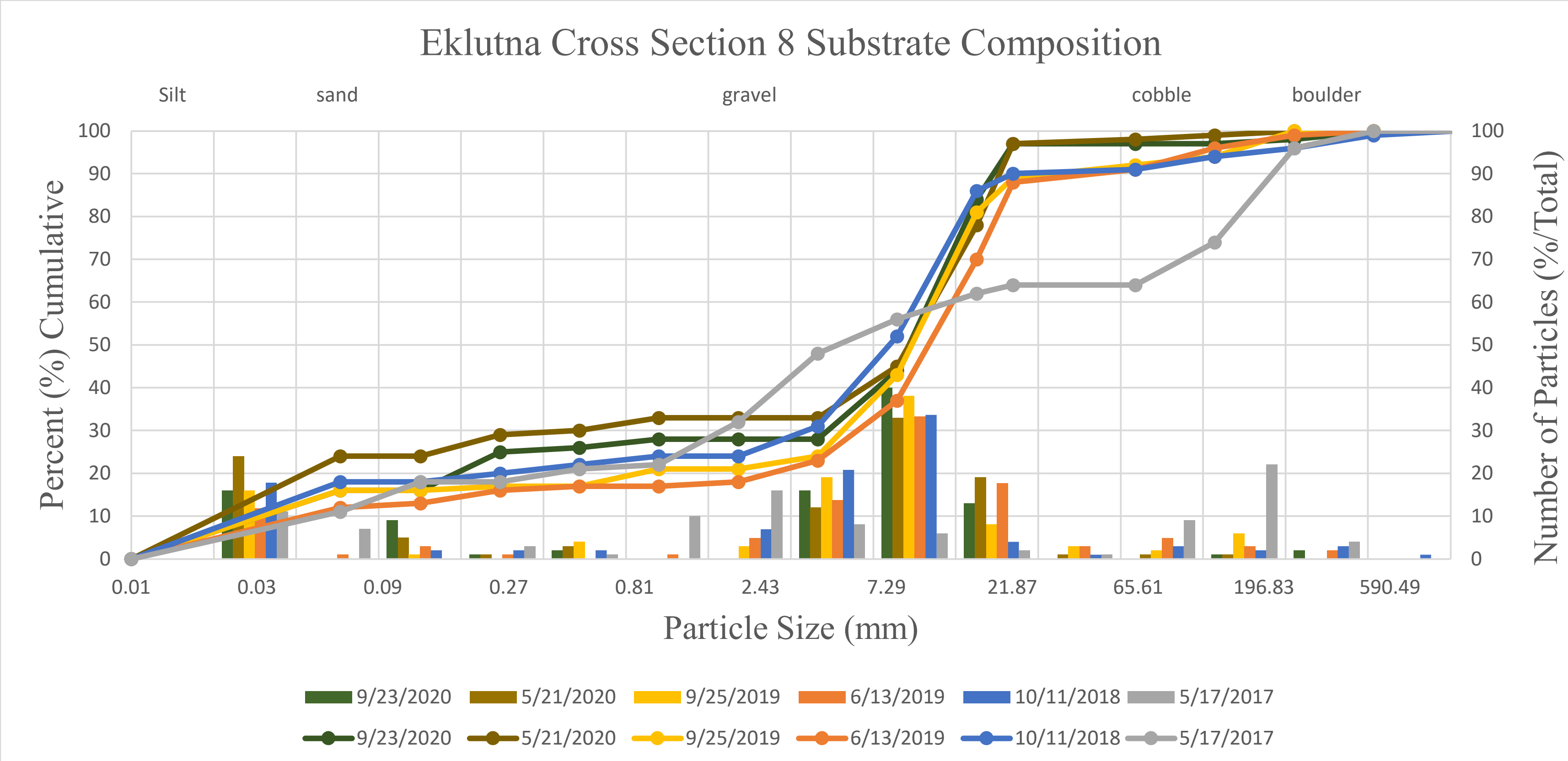
Appendix A1.–Eklutna 6 Channel Geometry and Substrate Composition.




Eklutna Cross Section 6 Substrate Composition
Silt
sand
gravel
cobble
boulder
Percent (%) Cumulative
Number of Particles (%/Total)
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)
9/23/2020
5/21/2020
9/25/2019
6/13/2019
10/11/2018
5/17/2017

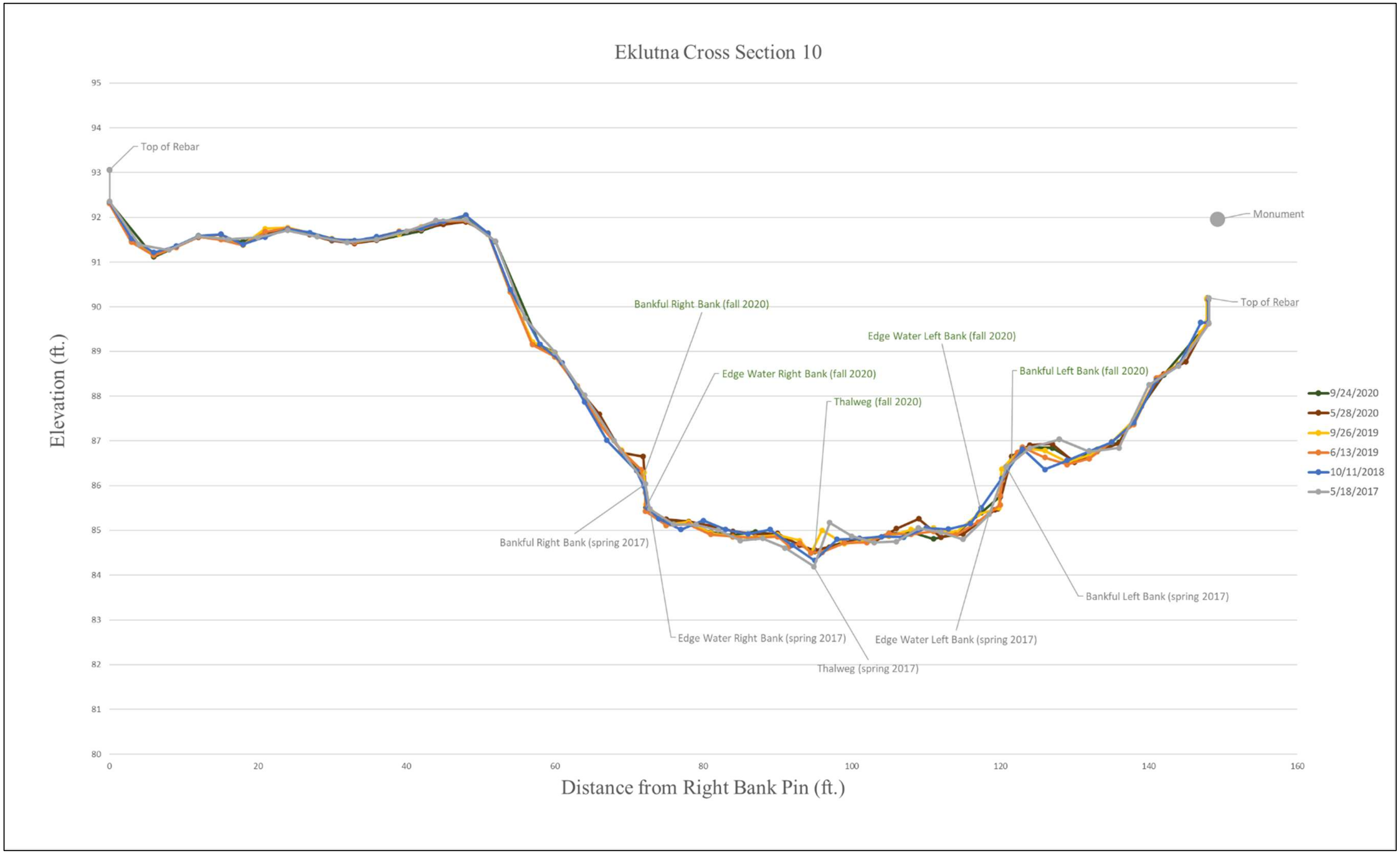
Appendix A2.–Eklutna 8 Channel Geometry and Substrate Composition.

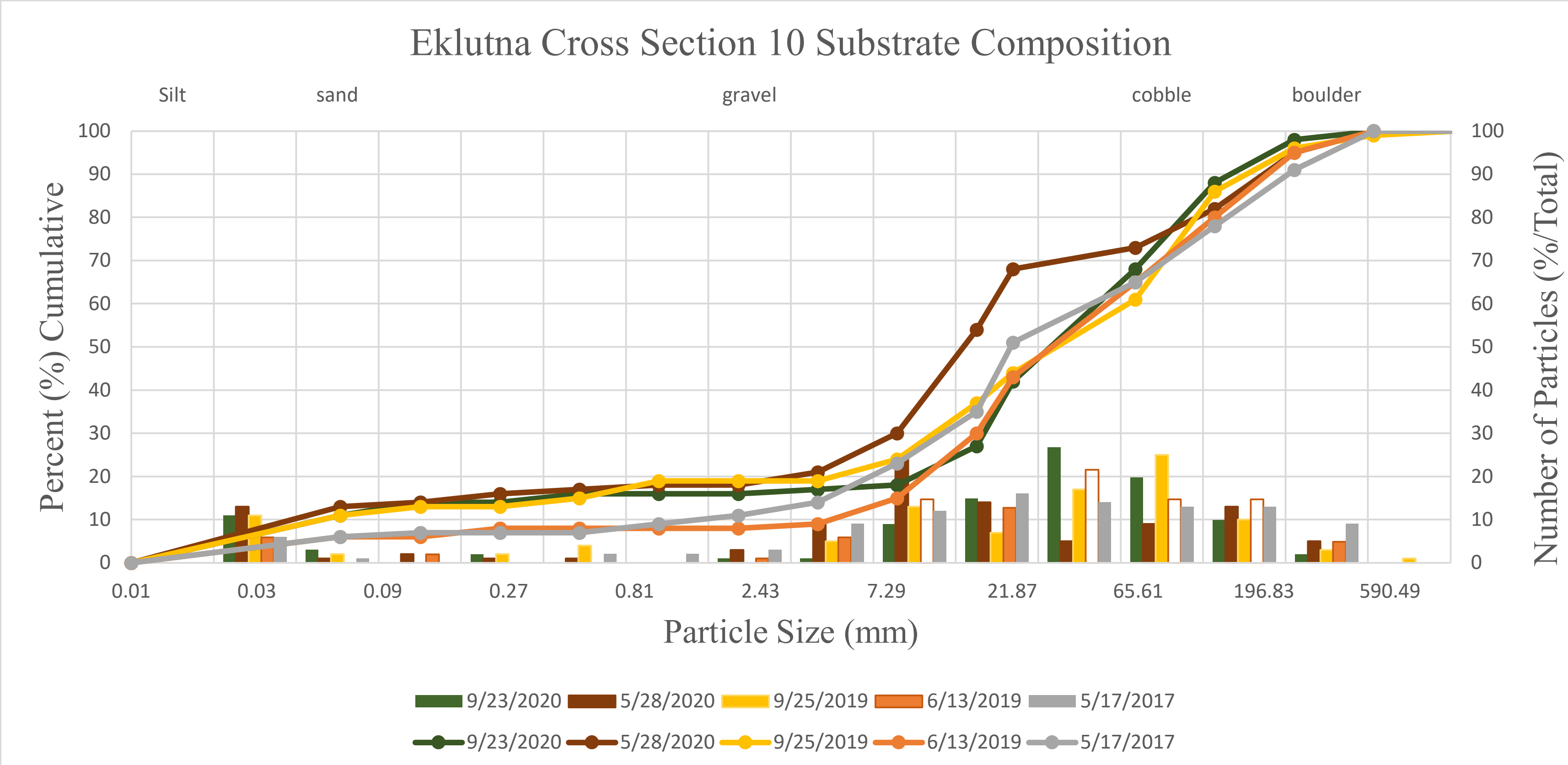




Eklutna Cross Section 8 Substrate Composition
Silt
sand
gravel
cobble
boulder
Percent (%) Cumulative
Number of Particles (%/Total)
100
90
80
70
60
50
40
30
20
10
0
0.01
0.03
0.09
0.27
0.81
2.43
7.29
21.87
65.61
196.83
590.49
Particle Size (mm)
9/23/2020
5/21/2020
9/25/2019
6/13/2019
10/11/2018
5/17/2017

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)
9/23/2020
5/28/2020
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
5/21/2020	Medium Gravel	coarse gravel	Medium Gravel	Coarse Gravel	Medium Gravel	Large Cobble
9/24/2020	Coarse Gravel	Very Coarse Gravel	Medium Gravel	Medium Gravel	Very Coarse Gravel	Small Cobble

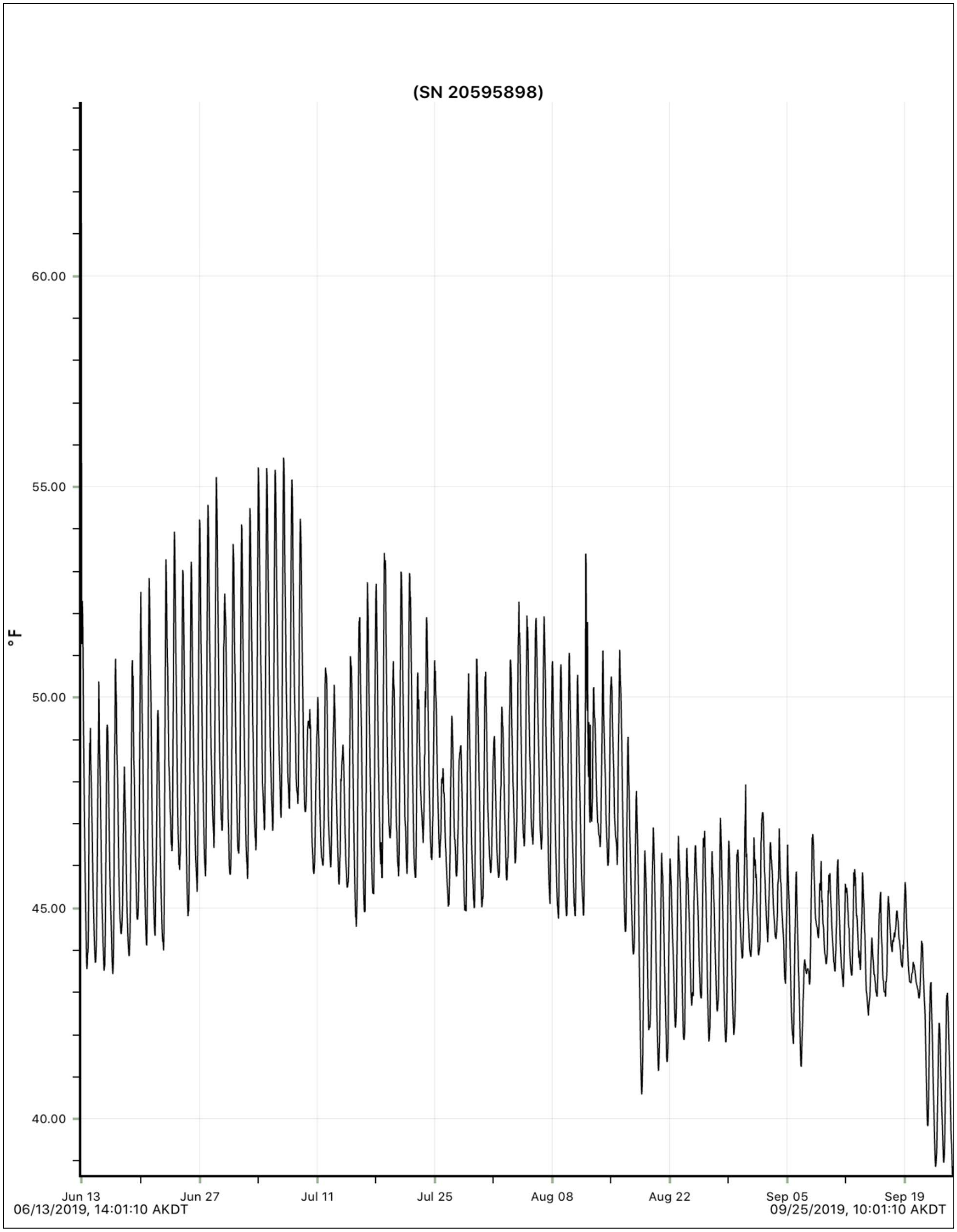
Note: Size ranges for substrate classifications: Fine Gravel = 4–8 mm; Medium Gravel = 8–16 mm; Coarse Gravel = 16–32 mm; Very Coarse Gravel = 32–64 mm; Small Cobble = 64–128 mm; Large Cobble = 128–256 mm.

Appendix A5.–Water Quality Variables.

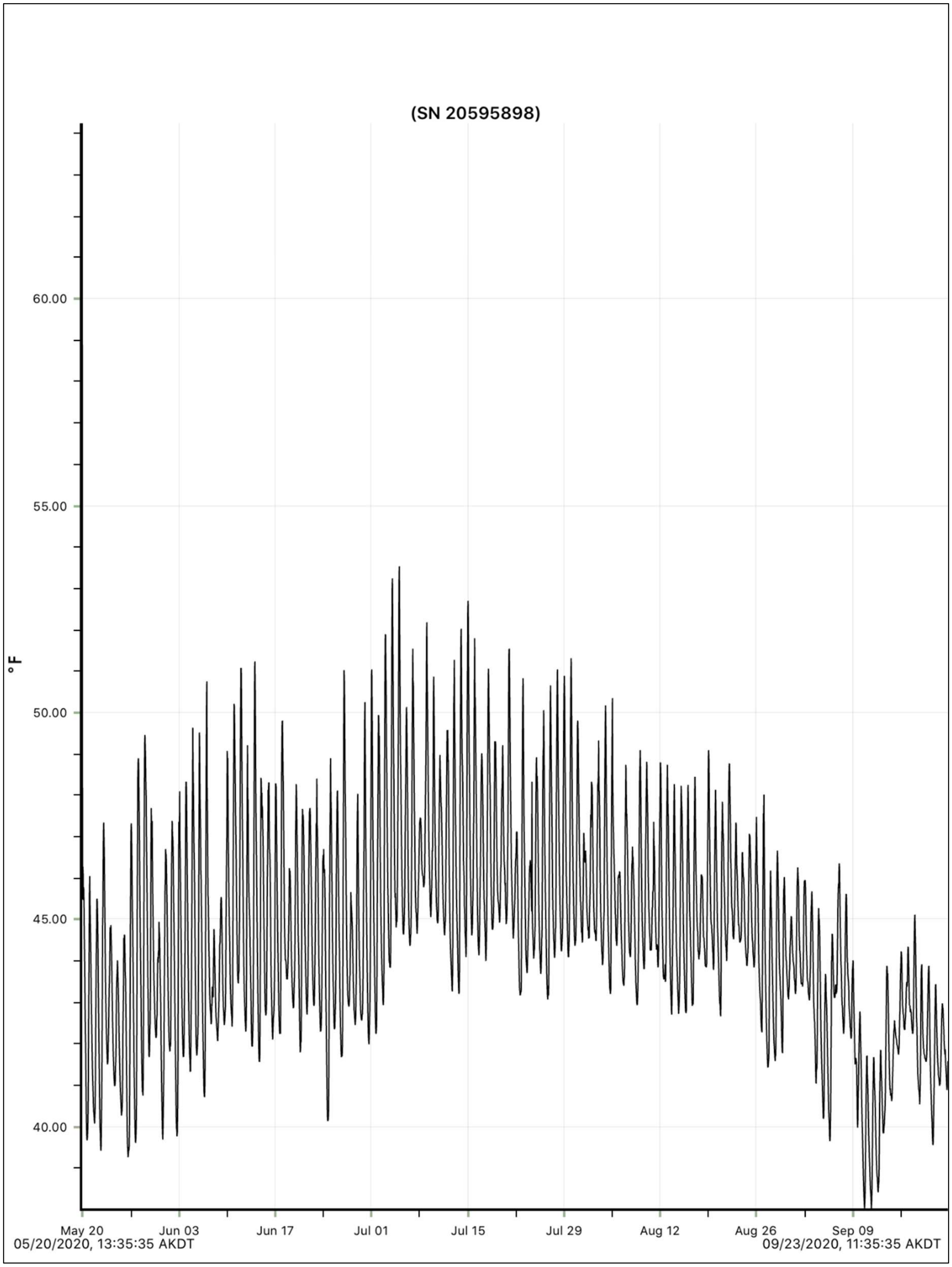
	Eklutna 6					Eklutna 8					Eklutna 10					WQ Site			
Water Quality Variable	**10/2018 ***	**6/2019**	**6/2019**	**5/2020**	**9/2020**	**10/2018 ***	**6/2019**	**9/2019**	**5/2020**	**9/2020**	**10/2018 ***	**6/2019**	**9/2019**	**5/2020**	**9/2020**	**6/2019**	**9/2019**	**5/2020**	**9/2020**
Temperature	4.7	11.2	3.9	7.5	6.2	4.9	11.6	4.3	8.2	6.7	4.6	9.7	3.7	6.6	6.1	2.5	3.4	9	5.9
Dissolved Oxygen (DO) (mg/L)	17.52	11.28	12.69	12.6	13.2	18.2	11.1	12.53	12.9	13.25	17.2	11.75	12.71	13.53	13.27	10.46	13.65	11.08	12.2
DO (% Saturation)	136.4	102.8	97	105.4	107	142.4	102.6	96.3	104.8	108.3	133.6	103.6	96.3	111.4	107.7	98	102.6	97.5	98
Conductivity	245	279	248	255	267	205	302	246	258	265	255	255	277	268	311	304	231.6	264	256
pH	~	8.7	8.44	8.28	8.28	~	8.52	8.58	8.3	8.34	~	8.36	8.53	8.2	8.26	8.35	8.51	8.01	7.97
Turbidity	~	78	54	592	35	~	118	56	499	26.4	~	18	13	174.6	7.6	48	29	251	9.42

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

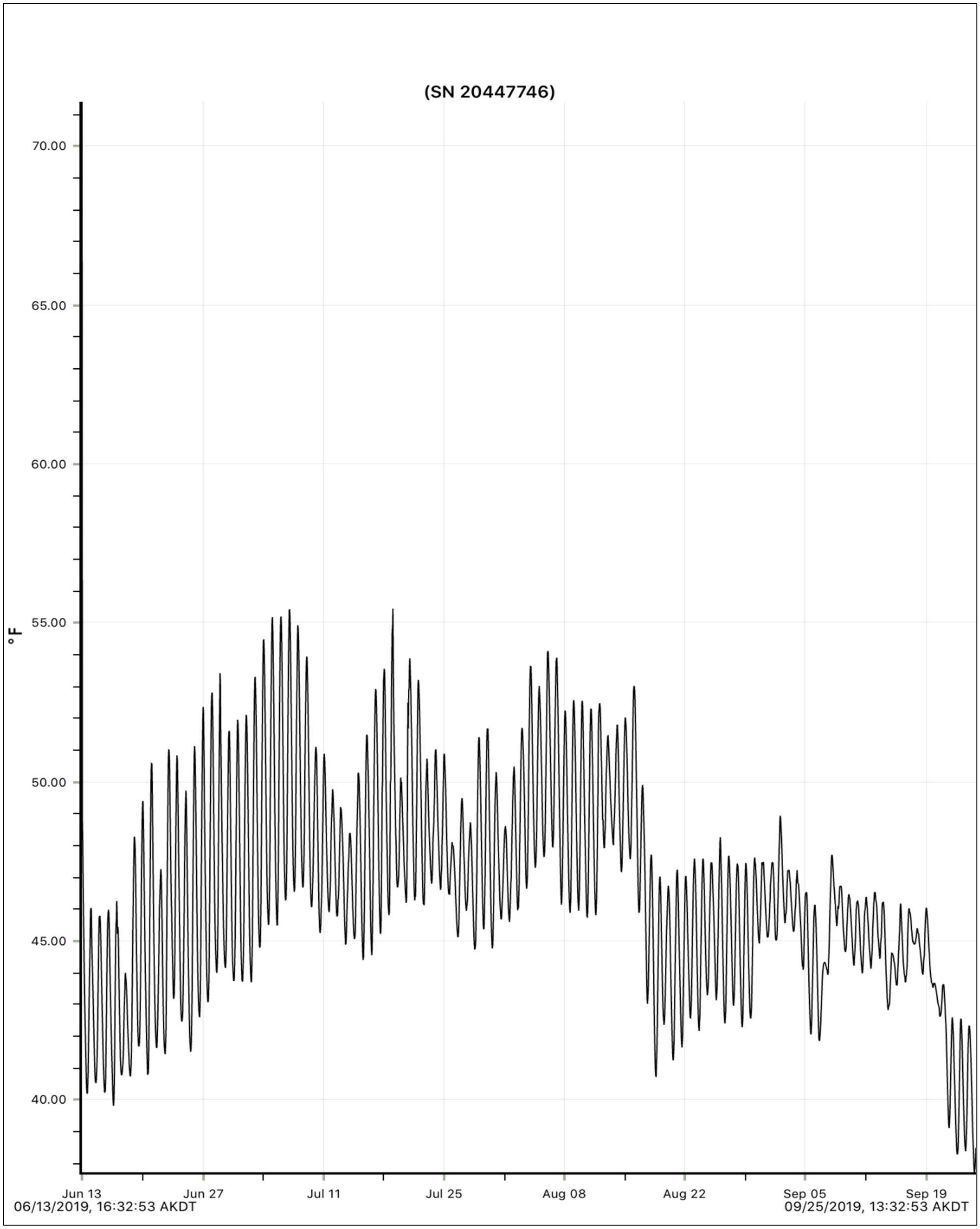
Appendix A6.–Eklutna 6 Continuous Temperature Data 2019.



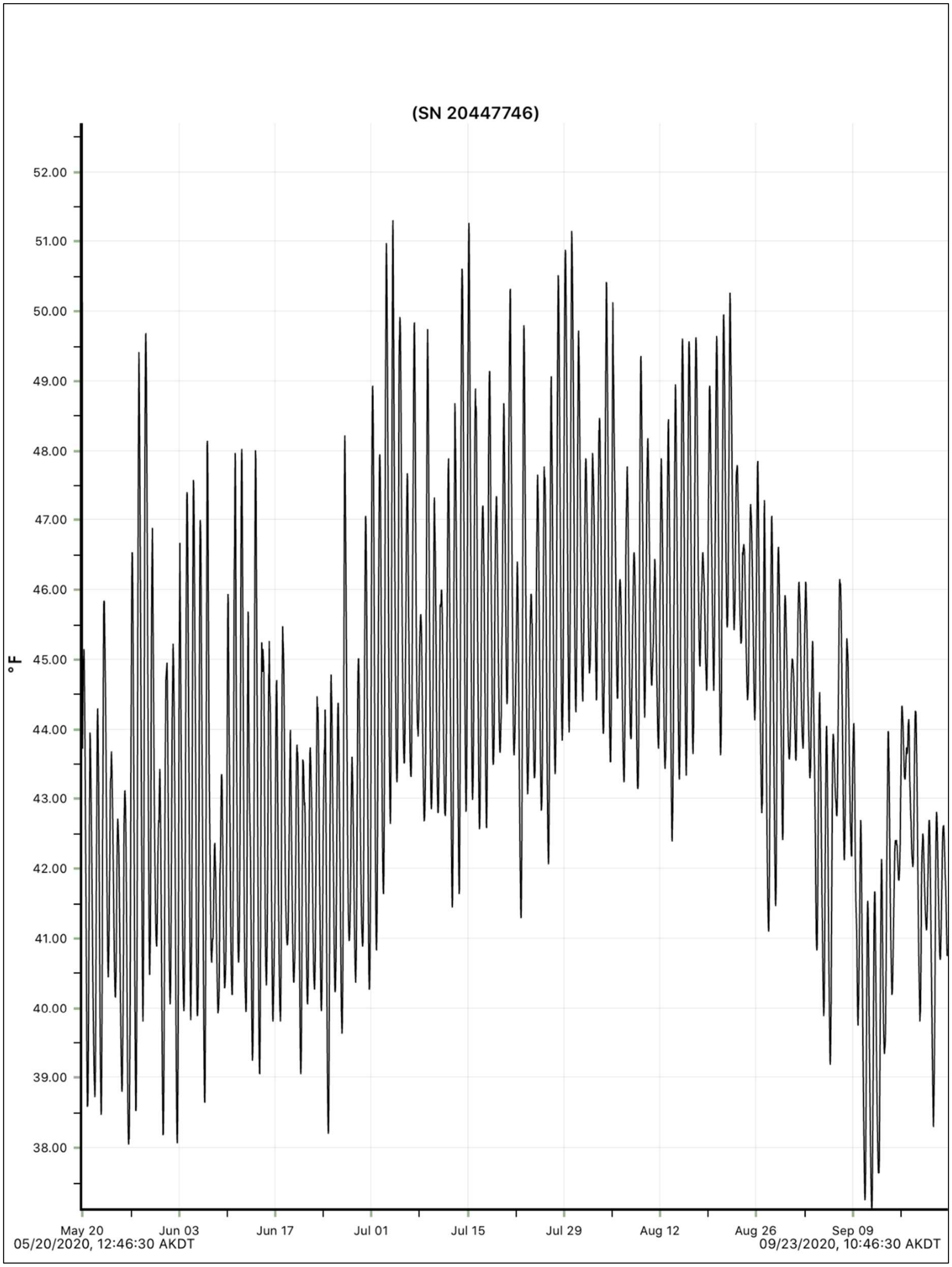
Appendix A6.–Eklutna 6 Continuous Temperature Data 2020.



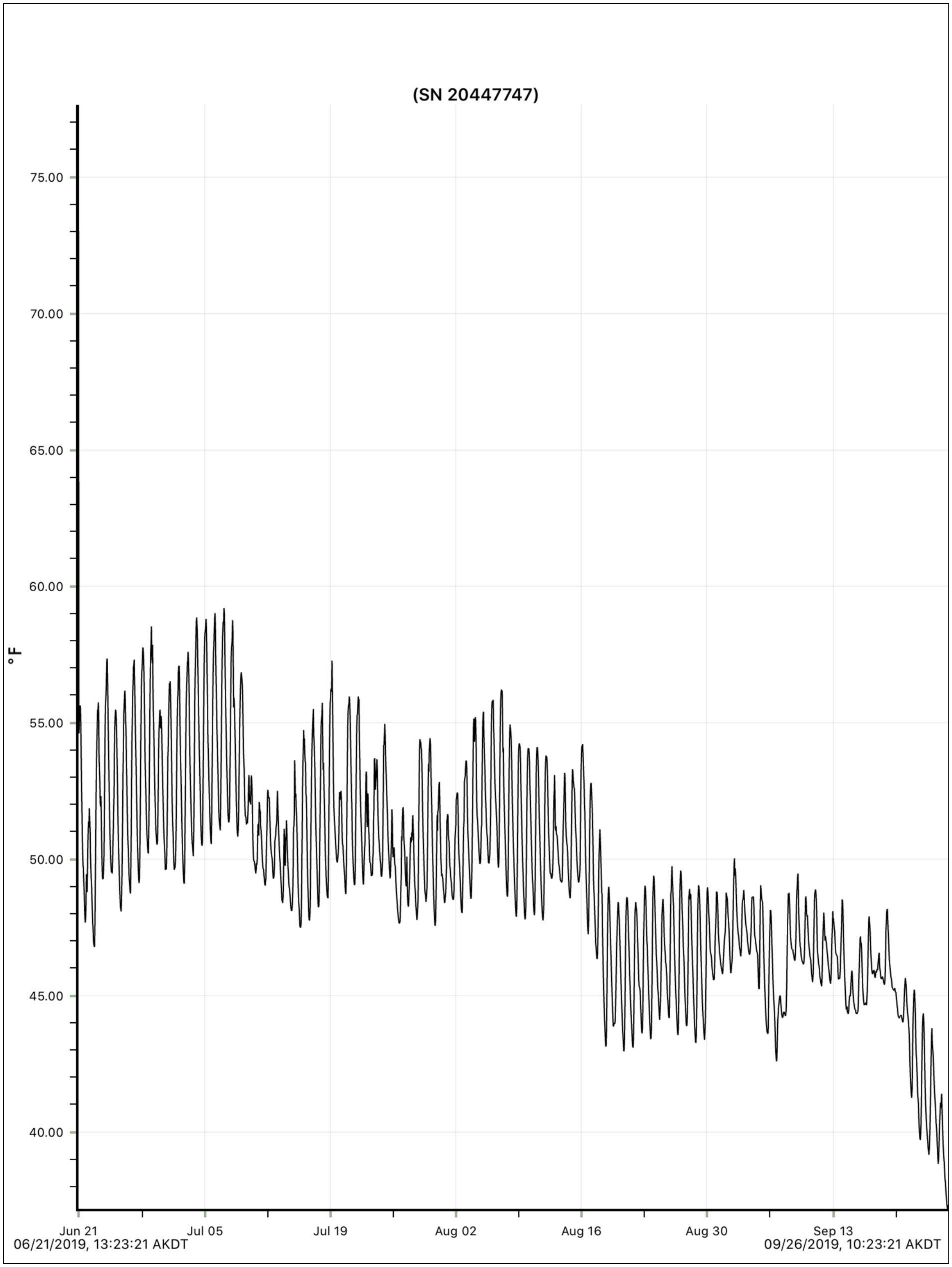
Appendix A7.–Eklutna 10 Continuous Temperature Data 2019.



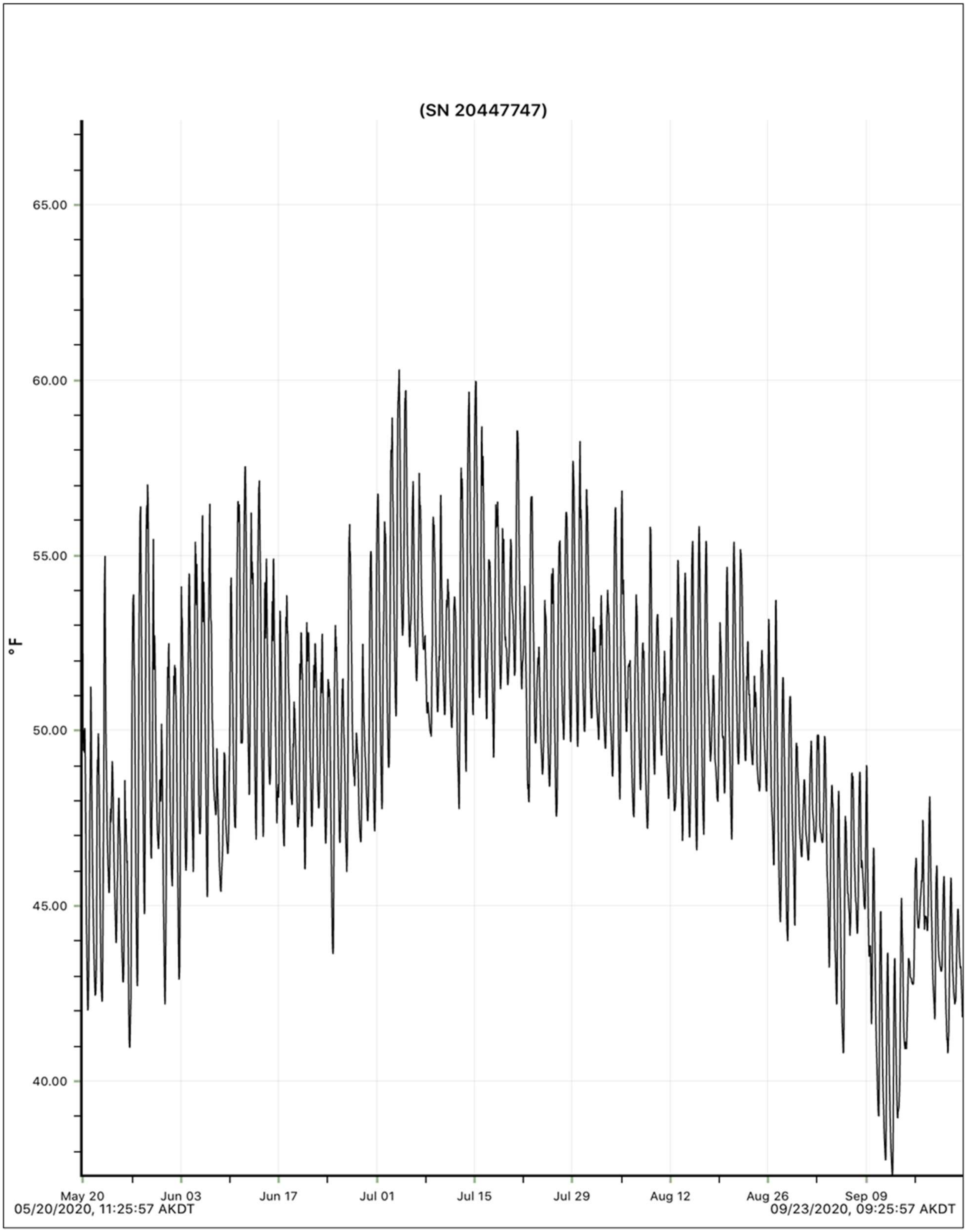
Appendix A7.–Eklutna 10 Continuous Temperature Data 2020.



Appendix A8.–WQ Site Continuous Temperature Data 2019.



Appendix A8.–WQ Site Continuous Temperature Data 2020.



APPENDIX B: EKLUTNA SITE PHOTOS

Appendix B1.–Eklutna 6 Spring Site Photos 2017 and 2020

Eklutna 6–May 2017

Eklutna 6–May 2020

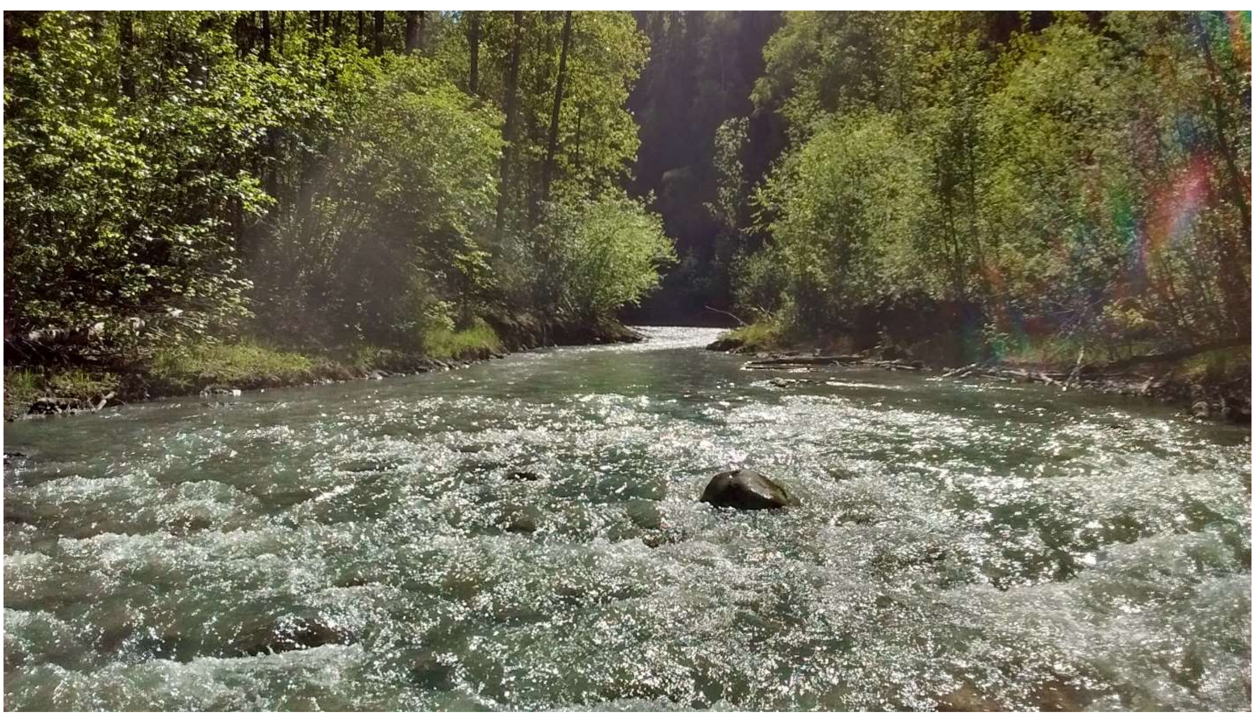
Appendix B2.–Eklutna 8 Spring Site Photos 2017 and 2020

Eklutna 8–May 2017

Eklutna 8–May 2020

Appendix B3.–Eklutna 10 Spring Site Photos 2017 and 2020

Eklutna 10–May 2017



Eklutna 10–May 2020