numerous channels. Approximately 1.1 miles upstream from the mouth of Eklutna Creek it splits into the East and West forks of Eklutna Creek (Figure 1-1).

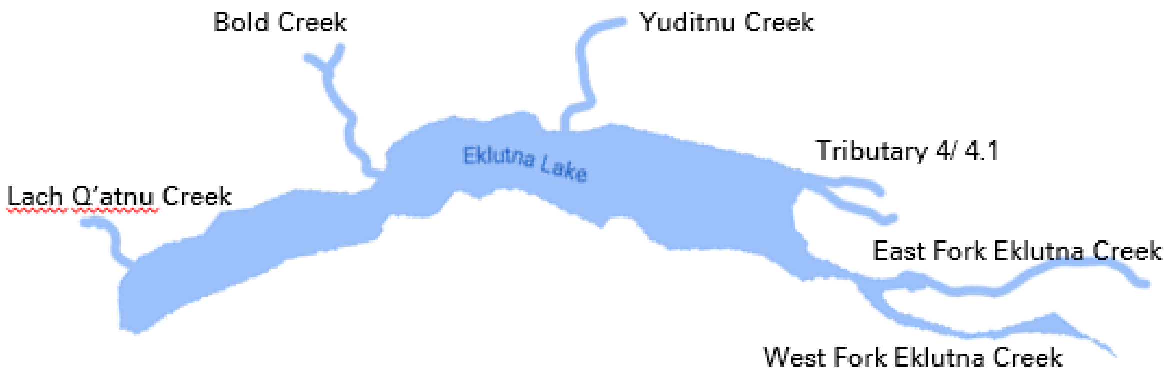

Figure 1-1 Eklutna Lake and focal tributaries in 2021 studies (Lach Q'atnu, Bold, Yuditnu, Tributary 4, and Eklutna Creek East and West Fork). Those on which additional spawning habitat studies were completed in 2022 included Tributary 4 and Eklutna Creek East and West forks.

Meso-habitat mapping in these tributaries in 2021 was brief and included only short (100-200 m) reaches corresponding to fish sampling areas. In 2022, we conducted additional and more extensive habitat surveys complimentary to NVE meso-habitat work in the East and West forks of Eklutna Creek and Tributary 4 to identify potential spawning habitat that may be suitable for Sockeye or other ocean-run Pacific Salmon (See Year 2 Final Study Plan, Section 3.4).

During the 2021 assessment of spawning habitat use by adult kokanee salmon in Eklutna Lake, more than 350 adult kokanee were observed along the lakeshore. These adults ranged in size from 4 – 6 in., smaller than most kokanee, and were emaciated. Adult kokanee included both male and female fish with mature gonads. Some females contained unspawned eggs which ranged in size from 0.1 -0.2 in, a size consistent with eggs produced by typical-sized kokanee (7.5-10 in.) from other oligotrophic systems (Kaeriyama et al. 1995). The fecundity of females found prior to spawning or partially-spawned ranged from only 20-30 eggs which is less than is typically reported for kokanee (500-700 eggs) (Kaeriyama et al. 1995). The tradeoff between egg size and fecundity has been well studied in Pacific salmon, including kokanee, and can be related to energetics, migratory distance, stock origin, adaptation to spawning gravel (Quinn et al. 2015) and even latitude where higher latitude has been correlated to smaller bodied and less fecund kokanee (McGurk 2000). In Eklutna Lake, the size-at-maturity, condition factor (length – weight ratio) and low fecundity are likely an indication of poor nutrient conditions and limited food sources in the environment.

In Alaska, infectious hematopoietic necrosis virus (IHN) is transmissible and potentially lethal to juvenile salmonids of other species (Emmenegger et al. 2000). Transmission between individuals occurs following the shedding of the virus in feces, urine, and external mucus and by direct or close contact with the surrounding water, entering fish at the base of the fins (Harmache et al. 2006). According to ADF&G, kokanee in Eklutna Lake tested positive for the virus when last surveyed over 20 years ago. To determine if IHN still exists in kokanee salmon populations in Eklutna Lake, samples were collected from kokanee carcasses encountered during surveys to test for the virus in 2022. Presence and prevalence of the virus in this fish population may have implications for fisheries management in the basin.

This technical memo presents a summary of data collected in Eklutna Lake tributaries in 2022, a preliminary discussion of potential spawning habitat in tributaries to Eklutna Lake, and a description of samples collected for IHN analysis. In-depth analysis as outlined in the May 2021 Final Study Plans (FSP) will be completed and reported in the Year 2 Final Report, scheduled to be complete in early 2023. This TM covers only interim results for Lake Study data collected in 2023.

1.1 2022 Objectives

The goals of the Eklutna Lake Study (MJA 2021) were to characterize the current aquatic habitat in Eklutna Lake and its tributaries and to begin to understand the current and potential future use of that habitat by fishes including ocean-run Sockeye, Coho, and Chinook salmon should fish passage be planned in the future. The objective for the Year 2 study effort was to conduct habitat surveys in East and West forks of Eklutna Creek and Tributary 4 to identify potential spawning habitat for ocean-run fish. A secondary goal was to determine whether IHN is present in Eklutna Lake kokanee.

1.2 Study Area

The study area includes the head of Eklutna Lake and inflowing tributaries with the potential to support spawning ocean-run salmon including Eklutna Creek and Tributary 4. Tributary 4 (Figure 1-2) is considerably smaller than Eklutna Creek and has a pair of culverts in the lower 25% of the channel which likely constitute a passage barrier to migrating fish. Based on consensus with the Aquatics TWG, we completed spawning habitat surveys in Tributary 4 both downstream and upstream of the culverts, understanding that culvert removal may be planned in this area in the future.

Additionally, the 2022 study area included East and West forks of Eklutna Creek (Figure 1-2). The East Fork of Eklutna Creek was surveyed to a point ~0.3 mi above the boulder cascade located about .75 mi above the ATV trail bridge. In 2021, the boulder cascade was plugged with large woody debris and appeared to be a potential barrier to migrating fish. In 2022, the cascade was free of large wood and did not appear to represent a significant barrier to passage. The gradient and substrate size did change at this location as the river enters a constricting canyon. The survey was continued approximately 0.3 mi past this point. We know that NVE completed additional habitat and spawning surveys further upstream in 2022. The West Fork of Eklutna Creek was surveyed to a point approximately 0.3 mi above the end of the Eklutna Lakeside Trail. Similar to the East Fork, the Creek near this location has a steeper gradient (>5%), contains significantly larger substrates, and is constrained by steep canyon walls. Additionally, the river at this point is very glacially turbid (>100NTU) and colder than is typically suitable for target species (Coho and Chinook salmon) that prefer a stream temperature range of (6°C – 12°C) for spawning. Tributary 4 and its branch (Tributary 4.1) was surveyed upstream approximately 1.2 miles until a point where accumulations of large wood, water temperature under 0.1m, and lack of solid gravel substrate suggested an end of potential spawning habitat.

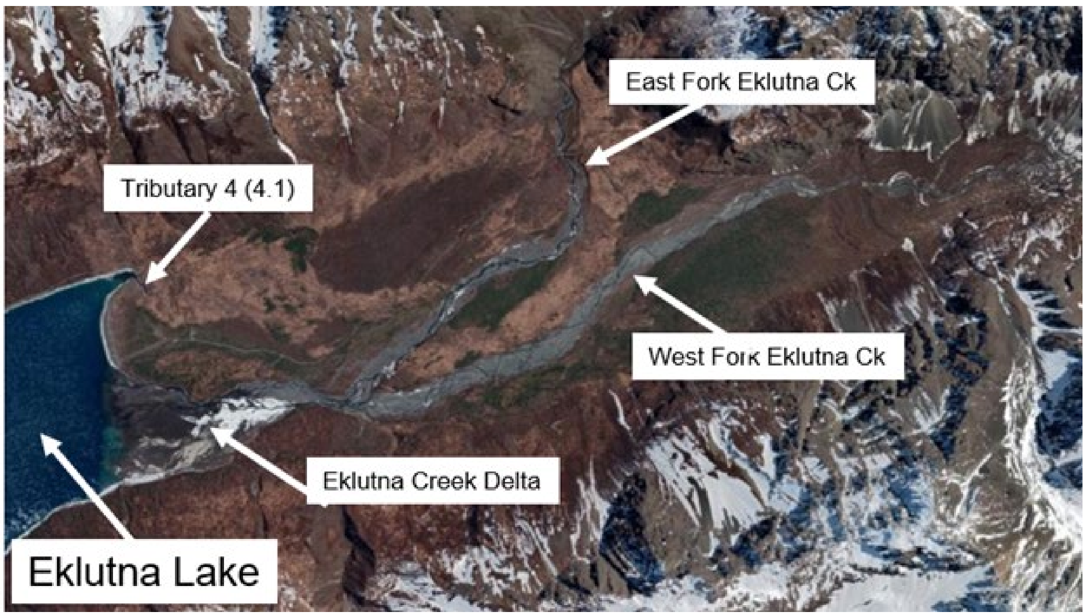

Figure 1-2 2022 Study area including Tributary 4 (4.1) and the East and West forks of Eklutna Creek including the delta at Eklutna Lake.

1.3 METHODS

Salmon spawning habitat surveys were conducted using methods established in the May 2021 FSP. Potential salmon spawning habitat in the study area was identified and characterized. Basic physical habitat data were collected including an estimate of the area (m^2), average water depth (nearest 0.1 m, gradient (%), pebble count (Wolman 1954; Kondolf 1992), and embeddedness (%). Any visual observations of fish present and their behavior were documented.

Between September 28 and October 4, 2022, spawning and spawning habitat surveys were completed in accessible portions of Eklutna Creek and Tributary 4 and its east fork, 4.1 that were determined to be accessible to lake fish and totaled approximately 4.5 river miles. A portion of the East and West forks were omitted due to inaccessibility for survey crew though the gradient and substrate at interim points were similar to the surveyed lower portions and are accessible to potential ocean-run fish. Both surveys were continued upstream to a point when the forks entered a narrower canyon likely to result in changes in substrate and gradient (Figure 1-3). Habitat characteristics including substrate size, gradient, channel complexity, and embeddedness, were measured.

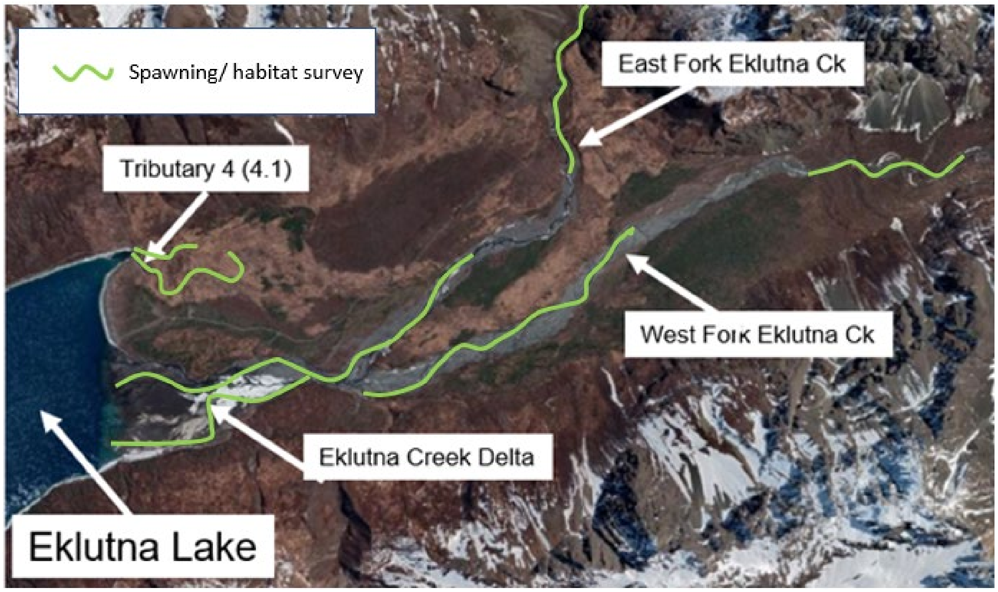

Figure 1-3 Habitat and spawning surveys completed in fall of 2022

IHN samples were collected under guidance provided by ADF&G and using methods described by Laurin et al. (2020). Fresh moribund post-spawned kokanee were collected along the shorelines of Eklutna lake where spawning was observed in 2021. Kidney and liver tissue were removed aseptically, and all tools were rinsed in 70% isopropyl alcohol. Tissue samples were placed in individually labeled 2oz. Whirl-Pak bags, labelled and stored under refrigeration. Samples were transported within 24 hours to the ADF&G Fish Pathology Laboratory (Anchorage, Alaska) for processing.

1.4 PRELIMINARY RESULTS

1.4.1 HABITAT SURVEYS

1.4.1.1 EKLUTNA CREEK

Both forks of Eklutna Creek have braided channels with extensive exposed gravel bars that appear to be dynamic and contain substrates ranging from small gravel to large cobble and bedrock (Kondolf 1992). In some areas, side channel and off-channel habitat complexes were found including sheltered vegetated alcoves, backwaters, and shallow pools with predominantly small gravel substrates. In 2021, rearing and spawning Dolly

Varden were documented in these areas, and in 2022, a small number of spawning kokanee were observed in this habitat type in the lower mainstem of Eklutna Creek (see Section 1.4.2).

Gravel and cobble substrates potentially suitable for ocean-run salmon spawning were documented throughout the East and West forks of Eklutna Creek from the confluence with the lake to a point approximately 3.0 miles up the East fork and 3.2 miles up the West Fork (Figure 1- 4) where surveys ended. Aquatic habitat in the lower reaches was predominantly riffle and glide, containing gravels and cobbles (1.7-5 in) (Figure 1-5). At the upper points, the stream gradient steepened, and the aquatic habitat changed with an increase in rapid and cascade habitats that contained large cobble (>10 in) and boulders—conditions not suitable for ocean-run fish spawning

Figure 1-4 Typical substrate observed in the lower 3.0 miles of East and West forks of Eklutna Creek. A gravelometer was used to categorize substrate size.

Figure 1-5 Typical aquatic habitat observed in the canyonised upper reaches of East (left) and West (right) Fork Eklutna Creek above River Mile 3-3.2.

Water depth ranged from 0.3 ft – 0.0 ft in riffle habitats, and from 0.9 ft- 3.2 ft in glides. Some mainstem riffle complexes had long (>350 ft) stretches of water under 0.6 ft deep which may play a role in the accessibility of habitat for larger bodied fish (Bjornn and Reiser 1991), though the system is clearly dynamic and may change annually during spring run-off. A geomorphic analysis including sediment transport has not been completed for Eklutna Creek, but gravel bars in East and West Forks of Eklutna Creek tended to lack vegetation, large wood, or other features likely to result in the development of more stable gravel bars and therefore channel position (McKean and Tonina 2013). Channel migration associated with dynamic sediments can lead to challenges for overwintering survival of eggs, though floodplain topography and channel confinement are determining factors (McKean and Tonina 2013). One right-bank pool greater than 5 ft deep was documented near the ATV bridge on the East Fork of Eklutna Creek (measured in 2021). Water temperature in the East Fork ranged from 4.5-5.5 ^{o}C while the West fork ranged from 2.9-5.5^{o}C. While these incidental surface measurements are within ranges reported for sockeye salmon spawning in Alaska rivers and lakes (4-12^{o}C; Lisi et al, 2012), egg incubation success in some Pacific salmon species can be negatively impacted at temperatures below 4^{o}C (Beacham and Murray, 1990).

During surveys in both 2021 and 2022, very little evidence of productivity in Eklutna Creek East or West forks was observed. In mainstem glacially-turbid habitats, no macroinvertebrates or macrophytes were observed though some algae was noted in clearwater off-channel or backwater areas. The periphyton layer on in stream substrate that is also typical of productive river systems was absent from the West fork Eklutna Creek, but evident in some side channels of the East Fork about 3.0 miles from the confluence. Additionally, mainstem habitat in both forks seemed devoid of fine organic matter that typically exists in shallow shoreline areas of streams and rivers. These qualitative observations suggest that the Eklutna Creek system may not be sufficiently productive to supporting multi-year rearing of ocean-run species that reside in the river prior to downstream migration such as Coho and Chinook salmon.

A summary of the physical characteristics of potential spawning reaches in East and West Fork Eklutna Creek is provided in Table 1-1 including range and median substrate size by site, embeddedness, average wetted area, and average depth. Preliminarily, there appears to be some available physical habitat in the mainstem Eklutna Creek East and West forks with depths and substrate size suitable for ocean-run Pacific Salmon. Velocity, groundwater-surface water interactions, overwintering thermal conditions, and other physical factors that play a critical role in spawning habitat quality were not studied. Another factor that was not addressed in this study but that has been documented elsewhere in Alaska to affect the use of main channel spawning habitat in glacial rivers include sedimentation of redds with fine sediment that can smother developing embryos (Young and Woody 2007). There are many turbid and glacial river systems with productive salmon populations, but these systems often contain available clear-water habitats outside the mainstem where spawning and juvenile rearing are concentrated (Burger et al. 1995).

Locations of samples are shown in Appendix 1. Further analysis of spatial data on substrate size, the potential for that substrate to support spawning of ocean-run salmon based on substrate requirements by species, and other physical habitat analysis will be presented in the final Eklutna Lake Study Report, 2023.

Table 1-1 Eklutna Creek substrate survey for East and West fork mainstem areas and the confluence area (Eklutna) – substrate size range and median and embeddedness are presented for potential spawning habitat reaches. *Wetted area does not represent suitable spawning habitat, only total wetted area within each reach that will be considered for spawning habitat quality assessment in the Final Year 2 Report.*

Site ID Column	North	East	Channel Type	Dominant Habitat	Ave. wet width (ft)	Ave. depth (ft)	Reach length (mi)	Wetted area (ac)	Substrate range (in)	Substrate Median (in)	Embed (%)
East_0	61.312750	-148.955917	Braided	Cascade	27.8	1.6	0.1	0.12	5-12	8.5	25
East_1	61.312810	-148.958250	Braided	Riffle-Glide	21.3	1.3	0.36	0.94	.07-7	1.7	25
East_2	61.315010	-148.968610	Braided	Riffle-Glide	31.2	0.9	0.3	1.88	.07-7	1.7	25
East_3	61.313805	-148.979507	Braided	Riffle-Glide	29.5	0.65	0.72	1.67	.07-7	1.7	50
East 3.5	unsurveyed						.5				
East_4	61.323266	-148.994854	Braided	Riffle-Glide	31.2	0.65	0.6	2.29	0.3-7	2.1	50
Eklutna_5	61.331290	-149.003400	Braided	Riffle-Glide	59.0	0.9	3.41	2.24	0.6-5	2.5	50
Eklutna_6	61.333590	-149.005430	Braided	Riffle-Glide	72.2	0.65	.43	3.80	.07-7	1.7	50
West_7	61.325051	-149.006434	Braided	Riffle-Glide	26.2	1.6	0.3	1.18	.07-7	2.1	50
West_8	61.316886	-148.999213	Braided	Riffle-Glide	24.6	1.6	0.4	1.38	.07-7	1.7	50
West 8.5	unsurveyed						.8				
West_9	61.295517	-148.975599	Single	Chute	14.7	2.3	0.2	0.45	32-7	2.5	75
West_10	61.286130	-148.975270	Braided	Riffle-Glide	41.0	0.3	.8	0.94	.07-7	2.5	75
West_11	61.282859	-148.973091	Braided	Cascade	34.4	0.9	.2	1.03	2.5-10	5.0	25

1.4.1.2 TRIBUTARY 4 AND TRIBUTARY 4.1

In Tributary 4 and 4.1, surveys were completed both above and below the paired culverts at the Eklutna Lakeside Trail crossing. The portion of Tributary 4 that was actively flowing was considerably shorter in 2022 than was observed in 2021 due to the difference in the lake elevation between years (864.02 ft on 10/1/2021, 867.77 ft on 10/1/2022). In 2022, much of Tributary 4 was backwatered from the lake and packed with large woody debris from the 2010 Eklutna fire. Downstream of the culverts, approximately 150 m of Tributary 4 was riverine habitat as was 25 m of Tributary 4.1. Upstream of the culverts, the substrate was characterized mostly by compacted silt and fine sediment, macrophytes, large woody debris, and silt-embedded small gravels. Small areas (<20 ft^2) of gravel were observed in upper portions of Tributary 4 where Dolly Varden were observed spawning in 2021, but these were rare (Figure 1-6). Water depth in both tributaries was generally from 0.3 – 0.5 ft with very few areas of greater depth.

Figure 1-6 Tributary 4 downstream of the culverts under the Eklutna Lakeside Trail (right) and example of substrate size in limited areas with gravel (left).

While the small gravel in Tributary 4 and 4.1 appears to be suitable for small-bodied Dolly Varden and the kokanee present in Eklutna Lake, no portions of either tributary were identified as potential habitat for ocean-run salmon of typical body size. Currently, the culverts under the Eklutna Lakeside Trail likely make these habitats inaccessible to most fish.

Analysis of spatial data on the distribution of size-classes substrate, the potential for that substrate to support spawning of ocean-run salmon based on substrate requirements by species, and other physical habitat characteristics will be presented in the final Eklutna Lake Study Report, 2023.

1.4.2 SPAWNING SURVEYS

Kokanee spawning activity was documented in both Tributary 4 downstream of the culverts and in the east fork of Eklutna Creek near the confluence in a small (<6 sq ft wetted width) side channel (Figure 1-7). Spawning activity in kokanee was determined by the presence of degraded fins and growth of fungus, the presence of carcasses with mature gonads (unspawned eggs and milt), and milling/ guarding behavior. Active spawning was not observed. A total of 35 kokanee spawners were documented in a 0.1mi. reach of Tributary 4 downstream of the culverts. A total of 3 kokanee spawners were documented in a small clear side channel of the mainstem Eklutna Creek near the split into East and West forks (Figure 1-8). Observed kokanee spawners ranged from 4.0-6.5 in, expressed no sexual dimorphism, and none of the coloration typical of spawning *O. nerka* in other systems. Disturbed substrate where kokanee were observed redd-guarding (0.3-1.5 in.) was smaller than that typically considered appropriate for adult kokanee, likely due to the small size of adult kokanee in area.

No kokanee were observed spawning elsewhere in the East or West forks, though Dolly Varden in spawning colors were observed throughout both systems.

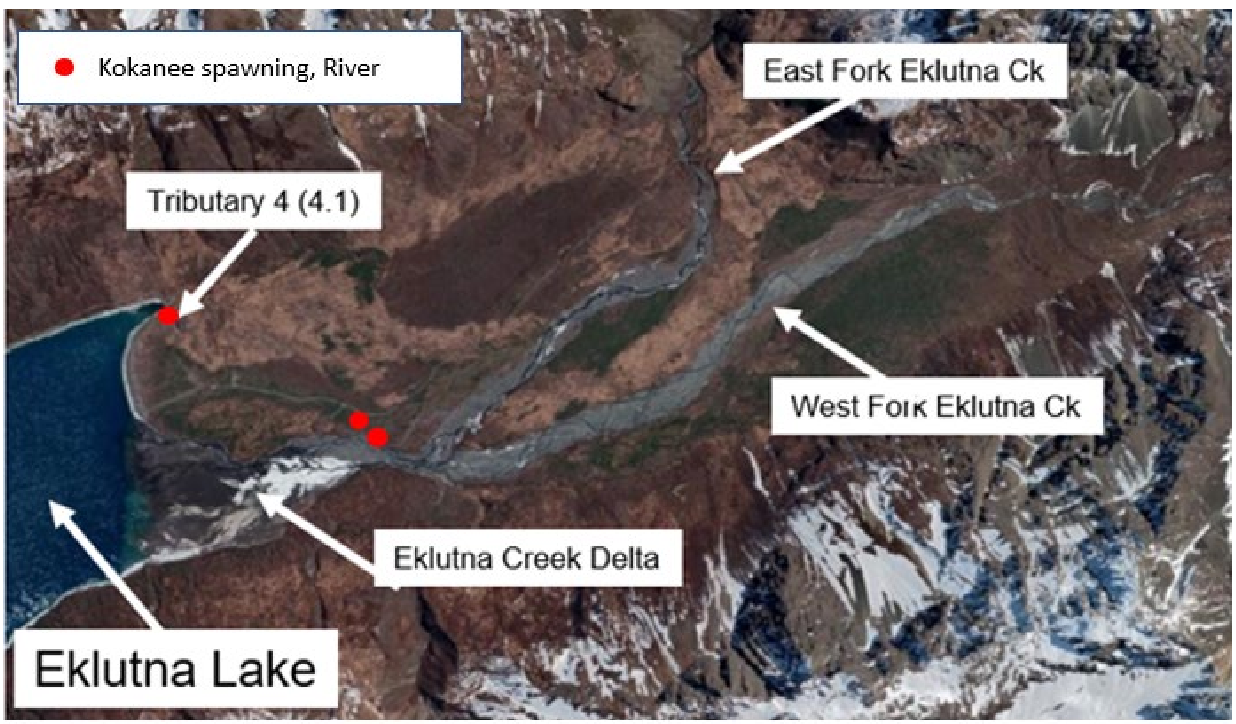

Figure 1-7 Location in the Mainstem Eklutna Creek and Tributary 4 where kokanee spawners were observed in fall, 2022.

Figure 1-8 Kokanee spawner collected in mainstem Eklutna Creek below the confluence of East and West forks (left) and a kokanee carcass in lower Tributary 4 (right).

1.4.3 LAKE-SPAWNING KOKANEE IHN SAMPLING

Adult kokanee carcasses collected at Eklutna Lake in 2021 ranged from 4.5-6.5″ in size. There was no external indication of sex (dimorphism) or coloration typical of spawning *O. nerka* (Figure 1-9). Tissue samples from 100 individuals were sent to ADF&G for genetic analysis to identify origin stock (results pending). In 2022, post-spawned kokanee were sampled for IHN by removing kidney and liver tissue from individual fish for processing by the ADF&G Fish Pathology Lab under Dr. Jayde Ferguson. A total of 60 samples are required to detect IHN in populations of *O. nerka*. Due to the small size of the fish and the potential that some samples may have to be pooled to obtain enough tissue for the analysis, a total of 75 tissue samples and 25 whole kokanee were collected on October 2, 2022, and delivered to the Pathology Lab on October 3, 2022. The processing of IHN samples can take weeks to months, depending on culturing success and workload at the lab. Preliminary findings are expected late in 2022. A subset of these samples (~20 fish) were taken from Tributary 4 near the confluence with the Lake. Several of the sampled fish from Tributary 4 were post-spawned, but had un-digested terrestrial invertebrates in their stomachs. Feeding during spawning migration and active spawning is atypical for pacific salmon and may be another indication of nutrient deprivation.

Figure 1-9 Kokanee carcass showing the position of liver and kidney to be collected for IHN analysis (left) and representative kokanee carcasses from Eklutna Lake (right).

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Appendix 1: Eklutna Lake Substrate Sample Locations

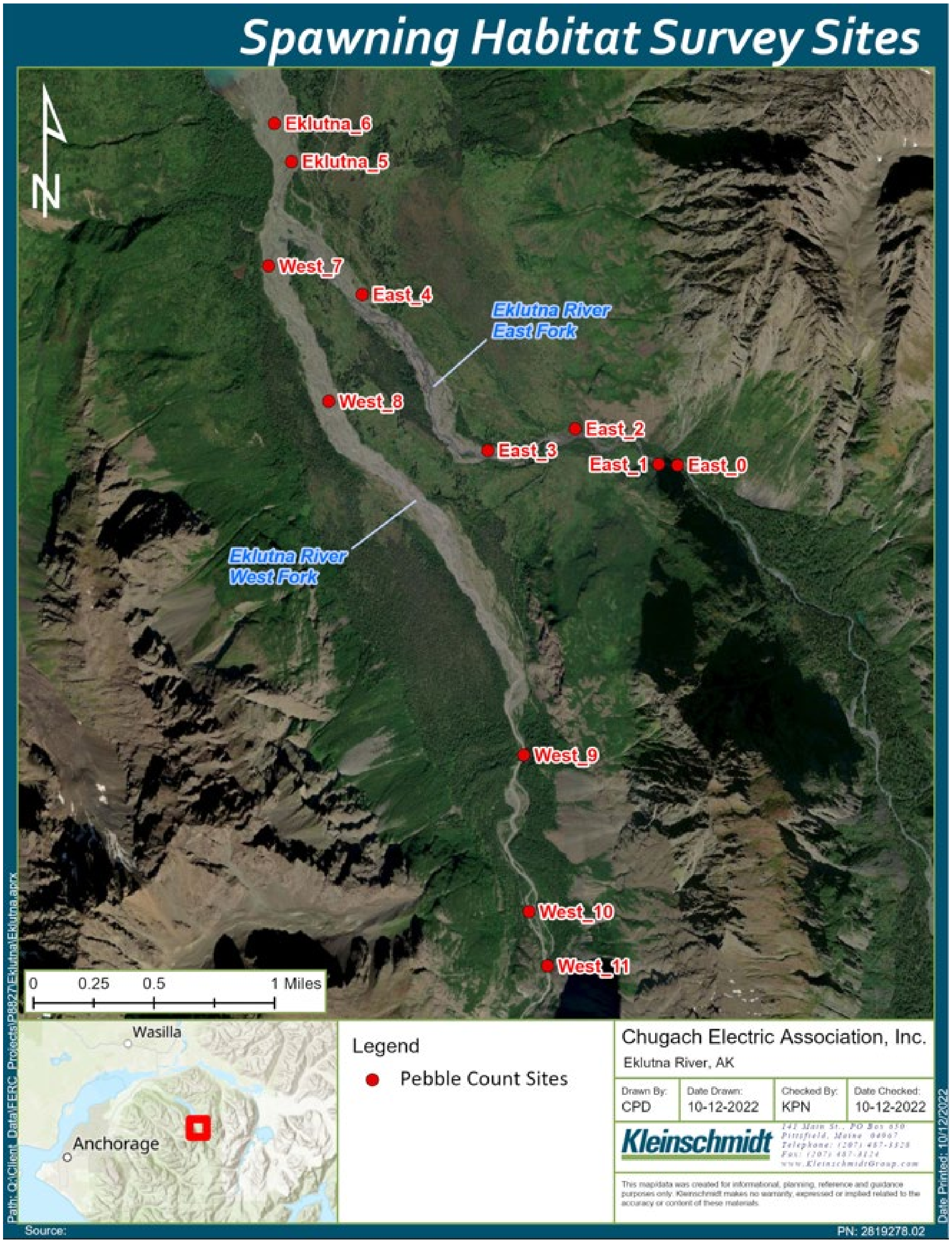

Figure A-1 Spawning habitat survey locations (substrate measurements)