

**Anadromous Cataloging and Fish Inventory in Select
Drainages of the Upper Yukon and Tanana Rivers**

by

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and

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July 2019

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	<i>all standard mathematical signs, symbols and abbreviations</i>	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H _A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	<i>e</i>
hectare	ha	at	@	catch per unit effort	CPUE
kilogram	kg	compass directions:		coefficient of variation	CV
kilometer	km	east	E	common test statistics	(F, t, χ^2 , etc.)
liter	L	north	N	confidence interval	CI
meter	m	south	S	correlation coefficient	
milliliter	mL	west	W	(multiple)	R
millimeter	mm	copyright	©	correlation coefficient (simple)	r
		corporate suffixes:		covariance	cov
Weights and measures (English)		Company	Co.	degree (angular)	°
cubic feet per second	ft ³ /s	Corporation	Corp.	degrees of freedom	df
foot	ft	Incorporated	Inc.	expected value	<i>E</i>
gallon	gal	Limited	Ltd.	greater than	>
inch	in	District of Columbia	D.C.	greater than or equal to	≥
mile	mi	et alii (and others)	et al.	harvest per unit effort	HPUE
nautical mile	nmi	et cetera (and so forth)	etc.	less than	<
ounce	oz	exempli gratia	e.g.	less than or equal to	≤
pound	lb	(for example)		logarithm (natural)	ln
quart	qt	Federal Information Code	FIC	logarithm (base 10)	log
yard	yd	id est (that is)	i.e.	logarithm (specify base)	log ₂ , etc.
		latitude or longitude	lat or long	minute (angular)	'
Time and temperature		monetary symbols (U.S.)	\$, ¢	not significant	NS
day	d	months (tables and figures): first three letters	Jan, ..., Dec	null hypothesis	H ₀
degrees Celsius	°C	registered trademark	®	percent	%
degrees Fahrenheit	°F	trademark	™	probability	P
degrees kelvin	K	United States (adjective)	U.S.	probability of a type I error (rejection of the null hypothesis when true)	α
hour	h	United States of America (noun)	USA	probability of a type II error (acceptance of the null hypothesis when false)	β
minute	min	U.S.C.	United States Code	second (angular)	"
second	s	U.S. state	use two-letter abbreviations (e.g., AK, WA)	standard deviation	SD
				standard error	SE
Physics and chemistry				variance	
all atomic symbols				population sample	Var
alternating current	AC			sample	var
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				

REGIONAL OPERATIONAL PLAN SF.4A.2019.02

**ANADROMOUS CATALOGING AND FISH INVENTORY IN SELECT
DRAINAGES OF THE UPPER YUKON AND TANANA RIVERS**

by

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July 2019

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Signature Page

Project Title: Anadromous Cataloging and Fish Inventory in Select Drainages of the Upper Yukon and Tanana Rivers

Project leader(s): *Joseph Giefer, Nate Cathcart*

Division, Region and Area Division of Sport Fish, RTS, Anchorage

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Period Covered June 2019 through May 2020

Field Dates: August 2nd – August 24, 2019

Plan Type: Category I

Approval



Title	Name	Signature	Date
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Research Coordinator	Gillian O'Doherty		30 June 2019

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ABSTRACT

From August 2nd to August 24th, 2019, the Alaska Department of Fish and Game (ADF&G), Division of Sport Fish, will inventory stream fish assemblages and associated habitats in a 103,025 square kilometer (sq km) study area selected around the upper Yukon and upper Tanana rivers. Staff identified 255 potential sample sites on small and intermediate sized stream of which we anticipate sampling at least 100 headwater streams and 20 intermediate un-wadeable streams. At each site, prior to electrofishing crews will collect data describing location, water quality, stream characteristics, aquatic habitat, and riparian vegetation. Fish will be collected primarily using backpack and raft mounted electrofishing equipment, and hook-and-line, minnow traps, and aerial observations will be used as supplemental sampling methods. Anadromous fish assemblage data collected will be used to nominate waters to the State of Alaska's Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (Anadromous Waters Catalog, AWC), or to update fish life stage information for waters already listed in the AWC. All sampling data will be available via the ADF&G Alaska Freshwater Fish Inventory (AFFI) online mapping application.

Key words: fish inventory; fish distribution; stream survey; anadromous; Catalog of Waters Important for the Spawning, Rearing of Migration of Anadromous Fishes; Anadromous Waters Catalog; AWC; AFFI; salmon; whitefish; rearing; spawning; electrofishing; Arctic; Yukon River; Tanana River; Draanjik River; Porcupine River; Charley River; Birch creek

PURPOSE

The State of Alaska is committed to conserving fish and their habitat. Alaska is the only state with a constitutional mandate to maintain sustained yields of fish stocks (ADCCED 2009), and the Alaska Department of Fish and Game has a statutory responsibility to manage the use of wild fish stocks for sustained yield (AS 16.05.730(a)). Along with proper management of harvests, protection of fully functioning and connected aquatic habitats is necessary to sustain fish stocks supporting Alaska's commercial, subsistence, and recreational fishing economies.

The state has multiple administrative tools to protect fish habitat. Alaska Statute (AS) 16.05.871 (the Anadromous Fish Act), along with the Fishway Act (AS 16.05.841, which requires that fish passage be maintained in any stream "frequented by salmon or other fish"), constitute Alaska's strongest and most comprehensive instream fish habitat protection standards. Several other Alaska statutes specifically reference fish habitat, including multiple sections in AS 41.17 (Forest Resources and Practices Act) and AS 46.15 (Water Use Act), both administered by the Department of Natural Resources, and AS 46.03.758 (Civil penalties for discharges of oil), administered by the Department of Environmental Conservation.

The Anadromous Fish Act requires ADF&G to "specify the various rivers, lakes and streams or parts of them" of the state that are important to the spawning, rearing or migration of anadromous fish. The Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes and its associated atlas are the media used to accomplish this specification, and are adopted as regulation under 5 AAC 95.011. Activities and uses conducted in, or otherwise affecting, any AWC listed water bodies (under the Anadromous Fish Act), or fish passage in any fish-bearing waters (under the Fishway Act), require prior approval from the ADF&G Division of Habitat (ADF&G Habitat). ADF&G Habitat is responsible for reviewing project plans and specifications submitted by permit applicants. Permitting biologists work closely with permit applicants to ensure that project plans provide for the proper protection of fish habitat. If so, a Fish Habitat Permit is issued to authorize the activity. Permit applications may be denied if impacts to fish or fish habitat cannot be adequately avoided, minimized, or mitigated.

Many other federal, state, and local government policies specify additional protections for anadromous fish habitat in Alaska. Like the Anadromous Fish Act, these only apply to those waters where anadromous fish use is explicitly documented, typically by reference to the AWC. For example, the National Marine Fisheries Service (NMFS) identifies Essential Fish Habitat (EFH) for Alaska stocks of Pacific Salmon in freshwater by reference to the AWC. Three of the U.S. Army Corps of Engineers' regional conditions for nationwide permits in Alaska specify additional requirements and restrictions for proposed projects located in or near AWC listed water bodies. Other government policies that protect AWC listed water bodies are found in; state forest management plans; resource management plans for Bureau of Land Management (BLM) lands; federal and state regulations specifying waters closed to fishing; and city or borough ordinances.

Comprehensive fish distribution information is required for effective land use, conservation, and restoration planning to identify sensitive and important habitats. State land management plans, such as the Susitna Area Plan, Bristol Bay Area Plan, and the Kenai Peninsula Brown Bear Conservation Strategy, identify management guidelines or specify geographic areas of concern based largely on the known distribution of fish. Watershed and conservation planning efforts also rely heavily on knowledge of fish distributions and aquatic habitat characteristics and their spatial and temporal relationship to other valuable resources (e.g. mineral, timber) and activities (e.g. construction, recreation). Planning for habitat restoration programs, such as fish passage enhancement, is also better informed with access to comprehensive fish distribution information.

Resource developments, such as transportation and utility corridors, are most effectively informed if complete fish distribution data is available at project onset. If comprehensive fish distribution information is provided during project scoping, projects can be designed to avoid habitat impacts; alternatively, the absence of comprehensive fish distribution information can lead to unintended fish habitat impacts.

All these fish habitat conservation authorities and planning processes are limited by the extent of current knowledge of fish habitats and their distribution. The Anadromous Fish Act, along with other federal, state, and local government policies that refer to the AWC, provides protection only to those waters identified in the AWC. Listing new water bodies in the AWC requires site specific, direct, and unambiguous observations of anadromous fish followed by a biological and public review process. Habitat modeling, speculation, or professional judgment is insufficient to add water bodies to the AWC currently. The state has limited authority to protect undocumented fish habitat.

Previous field inventories have demonstrated significant data gaps in the understanding of Alaskan freshwater fish distribution and habitat characteristics. To address these gaps, the ADF&G AFFI program began focused efforts to identify anadromous waters at a landscape scale in 2002. For example, anadromous cataloging work from 2003-2008 resulted in a 75% increase in the sum total of the lengths of AWC listed streams, and a 72% increase in the number of cataloged water bodies in the Nushagak River basin.

To refine fish habitat management in specific waters, resource agencies also need knowledge of local aquatic and riparian habitat characteristics. Since aquatic and riparian habitats vary in their sensitivity to human activities as well as their utility to fishes, these habitats should be well understood when planning or permitting activities. Physical and biological characteristics of riparian and aquatic habitats are important factors in determining appropriate best management

practices and mitigation strategies. Documenting habitat characteristics at fish collection reaches also provides baseline information of fish habitat associations.

In response to the above needs, in the summer of 2019, staff will begin year one of a planned two to three-year project to conduct a landscape wide, baseline inventory of fish assemblages and associated habitats characteristics in select drainages of the upper Yukon and Tanana rivers.

This project enables ADF&G, Division of Sport Fish to accomplish objective 1A, under Goal 4 of the Division's 2015-2020 Strategic Plan. The objectives also support the conservation actions of the Alaska Wildlife Action Plan by addressing recommendations for key habitats in Alaska through; data gathering, land and water protection; and habitat work.

OBJECTIVES

The overall goal of the AFFI program is to provide information needed for management of the habitats that support Alaska's freshwater fish.

This project will contribute to that goal by achieving the following objectives:

Objective 1: To maximize the spatial increase of mapped anadromous fish habitat depicted in the AWC by completing a baseline inventory of fish (with emphasis on anadromous fish) assemblages in select drainages of the upper Yukon and Tanana rivers.

Task 1: Locate fish collection reaches to maximize the spatial increase in length of AWC-listed streams while minimizing the number of reaches sampled per stream.

Task 2: Sample each reach with sufficient effort using standardized fish collection techniques such that, in at least 90% of the reaches sampled, the number of species detected is within 1 species of the true species richness.

Task 3: For each water body in which anadromous fish are observed, submit a nomination to the AWC, providing enough information to achieve the intended result (i.e., life stage, addition, deletion, correction, or backup information).

Objective 2: To record, at each fish collection reach, characteristics of aquatic and riparian habitats such that sufficient information is documented to: (a) identify well supported and adequate habitat protection stipulations for permitting of local low level disturbances; or (b) identify further sampling needs necessary to design adequate habitat protection stipulations or mitigation for permitting greater level disturbances.

Task 1: Establish a habitat transect at each fish collection reach and record a suite of standard aquatic and riparian habitat variables.

Objective 3: To make fish distribution information for anadromous and resident fish species and the riparian and aquatic habitat characteristics collected available to federal and state agencies and the public.

Task 1: Inventory data will be available via the ADF&G Fish Resource Monitor - Fish Inventory online mapping service.

STUDY DESIGN

STUDY AREA

The study area was selected for fish inventory fieldwork based upon; expected gaps in AWC coverage; human activities and infrastructure potentially affecting fish habitat; land conservation status; stipulations related to funding source objectives; and practical considerations of helicopter fuel ranges and time needed to conduct sampling.

2019 STUDY AREA

For investigation in 2019, a 103,025 sq km study area was delineated around watershed subbasins in the upper Yukon River and select tributaries of the upper Tanana River (Figure 1). A U.S. Fish & Wildlife Service (FWS) bunkhouse in Fort Yukon and a U.S. National Park Service (NPS) bunkhouse near Coal Creek in the Yukon-Charley National Park will serve as the projects base camps and are at the approximate center of the two regions in the study area where sampling will occur. Crews may also spend up to a few nights in the village of Chalkyitsik to extend the sampling range further up the Black Fork River region. Following the methods outlined in the Target Streams section of this document, a set of target streams (200 headwater and 55 un-wadeable) were identified within the study area.

The upper Yukon and Tanana rivers were identified by the AFFI program as a high priority area due to the limited number of fish surveys in this region, the importance of Yukon fish resources to local & distant communities, and the amount of waters not already in the AWC. As was mentioned above, the study area was, for logistical purposes, delineated primarily based upon proximity to the most accommodating field bases identified in the study area. A list of the subbasins was identified to most closely encapsulate the 2019 field bases and the associated target streams (Table 1). For the most part the 2019 study area does in fact follow watershed boundaries, however the subbasins located along the study area boundary may not include the entire subbasin due practical concerns.

TARGET STREAMS

Using ArcMap, project staff defined 2 stream size classes based on upstream drainage (catchment) area. Headwater sites drain a 50 sq km catchment. Un-wadeable streams drain a 200 sq km catchment. From these 2 size stream classes, a downstream point is created (referred to hereafter as the 50 sq km and 200 sq km pour points), which are used as sample sites and prioritized as described below. In addition to these two stream size classes, a 1500 sq km pour point is defined, which are used as potential main stem river sample sites. The majority of 1500 sq km pour points are on water bodies already listed in the AWC, so they tend to have a low priority when compared to the 50 and 200 sq km pour points. However, there are circumstances where the 1500 sq km pour points are not located in existing AWC streams or are in locations where it's in a more practical location or terrain to sample, and there is potentially valuable fish presence data in those waters. It is for this reason we include them as a potential sample site with the other un-wadeable sample sites (200 sq km pour points), and if possible, they will be sampled with the cataraft in the same manner as the 200 sq km pour point sample sites.

Table 1.–List of subbasins with target sites in 2019.

Subbasin Name	HUC	Area (Sq Km)
Fortymile River	19070502	16,817
Tatonduck River-Yukon River	19070505	8759
Charley River-Yukon River	19070506	16,044
Coleen River	19080104	11,003
Sheenjok River	19080105	12,269
Black River	19080106	16,503
Grass River	19080107	7523
Porcupine Flats-Porcupine River	19080108	14,565
East Fork Chandalar River	19080202	14,416
Christian River	19080203	6438
Lower Chandalar River	19080204	5602
Healy Lake-Tanana River	19080303	12,920
Salcha River	19080305	5740
Chena River	19080306	5352
Birch Creek	19080401	12,921
Beaver Creek	19080402	7738
Yukon Flats-Yukon River	19080403	18,184
Ramparts-Yukon River	19080404	10,441

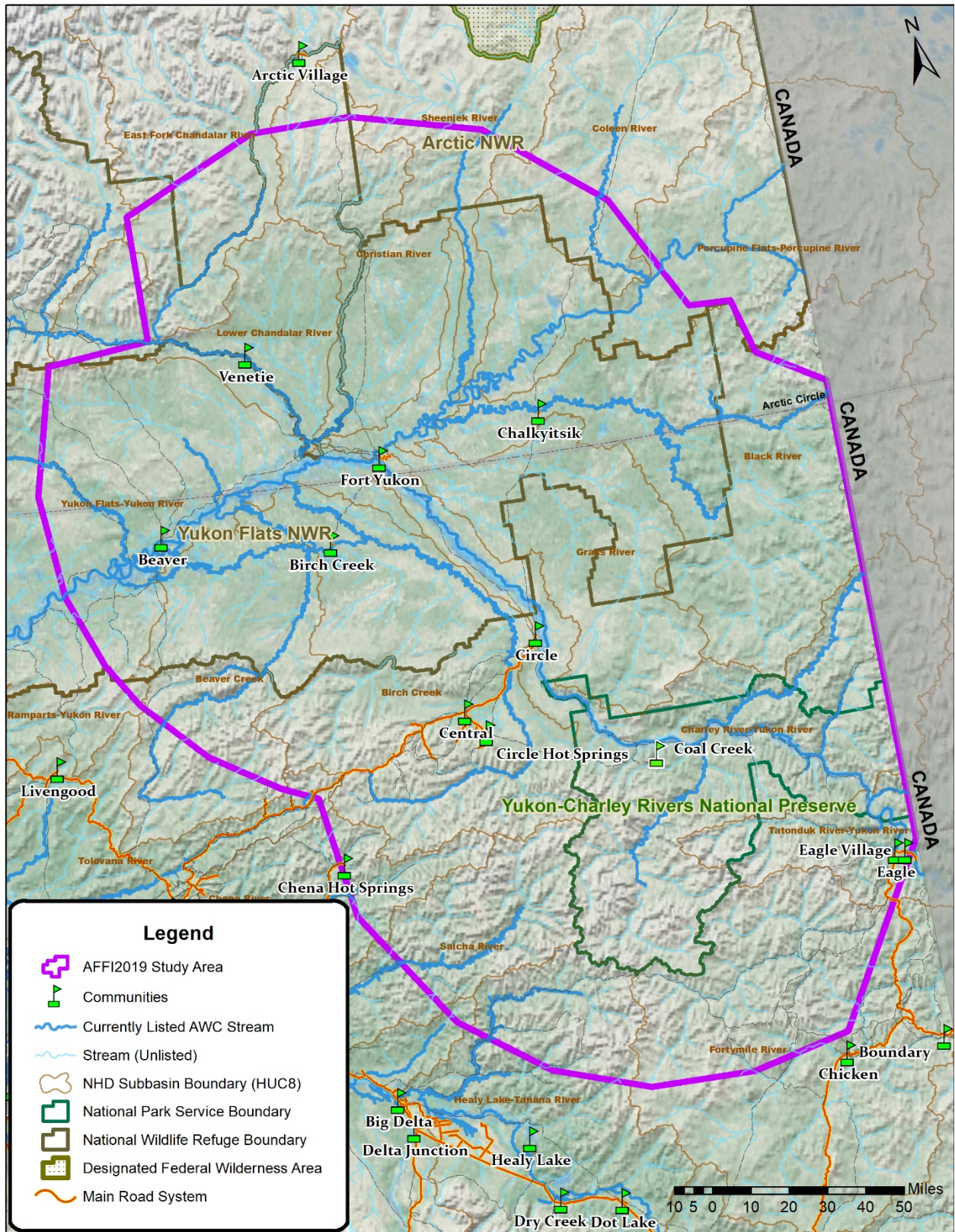


Figure 1.–AFFI 2019 study area map.

Headwater Streams

One headwaters team (Team C) transported by a Robinson R-44 helicopter will visit headwater target streams throughout the study area for a total of 20 field days. We identified 200 headwater sample sites, excluding streams that are already listed in the AWC, have been previously surveyed, and are located upstream of known fish migration barriers. From previous experience, staff anticipate Team C will have time to sample at least 6 target streams per day, for an approximate total of 120 target streams. Some of the 200 headwater sample sites will likely be deemed unsuitable by the crew leader in the field, either due to lack of a suitable helicopter landing zone, the lack of suitable fish habitat, or the presence of an obvious fish passage barrier downstream.

To maximize the length of previously uncataloged anadromous fish habitat documented by Team C, we ranked each headwater target stream by the length of stream located between the upstream terminus of AWC coverage, and the point along the stream where the upstream watershed area first reached 50 sq km. We do not understand enough about the ecological factors that may limit anadromous fish distribution in the study area to include additional calculable criteria (e.g., valley gradient, geology) in our target stream selection process.

Over 600 qualifying headwater target streams were originally identified and ranked using the following GIS based protocol:

1. All 50 sq km pour points within the study area were plotted.
2. Any already listed in the AWC were deleted.
3. Any that we already surveyed were deleted.
4. Any located upstream of known fish-migration barriers were deleted or shifted downstream of the barrier.
5. The length of stream from each 50 sq km pour point downstream to the upper terminus of AWC coverage, or in its absence saltwater, was measured and recorded using an ESRI ArcInfo script. Where more than one 50sq km pour point draining to the same AWC terminus was identified, we determined which pour point had the longest flow path downstream to the AWC terminus and recorded the length of that flow path. Then we recorded the length of the next longest flow path measured only to the confluence with the longest flow path determined in the previous iteration. This step was repeated until a flow path length was recorded for each 50 sq km pour point that shared a common downstream AWC upper terminus. This assures high ranking pour points are distributed across subbasin and watershed boundaries and not concentrated within subbasins.
6. To rank the more than 600 pour points, we sorted them in descending order by their recorded flow path length, and sequentially numbered them from 1 to n.

Once the original 600 headwater target sites were ranked, the top 200 were selected for the project, with some additional considerations. To more fully inventory species presence in areas of elevated environmental concern, target sites were also included and prioritized in the case of; previously surveyed sites that, based on survey notes and professional judgment, were deemed to have high potential to be anadromous fish habitat, unsubstantiated AWC streams in the study area, and input of regional biologists.

Un-wadeable Streams

One cataraft team (Team A) transported by a Bell 206BIII helicopter will visit un-wadeable target streams throughout the study area for a total of 20 field days. For logistical reasons, Team A will sample 1 stream per field day, consisting of multiple sample reaches, for a total of up to 20 un-wadeable streams sampled.

Using the same methods described above for selecting and ranking headwater target streams, 74 candidate un-wadeable streams were ranked and the top 55 were selected for the project. Some of our candidate target streams will likely be deemed unsuitable by the crew leader in the field, especially locations that may present unsafe rafting conditions due to woody debris or large rapids, fish migration barriers or no suitable helicopter landing zone.

Identifying more target sites than can be sampled during the planned 20-day field effort allows for numerous back-up sampling locations should some circumstance prevent sampling of the original top ranked target sample sites.

METHODS

WAYPOINTS AND STATIONS

At each target stream sample site, we will mark a waypoint at the habitat transect using a handheld GPS receiver (Garmin GPSMAP 60CSx or 76S). This point location will be referred to as the station. If fish sampling is attempted, staff will also mark additional GPS waypoints at the upstream and downstream ends of any fish collection reach. If a fish collection reach is established in the absence of a habitat transect (e.g., when crews observe an aggregation of adult fish spread throughout a stream segment from the helicopter), staff will refer to the upstream terminus of the fish collection reach as the station. Staff may also establish a station at sites with no habitat transect and no fish collection reach; for instance, target streams lacking a suitable landing zone, target streams deemed unlikely to support anadromous or resident fish species, target streams deemed inaccessible, un-wadeable or un-raftable, and waterfalls or other definite barriers to fish movement.

Staff will assign a unique 5-character alphanumeric identifier (Station ID) to each station. Any observations recorded in the project database must be associated with a Station ID. The structure of the Station ID will be:

1. The first 2 characters will represent the sequential survey day (e.g.,01,02...)
2. The third character will represent the team making the observation (e.g., A, B,). For this project, the cataraft team will be designated Team A and the headwater team will be designated as Team C.
3. The fourth and fifth characters (e.g.,01, 02,) will represent the sequential station number visited on a given survey day. Note that the station number (4th and 5th characters of the Station ID) will begin at 01 at the start of each survey day.

For example, station 04A01 will be the 1st station visited by Team A on the 4th field day.

Data pertaining to this project will be housed in the AFFI programs master database under a unique project code (FSYK19) for all sampling completed between during the 20-day field effort, and any subsequent follow up surveys. The combination of Project Code and Station ID will therefore ensure a universally unique identifier for each station.

See Table 2 for a list of geographic information variables to be recorded at each sample site.

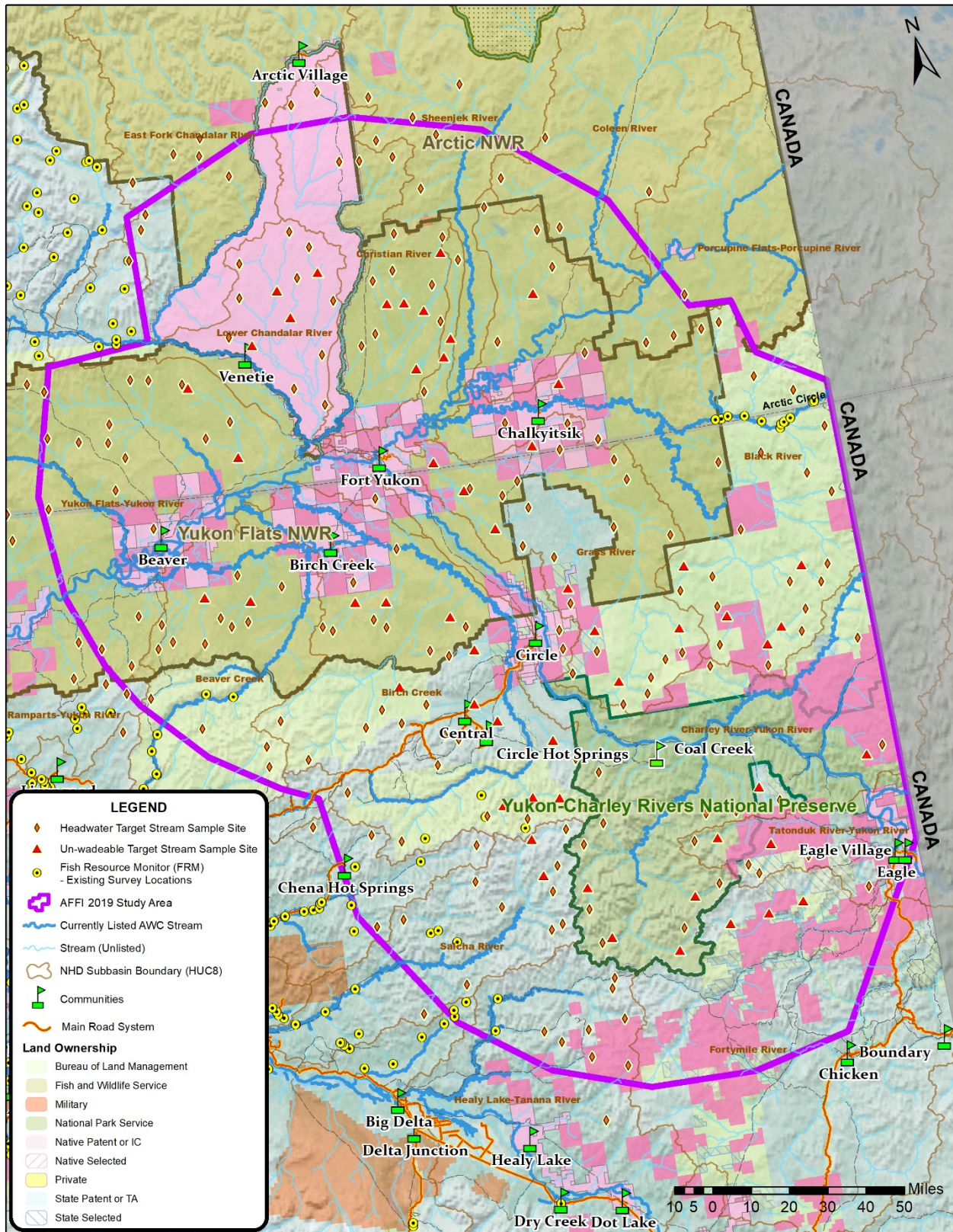


Figure 2.—2019 study area and target stream map.

FISH-COLLECTION REACHES

Sampling sufficiency and site selection

Headwater Streams

Since collecting all species of the local fish assemblage is the primary task, we will be sampling for fish species richness. According to Temple and Pearsons (2007), when species richness is the primary variable of interest, linear sampling distances should be based on multiples of wetted channel width (CW). Several recent studies have estimated the amount of stream length that should be sampled to capture most (typically 90-95%) of the species present in a stream reach. Based on studies (i.e., Patton et al. 2000, Reynold et al. 2003, Temple and Pearsons 2007) from regions with similarly low species richness as in Alaska, we have previously selected a standard minimum reach length of 40 CW for headwater target streams. This standard has been in place during AFFI projects since the 2003 field season.

To ensure adequate sampling effort occurs in the smallest headwater target streams, and to avoid spending an excessive amount of time in the largest headwater target streams, 40 CW fish collection reaches in headwater streams will be limited to a length of 150–300 m. This range of reach lengths is consistent with the National Water Quality Assessment Program (NAWQA) protocols for sampling fish communities (Fitzpatrick et al.1998) and with recommendations developed for small Wyoming streams (Patton et al.2000). Thus, in headwater target streams having a wetted width

< 3.75 m, actual reach length will exceed 40 CW; and in headwater target streams having a wetted width > 7.5 m, reach length will be less than 40 CW.

Individual fish collection reaches in headwater target streams will be selected in the field by the Team C crew leader during slow, low altitude helicopter reconnaissance. Target stream reconnaissance will generally begin at the 50sq km pour point (Appendix C1) and proceed up the mainstem. As the helicopter flies upstream at altitudes and speeds sufficiently low to allow adequate visual inspection, the crew leader will evaluate the stream, paying particular attention to water flow, gradient, and barriers to fish passage.

The crew leader will select a fish collection reach meeting the following criteria:

1. a reach at or near the apparent upstream limit of anadromous fish distribution;
2. a reach where the crew leader anticipates anadromous fish could be present, based on observable characteristics including: fish observed from the air; stream substrate; velocity; juxtaposition of aquatic habitat types; known seasonal variation in instream flow; and accumulated experience in evaluating the presence of anadromous fish in adjacent and similar water bodies;
3. a safe helicopter landing site within a 5-minute walk of the selected reach, and;
4. where prior approval to access private, native, military, or municipal lands has been provided.

In some cases, the crew leader may judge that the target stream is not likely to provide anadromous fish habitat or significant resident species, and that the objective of maximizing the increase in length of AWC listed anadromous fish habitats would be better served by devoting effort to another stream. In such cases, the crew leader will designate a Station ID, take an aerial

photograph(s) of the target stream, takes notes on what informed the decision, and then direct the pilot to the next target stream.

If anadromous fish are collected from a reach, and in the absence of migratory barriers upstream, additional upstream sampling may be conducted at the discretion of the crew leader. Likewise, if no anadromous fish were collected from a reach, the crew leader may select another fish collection reach further downstream. These options will be weighed against the need to visit other higher priority target streams.

Un-wadeable Streams

Recent analysis of prior (2007-2010) AFFI fish collections indicate that single pass electrofishing in a standard 40 CW reach typically underestimates true species richness in the larger un-wadeable streams of Western and Interior Alaska (Buckwalter et al. 2012). Therefore, to better ensure that all common species of the extant fish assemblage in un-wadeable target streams are detected, Team A will sample a minimum of 12 (or as many as can be sampled in the time available on site) spatially sequential subreaches. Each subreach will be equivalent in length to 10 CW of the target stream. Additional subreaches will be sampled until no new fish species are recorded from 6 consecutive subreaches.

Prior to landing at an un-wadeable target stream, the cataraft team will generally travel by helicopter to the 200 sq km pour point associated with each target stream (Appendix C2) then proceed slowly and at low altitude upstream from there. As the helicopter travels along the target stream, the crew leader will evaluate the channel's aquatic habitat, paying attention to water flow, gradient, barriers to fish passage, and any potential rafting hazards (e.g., rapids, sweepers, falls). The crew leader will select a segment of the target stream for the day's float meeting the following criteria:

1. a segment that can be safely floated in a day;
2. a segment where the crew leader anticipates anadromous fish may be present, based on observable characteristics including: fish observed from the air; stream substrate; velocity; juxtaposition of aquatic habitat types; known seasonal variation in instream flow; and accumulated experience in evaluating the presence of anadromous fish in adjacent and similar water bodies;
3. a safe helicopter landing zone within a 5-minute walk of the stream at both the upstream (put-in) and anticipated downstream (take-out) ends of the segment;
4. where prior approval to access private, native, military, or municipal lands has been provided (unless both landing zones and the reach are accessible within the bounds of the ordinary high water level, in which case no access permission is needed, except for sites located within restricted military land or airspace).

FISH COLLECTION

A primary project objective is to sample the entire fish assemblage in each target stream. While it is usually best to use multiple gear types to get a more representative sample of the fish assemblage, logistical constraints affect the practical ability to use a variety of gear types. To achieve this objective in a large number of remote streams in a short amount of time, it was decided to rely primarily on one fish collection method. Single pass electrofishing was chosen because 1) electrofishing is considered to be the single most effective (Barbour et al. 1999, Simon and Sanders 1999, Flotemersch and Blocksom 2005) and widely applicable (Hughes et al.

2002) method in streams and rivers, 2) electrofishing typically captures more species with less size selectivity than other gear types (Hendricks et al. 1980), 3) electrofishing is a relatively safe method for biologists and captures fishes with minimal mortality or injury (Curry et al. 2009), 4) long reaches can be sampled relatively quickly (Curry et al. 2009); 5) electrofishing equipment is compact and portable, and 6) electrofishing is recommended as a standard fish sampling method for coldwater fishes in streams and rivers (Bonar et al. 2009). AFFI standardized our electrofishing effort by adopting a systematic protocol to identify sample site locations, determining electrofishing reach length as a according to wetted CW, and using standardized electrofisher power outputs (Appendix A1, A2, and A3).

Since electrofishing tends to be size selective, with larger fish being more vulnerable to capture (reviewed by Reynolds [1996]), smaller fish species and life stages are likely to be underrepresented in our catch. Furthermore, large fish are more likely to be seen and counted than small or cryptic species. Small or cryptic fish are only likely to be observed if mobilized toward the anode; however, large fish and their carcasses are typically easier to observe and count, even if they remain beyond the electrical field. Therefore, our results should not be used to infer absolute or relative abundance of fishes.

Project staff understand that some fish may be injured or killed as a direct or indirect result of selecting electrofishing power output settings high enough to capture members of the entire fish assemblages. Since our sampling efforts will be restricted to single pass electrofishing, representing a very small fraction of a given target streams length; this project is not expected to significantly affect fish populations. For example, Kocovsky et al. (1997) found no population level effects in salmonids after 8 years of repeat electrofishing in three Colorado streams.

Single pass electrofishing will be the principal fish collection method, supplemented on a limited basis by other gear types (i.e., hook-and-line, dip net, minnow trapping, or visual observations) where appropriate. To determine where to end each electrofishing reach, crew members will use a handheld, consumer grade GPS unit (Garmin GPS Map 60CSx or 76S) in trip computer mode to measure the distance traveled from the starting point. The GPS unit will be configured to record a track point in short intervals and the waypoints and track log is saved daily.

Crews will follow electrofishing protocols (Appendix A) to minimize stress to fish, maintain crew safety, and standardize sampling efforts between target streams. Team C will use a Smith-Root model LR24 battery powered backpack electrofisher, and Team A will use a Smith-Root model GPP 2.5 gas generator powered electrofisher. We carefully choose electrofisher output settings to minimize trauma to fish and will generally cease electrofishing in the vicinity of any observed large (>300 mm) salmonids, except to collect individuals to confirm species identification.

All collected fish will be identified to species and measured to fork length [measured from tip of snout to fork of tail (or to tip of tail, if no fork)] at the nearest millimeter (mm). Field reference books (e.g., Pollard et al.1997), or copies of appropriate pages from desk references (e.g., Mecklenburg et al.2002; Morrow 1980) and other materials containing species descriptions, ranges, and identification keys will be available and consulted as necessary. If a species cannot be confidently identified in the field, crews will photograph the specimen, record the observations under a higher taxonomic level (e.g., genus or family name) in the database, and retain a voucher specimen(s) fixed in a 10% formalin solution. Entries for unknown or uncertain species will be annotated in the appropriate comment field with the best guess at identification.

At the first opportunity, the voucher specimens and photographs will be examined and identified to species, and the corresponding records in the database updated.

If spawning by a given species is not directly observed, but the crew leader suspects (based on indirect evidence such as external morphological characteristics, behavior, condition, expression of gametes when handled, or presence of newly emerged young) the species likely spawns within or near the study reach, "suspected spawning" will be recorded in the database for the given species. In addition to recording fish that are collected, we also will record counts or estimates (by species and life stage) of additional fish detected, but not collected. We will document any definite barriers to fish passage (Appendix B3).

Up to 30 fish of each species and life stage will be measured from each reach for Team C, and from each subreach for Team A. Any additional fish captured or seen will be identified and counted. Where more than 30 fish of a given species and life stage are collected, in order to avoid biased sampling of fish to be measured, we will measure every *n*th fish removed from the bucket, where the value of *n* is the estimated number of fish of a given species and life stage collected, divided by 30. For each fish, we will record species (Appendix B5), life stage (Appendix B1), life history (i.e., anadromous, resident, unknown), and anomalies in fish appearance or condition (Appendix B2; McCormick and Hughes 1998). Where life stage cannot be determined by external features, we will use fork length thresholds identified in Appendix B1 to classify fish into life stage categories. Injuries due to sampling will be noted in the comments field. Bruising (blackening, usually following the myomeres) may result from electrofishing, and may be accompanied by spinal injury that may not be visible externally. We will minimize voltage and pulses-per-second (pps) when electrofishing to avoid unnecessary stress and injury to fish. If fish die while being captured or in the recovery tank, we will note the mortality in the comments field.

After being identified, measured, and allowed a period of recuperation, all fish (except specimens to be retained for further study) will be released. Specimens to be retained include:

- Those needed to confirm species identification.
- On behalf of Andres Lopez (Curator of Fishes, University of Alaska Museum, Fairbanks), we will retain (in 10% formalin solution) up to 10 (from the entire study area or each major drainage) voucher specimens (<

300 mm-long specimens only) representing each fish species collected. Before storing these specimens in formalin, we will take from each specimen a right-side pectoral fin clip and store it in a uniquely-numbered vial with 95% ethanol—one clip per vial. We will label each whole retained specimen with a pre-numbered tag attached to the right operculum with a zip tie. Each individual fin clip retained for this task will be placed in a separate pre-numbered vial. Tag numbers and vial numbers will be recorded on a datasheet for each individual fish. For specimens >200 mm, we will make an incision through the peritoneum before placing in formalin.

See Table 2 for a list of variables associated with fish collection events and that will be recorded at each study site.

Table 2.–List of variables to be collected during fieldwork.

Variable name	Equipment	Units/Domain	Precision	Comment
Geographic information				
Project Code & Station ID	-	text	-	5-digit alphanumeric—see Waypoints and Visits heading in text.
Station location	consumer-grade GPS unit (e.g. Garmin GPSmap 60CSx or 76S)	decimal degrees: latitude (DD.DDDDD); longitude (-DDD.DDDDD)	0.00001 degrees	
Upper end of reach				
Lower end of reach				
Geodetic datum		text	-	Default is NAD83.
Water-body name	Water-body name from USGS topo map	text	-	
Geographic comments	-	text	-	Describes location of study site in relation to adjacent long-term or permanent geographic features
Observers	-	list of field staff	-	
Date/time	field notebook computer	mm/dd/yyyy hh:mm:ss	1 s	Value input automatically from computer's clock when data entry is begun
Camera counter	-	sequential integers	-	List of photo filenames (last 3 digits only) associated with each station
Visit comments	-	text	-	Physical and biological conditions at the station during the visit—focus on ephemeral conditions, such as weather or stream conditions, or the dynamics of riparian conditions, that may help explain other recorded observations
Wildlife comments	-	text	-	Anecdotal wildlife observations, particularly those that relate to fish.
Water quality				
Water temperature	YSI 556 meter	°C	0.01 °C	Sample thalweg
pH		pH units	0.01 pH units	Sample thalweg
Dissolved oxygen		mg/L	0.01 mg/L	Sample thalweg
Conductivity		µS/cm	1 µS/cm	Ambient conductivity (not temperature corrected). Sample thalweg
Turbidity	LaMotte 2020e turbidimeter	NTU	1 NTU	Sample thalweg
Water color	-	see Appendix B4	-	

-continued-

Table 2.–Page 2 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment	
Channel morphology					
Channel width (wetted and BF)	30-m fiberglass tape	m	0.1 m	In wadeable channels < 30 m wide	
	laser range finder (Bushnell Yardage Pro)	m	1 m	In un-wadeable channels, or where width > 30 m	
Thalweg depth (wetted and BF)	handheld sonar (HawkEye Digital Sonar) and clinometer (to find the BF level)	m	0.1 m	For un-wadeable channels	
	graduated rod	m	0.01 m	All teams—wadeable channels	
Stream gradient	clinometer (Sokkia 5x magnifying abney level with clinometer, or Suunto PM-5)	%	0.1%	Water surface angle between consistent channel features near habitat transect.	
Substrate composition	-	see Appendix B4	-	3 most dominant substrate classes within scoured portion of streambed in a 5-CW (<100 m) section centered on habitat transect.	
Embeddedness category		see Appendix B4	-	Estimated embeddedness of gravel, cobble, and boulder particles in, or as near to as possible, the thalweg in a 5-CW (<100 m) section centered on the habitat transect.	
Entrenchment category	ratio	Visual estimate or laser range finder (floodprone width), and see channel width (BF)	1.0–1.4=entrenched; 1.41–2.2=moderately-entrenched; >2.2=slightly-entrenched	-	Entrenchment ratio (Rosgen 1994) = flood-prone width ÷ BF width. Flood-prone width is the width of the floodplain measured at a water level of twice the thalweg BF depth.
Channel type	see Channel width, Thalweg depth and Stream gradient	Rosgen (1994) level-II channel types, plus the following: Lake/Pond; Slough; Beaver pond complex; Wetland; or No defined channel	-	To be determined in the office following fieldwork based on BF width and BF depth (width-to-depth ratio), gradient, entrenchment ratio, dominant substrate, and estimated sinuosity values.	
Valley type	Visual estimate	Rosgen (1994) level-II valley types.		To be determined in the office following field work based upon site observations, photos and Imagery.	
Stream flow					
Stream stage	-	see Appendix B4	-	Water level relative to BF stage.	
48-hour precipitation	-	none/trace, moderate, heavy	-		

-continued-

Table 2.–Page 3 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Stream flow (continued)				
Thalweg velocity	Transparent velocity-head rod (TVHR)	Head depth (mm)→mean water column velocity (m/s)	1 mm (0.1 m/s)	Wadeable streams, depth <0.9 m
	Whole orange, fiberglass tape, stopwatch	m/s	0.1 m/s	Wadeable streams (alternate). Timed orange float through a 6-m length.
	consumer-grade GPS unit (Garmin GPSmap 60CSx or 76S)	m/s	0.1 m/s	Nonwadeable streams—maximum sustained GPS velocity of boat drifting in thalweg.
Meter type	-	TVHR, orange, or GPS	-	
Riparian vegetation communities				
Riparian vegetation composition	-	Viereck et al. (1992) vegetation communities	-	Dominant vegetation community recorded in 8 zones (4 zones on each bank): 0-5 m (from OHW); 5-10 m; 10-20 m; 20-30 m
Canopy height	graduated rod (< 1.5 m); clinometer & range finder (> 1.5 m)	m	0.1 m (< 1.5 m); 0.5 m (>1.5 m)	Recorded for each of the 8 zones described above
Disturbance	-	see Appendix B7	-	
Fish-collection events				
Channel	-	main-, side-, or off-channel	-	Channel type of fish-collection event
Fish-collection method	-	backpack electrofisher, boat electrofisher, visual observations (ground, boat, or helicopter), dipnet, angling, none	-	
Waveform	electrofisher setting	DC-pulsed; DC-unpulsed	-	
Voltage		V	1 V	(LR-24 only)
Range		Low or High	-	(GPP 2.5 only)
Percent of range		0–100 %	Continuous	(GPP 2.5 only)
Frequency		pulses per second (pps)	1 pps	
Duty cycle		%	1%	(LR-24 only)
Current	electrofisher output meter	A	0.01 A (LR-24); 0.1 A (GPP 2.5)	Peak current (LR-24); average current (GPP 2.5)
Power	electrofisher output meter	W	1 W	Peak power (LR-24 only)
Electrofisher on-time	electrofisher timer	s	1 s	
Efficiency	-	excellent, good, fair, poor	-	Perceived electrofishing efficiency, relative to optimal conditions.

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Table 2.–Page 4 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Catch				
Reach length	GPS (trip computer mode, or track)	m	1 m	Indicate actual length of fish-collection reach, measured by GPS.
Species	-	list of Alaskan freshwater fish species	-	
Life stage	-	see Appendix B1	-	
Life history	-	anadromous, freshwater-resident, marine, unknown, N/A	-	
Suspect spawning	-	yes, no	-	
Barrier	-	see Appendix B3	-	
Fork length	fish measuring board	mm	1 mm	
Sex	-	male, female, blank (if sex was not determined)	-	
Anomalies	-	see Appendix B2	-	
Retained	-	Checkbox (Y/N)	-	Indicate each individual fish retained.
Tag No.	-	10-digit alphanumeric text	-	For retained specimens, indicate the tag number affixed to each fish.
Vial No.	-	10-digit alphanumeric text	-	If a tissue sample was taken, indicate the vial number.
Photo No.	Digital camera	3-digit positive integer	1	For each fish photographed, indicate the photo number (last 3 digits of the photo filename) for each photo taken. May use comma or hyphen to separate non-sequential photo numbers or indicate a range of photo numbers.
Individual comments	fish	text	-	Comments pertaining to an individual fish (e.g., sampling injuries or mortalities, unusual features or behavior)
Additional counts	-	integer--no. of fish	1 fish	
Estimated	-	yes, no	-	Indicates whether the no. of additional fish recorded above was an estimate or a direct count
Species-life-stage comments	-	text	-	Comments pertaining to an entire group of fish of the same species and life stage

Fish collection protocols for headwater streams

See Appendix A1 for detailed fish collection protocols for Headwater streams.

After establishing a habitat transect location (station) and determining the location of the fish collection reach relative to the station (i.e., upstream, downstream, or at the habitat station), Team C will multiply the wetted CW by 40 to calculate the reach length to be sampled. A minimum reach length of 150 m will be sampled in target streams having a wetted CW < 3.75 m, and a maximum reach length of 300 m will be sampled in target streams having a wetted CW > 7.5 m.

The backpack electrofishing system to be used in headwater target streams is a Smith-Root LR-24 fitted with a standard Smith-Root rattail cathode (a 10-ft length of braided, 3/16-in stainless steel cable with the connected end insulated with a 6-ft length of neoprene) and a single anode pole having a standard (3/8-in diameter stock) Smith-Root 28-cm (11-in) diameter stainless steel anode ring.

By default, Team C will begin electrofishing with an unpulsed direct current (DC) waveform, but may switch to pulsed DC if necessary, to extend battery life or improve electrofishing efficiency. To avoid exposing fish to more harmful higher pulse frequencies, if pulsed DC is used, pulse frequency may not exceed 50 pps. A minimum electrofisher on-time of 300 seconds per reach will be required to ensure an adequate minimum level of electrofishing effort.

While collecting fish, the electrofisher operator should move in an upstream direction, zigzagging between the banks, sampling all accessible habitat types, with an emphasis on cover (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation). A second crewmember will follow closely, collecting fish with a fiberglass handled dip net. While walking back downstream to the start of the reach, we will electrofish the thalweg and pools as described in Appendix A1.

At the end of the reach, fish will be processed according to the protocol detailed in Appendix A4, and electrofisher settings and fish observations will be recorded in the database.

Fish collection protocols for un-wadeable streams

After arriving at the upstream terminus of each fish collection reach, Team A will measure the wetted CW of the channel in a straight, representative glide channel unit and multiply by 10 to calculate the subreach length. The reach will comprise a minimum of 12 consecutive subreaches (with observations recorded separately for each subreach), with additional subreaches added as necessary until no new species are detected in 6 consecutive subreaches (or as many subreaches as can be completed in 1 day).

In un-wadeable target streams, Team A will use a cataraft (Outcast model PAC 1200 frame with custom tubes) measuring 13-ft long and 65-in wide, with a load capacity of approximately 750 pounds and with a break down aluminum rowing frame equipped with; a Smith-Root GPP 2.5 generator powered electrofisher and control box, an anode system comprised of 2 Smith-Root SAA-6 adjustable spider array electrodes, each having 6 stainless steel dropper cables (38-in long, 3/16-in diameter), suspended from 2 booms [Smith-Root light-duty fiberglass booms (p/n 06248) extending out over the bow, and a cathode system consisting of 18 braided stainless steel dropper cables (38-in long; 3/16-in diameter) bolted directly to the forward platform. While electrofishing, a rower seated behind the midpoint of the cataraft, will maneuver the cataraft

laterally (across the current) with oars, and a second operator will stand on the forward platform and control the electrofisher foot switch while collecting fish with a fiberglass handled dip net.

The Smith-Root GPP 2.5 cannot produce smooth DC, so a pulsed-DC waveform will be selected. By default, Team A will begin electrofishing using a pulse frequency of 30 pps. To avoid exposing fish to more harmful higher pulse frequencies, pulse frequency may not exceed 60 pps. At the end of the reach, fish will be processed according to the protocol detailed in Appendix A4, and electrofisher settings and fish observations will be recorded in the database.

AQUATIC AND RIPARIAN HABITAT ASSESSMENT

At each site where fish collection is attempted, we will also measure a standard suite of habitat variables describing water quality, channel morphology, stream flow, and riparian vegetation. See Table 2 for a list of habitat variables, along with information about instruments used, units and domains, and precision of measurements.

Habitat Transect

We will establish the habitat transect perpendicular to the direction of flow across a representative (of the fish collection reach), non-pool channel unit. In selecting the habitat transect location, we will look for:

1. A straight section, ideally a glide or run, where streamflow lines are parallel.
2. The streambed is relatively uniform and free of numerous boulders and heavy aquatic vegetation growth.
3. Flow is relatively uniform and free of eddies, slack water, and excessive turbulence.

In pool-riffle stream reaches, the habitat transect will typically be at the transition between a pool and riffle. Most habitat variables will be assessed at the habitat transect (station); however, some variables (i.e., stream gradient, substrate composition and embeddedness, and riparian vegetation) will be assessed over a short (e.g., 5 CW) section of habitat up and/or downstream of the habitat transect.

Site Photos

For each Station ID recorded in the database, we will take ground and aerial photographs with a digital camera. After marking the station GPS waypoint, the first photo taken at each station will be of the GPS screen showing the GPS date and time. This will provide the information needed to accurately associate photos with the correct station and to geotag each photo with GPS data. We will take at least 4 additional photos at each station, including 2 photos from the streambank at the station, one upstream and one downstream, and at least 2 aerial photos of the drainage with the fish collection reach in the foreground, one upstream and one downstream. Additional photos will be taken of notable habitat features, fish, or other subjects of interest throughout the reach. After returning to the office, we will link photos with stations, geotag photos, and use GIS to derive the elevation of each station from the National Elevation Dataset digital elevation model, along with other attributes (legal description of station locations, USGS quad name, HUC) to be reported.

Water Quality

We will measure 4 water quality variables (temperature, pH, dissolved oxygen, conductivity) with a YSA 556 multiprobe meter with a built-in barometer (used in calibrating dissolved

oxygen). The pH, dissolved oxygen, and conductivity sensors will be calibrated weekly (or more frequently if readings are suspect). To measure these variables, we will place the probe in flowing water as near to the thalweg as practical and wait for the readings to stabilize before recording them. We will measure turbidity with a LaMotte 2020e turbidimeter, which we will calibrate daily using 0- and 10, 10-, or 100-NTU standards (depending on the estimated turbidity of the sample). We will collect a water sample for turbidity analysis from flowing water as near to the thalweg as practical. We will also visually assess water color (Appendix B4).

Channel Morphology

To measure stream gradient, we will select a relatively straight stream segment in the vicinity of the habitat transect, which spans at least 2 consistent channel features (e.g., top of riffle to top of riffle). Then we will use a clinometer to measure the water surface angle (%) between consistent channel features. If no single suitable segment is found, multiple gradient measures can be averaged as follows, where y is water-surface angle (%) and x is segment length:

$$y = (y_1 * x_1 + y_2 * x_2 + \dots y_n * x_n) / (x_1 + x_2 + \dots x_n)$$

To characterize substrate composition, we will visually (or in turbid water, by feel under-foot, or with a pole) assess the 3 most dominant substrate classes (Appendix B4) within the perimeter of the scoured stream bed in a 5-CW (up to 100 m maximum) stream section centered on the habitat transect. Within the same stream section, we will also visually estimate substrate embeddedness (Appendix B4) in (or as close as possible to) the thalweg.

In wadeable channels <30m wide, we will measure channel width, both at the bankfull (BF) level (BF width) and at the wetted edges (wetted width), using a fiberglass tape stretched horizontally across the stream perpendicular to the direction of flow. We will also measure thalweg depths as the vertical distance from the stream bed in the thalweg to both the water surface (wetted depth) and the BF level (BF depth). In un-wadeable streams, or where channel width exceeds 30m, we will measure channel widths using a laser range finder, and wetted depth with a handheld sonar device. To calculate BF depth in un-wadeable streams, we will add the wetted depth to the estimated distance from the water surface to the BF level. We will use a clinometer to aid in estimating the BF level by sighting along the habitat transect to BF indicators on both banks and moving the clinometer up or down to achieve a level sighting. We will estimate the entrenchment ratio category in the vicinity of the habitat transect.

Following fieldwork, we will assign both a level-II Rosgen (1994) channel type code and a level-II Rosgen (1994) valley type code to each fish collection reach such that general ecological characteristics are described for each sample reach located in a lotic habitat. We will use site specific field observations, aerial and ground based photos, and digital imagery to determine valley type. To determine channel type, we will use site photos, measured stream gradient, calculated width-to-depth ratio, estimated entrenchment class, dominant substrate, and estimated sinuosity (calculated using GPS tracks, site photos, or NHD hydrography) values collected during fieldwork. For lentic habitats, we added 5 more channel-type classes, including: Lake/Pond; Slough; Beaver pond complex; Wetland; and No defined channel.

Streamflow

We will assess stream stage visually (Appendix B4). We will note recent (within approximately the past 48 hours) precipitation (None/Trace, Moderate, Heavy). At sites where the thalweg is wadeable at the habitat transect, and the wetted depth is <0.9 m, all teams will measure thalweg

head depth using a transparent velocity head rod (TVHR), then convert head depth to mean water-column velocity (Fonstad et al.2005). If use of a TVHR is not feasible, we will estimate thalweg velocity by timing the passage of a whole orange during a 6-meter long float in the thalweg beginning at the habitat transect. In un-wadeable streams where neither a TVHR nor an orange can be used, Team B will estimate thalweg (surface) velocity as the maximum sustained GPS ground speed of the boat drifting in the thalweg with minimal wind effects.

Riparian vegetation

In a reach 5 channel widths long (up to 100 m maximum) centered on the habitat transect, we will visually assess the dominant riparian vegetation community (Viereck et al.1992; Appendix B6) and measure its canopy height and identify any disturbance (Appendix B7) in each of the following 8 zones (4 zones on each bank): 0-5 m (from the bankfull level); 5-10 m; 10-20 m; and 20-30 m. We will estimate canopy heights <1.5 m with a graduated rod, and canopy heights >1.5 m with a clinometer and range finder.

PERMISSION FOR ACCESS TO STUDY SITES

ADF&G is responsible for the sustainability of all fish and wildlife throughout Alaska, regardless of land ownership. No prior permission is needed for ADF&G to access study sites located on State of Alaska lands. There are general BLM lands in the study area and a land use authorization will be obtained from the BLM. A master Memoranda of Understanding (MOUs) between ADF&G and BLM recognized the right of ADF&G to enter onto their lands at any time to conduct routine management activities. Under the MOU, ADF&G informs BLM of the project and estimated dates but does not need formal permission for these activities. There is the Yukon-Charley National Park, managed by the National Park Service (NPS) and the Yukon Flats National Wildlife Refuge, managed by the U.S. Fish & Wildlife Service (FWS) located within the study area boundary. Both entities are supportive of the proposed project. Project staff will work with both agencies to secure appropriate authorization to access sample sites within their respective boundaries. On lands under other ownership status (e.g., private, native, municipal, or Dept. of Defense), prior permission is needed to access study sites where a helicopter cannot land within the boundary of ordinary high water (OHW), which is often the case in small and medium streams. At large streams, we can typically access and conduct activities within the OHW level. To identify and study sites were prior approval may be needed for access, target stream location were plotted on land status maps in GIS (Appendix D). From inspection of this map it was determined that the 2019 target streams are located on lands belonging to the Doyon Ltd, and several Village Corporations. Prior to visiting these sites, we will apply for permission to access them. We will not access any sites on private land above the OHW level without prior permission from the landowner.

DATA COLLECTION AND REDUCTION

Other than derived values to be computed later, we will directly enter all measured or observed values in the field into a Microsoft Access relational database (MDB) using a laptop computer. Wherever appropriate, the MDB will use drop down lists or validation rules (e.g., for continuous data within an acceptable range of values, such as pH values restricted to 0–14).

In base camp, at the end of each field day, crew leaders will error check all data recorded that day. Each team's MDB file, GPS unit files (waypoints and tracks), and digital photographs will

be backed up each day onto an external hard drive and then transferred to a laptop computer, which will be securely stored and transported separately from the field computers.

After the field season, all the team MDBs will be aggregated and checked for nonsensical values. Using ESRI ArcGIS software and GIS layers, we will derive additional station location information (i.e., USGS quadrangle name, HUC, meridian, township, range, section, AWC Region, NED elevation) for each station. We will also update fish life stage assignments based on Appendix B1. These values will then be appended into the compiled MDB.

Data from the compiled MDB will then be replicated to the AFFI database (AFFID), a Microsoft SQL Server database, for long term usage. Accessing AFFID data for staff review, editing, and reporting is primarily achieved through a Microsoft Access Data Project (ADP). The SQL Server is also used to provide raw data and web-based reports for the Internet using ESRI ArcIMS, Adobe ColdFusion, and related GIS applications, along with other appropriate and available map layers (e.g., topographic maps, hydrography, and land ownership coverage).

DATA ANALYSIS

For each water body where we observe anadromous fish, we will prepare and submit a nomination package to the AWC. The nomination package will include all the information required by the AWC program (see Appendix G for an example) and will include a summary of all fish species observed (anadromous or not), from every sampling event on that water body (regardless if anadromous fish were observed during each sampling event).

SCHEDULE AND DELIVERABLES

The 22-day field trip with the full crew and helicopter support is planned for August 2 – August 24, 2019. Teams will be based out of a FWS bunk house in Fort Yukon, Alaska from August 2nd to August August 12th, 2019. On August 13th crews will be transported to Coal Creek, in Yukon-Charley National Park, and will base out of a NPS bunk house there until August 24th. By conducting fieldwork in August, it is believed crews will maximize chances of observing a variety of anadromous and resident fishes, especially stream rearing species and life stages, at the upstream limits of their range, in order to achieve Objective 1. See Table 3 for a schedule listing milestones and deliverables.

Table 3.–Schedule of project activities.

Year	Dates	Activity
2019	March-May	Planning logistics.
	May 1	Apply for any required access permits.
	June 1	Circulate sample sites to interested parties for final prioritization of sampling.
	June 15	Complete 2019 Operational Plan.
	July 29	Last week of field preparations, ship & transport gear.
	August 2	Crews depart for 2019 field work.
	August 3	First day of sampling.
	August 13	Halfway point, crew members swap.
	August 24	Crews return home.
	September 26	Data entry, review and validation.
	September 30	Submit AWC nominations.
December 30	Complete data review & QA/QC	
2020	March 1	Post all 2019 data to AFFI Online Mapping Application.

RESPONSIBILITIES

Table 4.–List of personnel and duties.

Name	Duties
Lisa Stuby	Team-A member. ADF&G Area Biologist.
Joe Giefer	Project leader and field crew supervisor. Prepare and manage project budget and funding proposals. Prepare operational plan. During fieldwork, perform daily data quality control and data backups. Complete post season data reduction, review and analysis. Prepare and submit nomination of appropriate waters to the AWC. Author publications and reports.
Ivy Schultz & Chet Murphy	Prepare land-status maps and field maps.
J Johnson	Project supervisor.
Nate Cathcart	Project Technician and Field Team leader. Under supervision of project leader, assist with all aspects of project. Coordinate fieldwork logistics. Coordinate field crew trainings. Inventory, procure, maintain, and package field equipment and supplies. Prepare and submit nominations of appropriate waters to the AWC. Conduct specimen dissections and otolith extractions if necessary.
Jason Graham	GIS analyses of target stream locations. Post summarized results to project web site. Maintain and develop online mapper.
TBD	Team-C member.
Ryan Snow	Design project database. Compile field data files in Anchorage network. Assist data retrieval and database reporting. Provide technical support for software and hardware development operations and maintenance. Develop software tools to integrate GIS and database functions. Develop software tools to display spatial, tabular, and graphic data via the Web.
Phil Stacey	Team-C member. ADF&G Fish & Wildlife Technician.
Max Newton	Team-A member. NPS Technician.

BUDGET

Table 5.–Budget summary.

Cost category	Allocation (\$K)
100 Personnel	195.5
200 Travel	9.5
300 Contractual	175
400 Supplies	19.4
500 Equipment	0.0
Total	399.4

Table 6.–Summary of personnel expenses.

Name	PCN	Job class	Months	OT (hr)	Haz (hr)	Salary & benefits (\$K)
Joe Giefer	11-6140	Habitat Biologist II	12.0	0	65	117.2
Ryan Snow	11-6087	Analyst/Programmer IV	1.0	0	0	12.3
Chet Murphy	11-6119	GIS Analyst II	3.0	0	0	28.1
Ivy Schultz	11-7076	GIS Analyst II	3.5	0	0	
Nate Cathcart	11-4335	F&W Tech III	9.0	140	65	54.4
Total						212

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APPENDIX A

The procedure to collect fish with a backpack electrofisher (Smith-Root LR-24) is presented below. The objective is to detect all the common fish species found in the reach. Fish collection should be completed within 30 minutes with a cumulative electrofishing time of *at least* 300 s.

Procedures to collect fish at wadeable sites. (adapted from McCormick and Hughes 1998).

1. Establish the habitat transect (Station) in a straight, representative, non-pool (preferably glide or run) channel unit, mark the first GPS waypoint at the Station, and complete habitat characterization and data entry.
2. Measure wetted channel width (CW, to the nearest 0.1 m) at the station. The minimum fish collection reach length is 40 CW, or 150 m, whichever is greater. The maximum reach length for wadeable streams is 300 m.
3. Both crewmembers must wear leak-free chest waders with wading belt snugly fastened, wading shoes that fit properly, electrically insulated gloves, and polarized sunglasses (preferably with amber lenses). A hat with a brim may also be helpful in reducing glare.
4. Make sure the electrofisher battery is securely fastened. Check electrical connections (battery, anode, cathode). Replace the battery cover securely.
5. Try on the backpack unit and make any adjustments to the suspension system to achieve a comfortable fit, with the unit snug against the operator's back and resting above the hip bones. If necessary, untangle and route the cathode (rat tail) and anode cables.
6. With both electrodes out of the water and clear of each other and both operators, turn the unit on and confirm the system is ready. Reset the timer to zero.
7. The two-person electrofishing team will typically begin electrofishing at the station and work their way upstream the predetermined reach length while collecting fish. If the downstream end of the reach does not coincide with the Station, the team will mark a second GPS waypoint at the downstream end of the reach. A handheld, consumer-grade GPS unit in trip computer mode, a hip chain, or other similarly accurate method, will be used to measure the reach length as they work their way upstream. At the upstream end of the reach, the team will mark a third GPS waypoint. While walking back downstream to the start of the reach, continue electrofishing in the thalweg (see Step 14 below).
8. To use a smooth-DC waveform (preferred):
 - a. Set the waveform to smooth DC, and select the initial voltage setting according to the ambient water conductivity (*not* specific conductance, which is temperature compensated) —see Appendix A3.
 - b. Ensure that all non-target organisms are clear of the water and begin fishing when both crewmembers are ready.
 - c. Closely observe the fishes' response and attempt to maximize capture-prone responses (i.e, taxis or forced swimming) and minimize responses associated with elevated trauma (i.e., immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds). Try to capture fish before they approach near to the electrodes and remove fish quickly from the electric field.

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- d. If fish are unresponsive, increase the voltage by 50 V, press the Enter key and try again. If fish exhibit symptoms of trauma, decrease the voltage by 50 V, press the Enter key, and try again.
 - e. If fish are still not showing capture-prone responses, or if it is necessary to extend battery life, switch to a pulsed-DC waveform.
9. To use a pulsed-DC waveform:
- a. Select initial voltage setting according to the ambient (not temperature compensated) water conductivity—see Appendix A3.
 - b. Set initial pulse frequency to 30 pulses-per-second (pps).
 - c. Set duty cycle to achieve a pulse width of 2 ms, according to the following table:

Frequency (pps)	Duty cycle (%)	
	2 ms	4 ms
30	6	12
35	7	14
40	8	16
45	9	18
50	10	20
60	12	24

- d. If electrofishing is unsuccessful:
 - i. Increase the voltage by 50 V, press the enter key and try again. Stop increasing voltage when fish exhibit a forced response (twitch).
 - ii. If fish twitch but are not showing taxis (induced movement of the fish toward the anode), increase the duty cycle to achieve a pulse width of 4 ms, according to the table in Step 9.c. Press the Enter key and try again. If necessary, repeat this step, increasing duty cycle by 10% until fish show taxis. If the duty cycle is increased to maximum, and taxis is still not achieved, proceed to Step iii.
 - iii. Increase the frequency by 10 pps and press the Enter key. Adjust the duty cycle to achieve a pulse width of 2 ms for the new frequency setting (see Step 9.c) and try again. Repeat Step ii after each frequency increase. Avoid frequencies >60 pps.
10. Beginning at the downstream end of the sampling reach, the electrofishing team will fish in an upstream direction, zigzagging across the channel from bank to bank in order to sample all habitat types. On the upstream pass, the emphasis is on sampling cover and channel margins. The thalweg is more effectively sampled during the downstream pass. Depress the switch and sweep the anode slowly from side to side in the water. Electrofish intermittently to avoid herding fish, especially in glides or long pools. After electrofishing continuously for a duration of up to 5 s, quietly advance upstream approximately 2–4 m before resuming electrofishing.

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11. Attempt to sample the variety of habitats (deep and shallow, fast and slow, complex and simple, warmer and colder) present throughout the reach. Be sure to sample available cover (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation). Move the anode into confined cover with the power off, then depress the switch and sweep the anode away from the cover to draw fish out into open. Do not attempt to sample in or near pools greater than waist deep, or where velocity is too fast to safely wade. Always move slowly and carefully to avoid startling fish and to minimize risk of falling.
12. The netter follows downstream of the electrofisher operator, collecting fish with a dip net with a non-conductive handle (e.g. fiberglass or wood) and placing them into a 5-gallon bucket with stream water for later processing. Try to net all fish seen. When this is not feasible (e.g., in highly productive systems), try to collect a representative sample of the fish assemblage (e.g., not just large game fish). Pay special attention to netting small and benthic fish, as well as fish that respond differently to the electric field—not just the big fish that move to the surface. Particularly when visibility is obscured by turbidity, debris, or vegetation, the netter should keep the dip net in the water downstream of the anode. The dip net opening should be near vertical, perpendicular to the current, with the dip net frame in contact with the substrate. The distance between the anode and the dip net is related to the current velocity: the faster the current, the greater the distance between the anode and dip net. In fast water, the net should remain several meters downstream of the anode.
13. Refresh the water in the bucket periodically to minimize physiological stress prior to measuring fish.
14. At the upstream end of the reach, mark a GPS waypoint. Then, while walking back downstream to the start of the reach, electrofish the thalweg while trying to walk the same speed as the water. Try to herd fish out of deep pools towards the pool tailout. When approaching the tailout, to avoid herding fish further downstream into the riffle, briefly (e.g., 2-s pause) cease electrofishing to allow fish to turn and attempt to re-enter the pool, then resume electrofishing as they swim past the anode. For the downstream pass, the netter should stay even with the electrofisher operator as they both walk downstream.
15. Record in the database the final, or most successful, electrofisher output settings (voltage, frequency, waveform, electrofisher on-time, duty cycle and typical peak current and power), sampling efficiency (poor, fair, good, excellent), and distance sampled, along with fish observations, including fish collected while electrofishing, as well as any additional fish observed within the reach, but not collected¹. If conditions prevent safe or effective electrofishing within a reach, the conditions, and their effect on sampling efficiency, should be noted in the Sampling Event tab in the database, and the length of stream that was actually sampled should be noted in Sampling Event comments.

¹ In the database, only those fish captured while electrofishing should be associated with an electrofishing sampling event. Fish observed, but not captured should be recorded under a separate sampling event (e.g., Visual observations-ground). Fish collected from off-channel habitats (e.g., tributaries, side channels, floodplain habitats, adjacent beaver ponds) should be recorded under a distinct sampling event.

The objective is to detect all the common fish species found in the reach. The procedure to sample with a generator powered boat electrofisher unit (Smith-Root GPP 2.5) is presented below.

Procedures to collect fish by boat electrofishing. (adapted from McCormick and Hughes 2000)

Onshore at launch site

1. Check generator oil and fill tank with gas (wipe up any spillage).
2. Attach electrodes to boat and connect their cables to the corresponding outlet on the control box. If the fishing site is distant, keep electrodes and anode poles in boat.
3. Connect generator and pulsator (control box).
4. Confirm that all gear for the day is in the boat.
5. Put on a life jacket. Wear polarized sunglasses to aid vision.

At sample reach

1. Establish the habitat transect (Station) in a straight, representative, non-pool (preferably glide or run) channel unit, mark the first GPS waypoint at the Station, and complete habitat characterization and data entry.
2. Measure wetted channel width (CW, in meters) at the station—multiply by 10—this is the length of a single subreach. The minimum fish collection reach length is 10 subreaches, plus any additional subreaches necessary until no new species are detected in the last 6 consecutive subreaches (or as much as can be sampled in a day). Record fish observations and electrofisher settings separately for each subreach under a unique sampling-event code.
3. Check all electrical connections and suspend the electrodes in the water. The wetted surface area of the cathode(s) should be greater than that of the anode(s). Fill live well and put on electrically insulated gloves. Verify that all electrical switches are off, that all non-target organisms are clear of the water or 2 boat lengths away, and that both crewmembers are clear of the water and electrodes and ready to begin electrofishing. Reset the timer on the electrofisher control box to zero at the start of each subreach.
4. If ambient conductivity is $<300 \mu\text{S}/\text{cm}$, set the Range dial to High. If ambient conductivity is $>300 \mu\text{S}/\text{cm}$, set the Range dial to Low. Switch the Mode dial to DC (**Caution! The position of this switch should not be changed when the foot switch is engaged!**) and select an initial frequency of 30 pulses-per-second (pps) and an initial Percent of Range (POR) setting of 10%.
5. Start the generator and depress the foot pedal to begin electrofishing. Increase POR as needed to elicit a capture-prone response [i.e., taxis (induced movement of the fish toward the anode) or forced swimming] from fish, while minimizing responses associated with elevated trauma (i.e., immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds).

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Note: Where water conductivity is high ($>300 \mu\text{S}/\text{cm}$), avoid using POR settings in excess of 60%, which will simply increase duty cycle, but not peak voltage, and may overload the generator (Martinez and Kolz 2009). If the generator sounds labored, decrease POR and/or switch from High to Low range.

6. If fish taxis cannot be achieved, increase frequency to 60 pps, return the POR dial to 10%, and repeat Step 5.
7. Select the riverbank for fishing (river left for odd-numbered target streams, river right for even), and stay along the selected bank through the entire reach, to the degree it is safely navigable. Position the boat so the bow is angled downstream and toward the bank. While drifting downstream, maneuver laterally in the channel to avoid obstacles and position the anode(s) into habitats providing cover for fish. Most effort should occur near the bank, where most fish are expected to occur, and at depths less than 3 m wherever possible. However, all habitat types should be sampled, so zigzag between the thalweg and the bank to allocate some sampling effort to a variety of habitats throughout the channel.

With electrical current off, maneuver the boat so the anode(s) approach near to fish cover elements (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation), then begin electrofishing as the boat is backed away from the cover. Electrofish intermittently to avoid herding fish, especially in glides or long pools. After electrofishing continuously for a duration of up to 10 s, drift quietly for 5–10 m before resuming electrofishing. Do not place the boat in danger in order to fish particular habitats. Cut the generator and stow the gear before negotiating hazards.

8. The netter uses a dip net with non-conductive (e.g. fiberglass) handle to retrieve fish, which are then deposited into a livewell for later processing. Try to capture fish before they approach near to the electrodes and remove fish quickly from the electric field. Try to net all fish seen. When this is not feasible (e.g., in highly productive systems), try to collect a representative sample of the fish assemblage (e.g., not just large game fish). Pay special attention to netting small and benthic fish, as well as fish that respond differently to the electric field—not just the big fish that move to the surface. If benthic fish are being missed, hold the net behind the anode just above the bottom so some are collected.
9. Change the water in the livewell periodically to minimize stress prior to processing.
10. Using a GPS unit in trip computer mode to monitor distance traveled, continue sampling downstream to the end of the subreach. At the end of the subreach, process the fish according to Appendix A4. Be sure to release them upriver, or preferably near the opposite bank, to reduce the likelihood of recapturing them.

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11. Record in the database the final, or most successful, electrofisher output settings (mode, range, POR, pulse frequency, current, electrofisher on-time, duty cycle and power, if known), sampling efficiency (poor, fair, good, excellent), and distance sampled, along with fish observations, including fish collected while electrofishing, as well as any additional fish observed within the reach, but not collected². If conditions prevent safe or effective electrofishing within a reach, the conditions, and their effect on sampling efficiency, should be noted in the Sampling Event tab in the database, and the length of stream that was actually sampled should be noted.
12. Be sure the station visit information is completely entered before leaving the site.

² In the database, only those fish captured while electrofishing should be associated with an electrofishing sampling event. Fish observed, but not captured should be recorded under a separate sampling event (e.g., Visual observations-boat). Fish collected from off-channel habitats (e.g., tributaries, side channels, floodplain habitats, adjacent beaver ponds) should be recorded under a distinct sampling event.

Appendix A3.—Recommended target voltage for standardized backpack electrofishing (constant power transfer) for predominantly juvenile salmonids in cold waters at various ambient water conductivities.

Ambient conductivity ($\mu\text{S}/\text{cm}$)	Target voltage		Ambient conductivity ($\mu\text{S}/\text{cm}$)	Target voltage	
	pulsed DC ³	Smooth DC		pulsed DC	Smooth DC
20	1155	490	170	306	130
30	834	354	180	299	127
40	674	286	190	294	125
50	577	245	200	289	123
60	513	218	210	284	121
70	467	199	220	280	119
80	433	184	230	276	117
90	406	173	240	273	116
100	385	163	250	269	115
110	367	156	260	266	113
120	353	150	270	264	112
130	340	145	280	261	111
140	330	140	290	259	110
150	321	136	300	257	109
160	313	133			

Note: Target voltage values were calculated for a Smith-Root LR-24 backpack electrofisher fitted with a standard Smith-Root rat-tail cathode (a 10-ft length of braided, 3/16-in stainless-steel cable with the connected end insulated with a 6-ft length of neoprene) and a single anode pole having a standard Smith-Root 11-inch-diameter stainless-steel anode ring, and are optimized for capturing juvenile salmonids in cold, wadeable flowing waters with predominantly rocky substrates. These target voltages may not be optimal for electrofishing systems having a different internal resistance (i.e., different electrofishing system, electrode type, or if electrodes are heavily corroded), if targeting different fish species/life stages, or when electrofishing in un-wadeable waters or over predominantly fine substrates.

We prepared this power-standardization table based on the power-transfer theory for electrofishing (Kolz 1989), using water ambient conductivity measurements and metered electrofisher output values (peak voltage and current) selected while electrofishing to maximize capture-prone responses (taxis and forced swimming) and minimize responses associated with elevated trauma (immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds) in target fish. We assumed fish conductivity = 100 ($\mu\text{S}/\text{cm}$).

This table provides a starting voltage setting for standardized backpack electrofishing. While electrofishing, always monitor the response of target and non-target organisms and fine-tune electrofisher operations and settings as recommended in the user's manual to achieve the desired response.

³ 30 pulses per second, 12% duty cycle (4 mS pulse width)

Appendix A4.—Procedure to process collected fish.

1. Anesthetize collected fish with AQUI-S 20E according to instructions.
2. Remove 1 fish at a time from the sedation bucket and place on a length measuring tube ($FL \leq 250$ mm) or board ($FL \geq 250$ mm).
3. Identify all collected fish to species (Appendix B5), life stage (Appendix B1), and life history (anadromous, resident, marine/estuarine, unknown) and measure fork length to the nearest mm. Refer primarily to Pollard et al. 1997 to identify unknown salmoninae (salmon, trout, or char) and to Mecklenburg et al. 2002 for all other species. Also refer to photos of known specimens for confirmation. Check each fish for external anomalies (Appendix B2). Document any definite fish passage barriers (Appendix B3) found in or adjacent to the reach. Immediately after identification and measurement, place fish in a second bucket of fresh stream water for recovery.
4. Take a representative photo of each anadromous species and life stage, as well as any rare or unusual fish, fish with anomalies, or fish where ID was uncertain. Record the photo number(s) associated with each fish in the database.
5. Take a fin clip from species requested by UAF (see UAF instructions) Record the fin clip vial number in the database.
6. Retain the following specimens:
 - Species unknown: In 10% formalin—up to 5 (from each site) individual fish of each species and life stage that cannot be confidently identified in the field;
 - UAF Museum: In 10% formalin—voucher specimens of each species (see UAF instructions);
 - Optionally-anadromous fishes for otolith study: Frozen—up to 12 large (> 300 mm, individuals from each study site where they are collected of each optionally-anadromous species, such as: Dolly Varden; humpback whitefish; least cisco, and Bering cisco.
 - ADEC Veterinarian: Frozen—up to 10 individual fish from each study site where they are collected (See DEC instructions).

Euthanize (by a blow to the head, or an overdose of AQUI-S 20E) all specimens to be retained. Tag any retained fish with a unique tag number and record the tag number in the database. For UAF, each fish must be individually tagged. For all other retained specimens, fish of the same species and life stage that were all collected from the same reach may be retained as a group with a single unique tag for the group. Any specimens retained for the otolith study must be frozen. All other specimens should be stored in 10% formalin solution. For specimens >200 mm, make an incision through the belly wall before placing in formalin. Keep specimens cool (e.g., in fresh stream water) until they can be put in formalin or frozen. ***CAUTION! MINIMIZE THE CHANCE OF ATTRACTING WILDLIFE BY KEEPING RETAINED FISH INSIDE A COVERED COOLER OR HEAVY-DUTY PLASTIC BAG. NEVER LEAVE SPECIMENS UNATTENDED IN THE FIELD.***

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7. While 1 crewmember processes fish, the other will enter fish observations into the appropriate fields in the database.
8. When fish have recovered, release them to slow water. When additional subreaches will be sampled downstream (un-wadeable streams), be sure to release the fish upriver, or preferably near the opposite bank, to avoid recapturing them.

Record the species, life stage, life history, and count, along with any comments indicating average size, behavior, anomalies, etc., of any additional fish that were observed, but not collected (e.g., visually observed adults).

APPENDIX B

Appendix B1.–Fish life-stage classes and threshold fork-length values.

Descriptions of fish life-stage classes.

Code	Name	Description
FXE	fixed egg	Eggs adhering to or buried within a substrate.
PLE	planktonic egg	Non-adherent, buoyant or nearly so, eggs drifting with currents.
FXA	alevin	Pre-emergent sac-fry within the interstices of the substrate.
PLL	planktonic larvae	Hatched juveniles drifting with currents and with no, or poorly, developed volitional swimming capabilities.
JUV	juvenile	Sexually immature free-swimming fish.
SMT	smolt	Juvenile anadromous fish on first emigration from fresh to marine water.
JOA	juvenile/adult	Free swimming fish whose sexual maturity is not determined.
ADT	adult	Fish at or approaching sexual maturity.
ASP	adult spawning	Adults observed in the act of spawning.
KLT	kelt	Post-spawning iteroparous anadromous fish in freshwater prior to return to marine water.
CAR	carcass	Post-spawning adult carcass.
NAP	not applicable	No fish observed or general information record only.
NRD	not recorded	Life stage not recorded.

Fork-length threshold values (mm) used to assign fish to selected life-stage classes.

Species	Life stage		
	Juvenile	Juvenile-or-adult	Adult
lamprey-unspecified	-	-	-
longnose sucker	<188	188–348	>348
northern pike	<330	330–448	>448
Alaska blackfish	<42	42–113	>113
broad whitefish	<343	343–448	>448
humpback whitefish	<280	280–363	>363
least cisco	<199	199–318	>318
round whitefish	<199	199–318	>318
inconnu (sheefish)	<586	586–648	>648
Arctic grayling	<190	190–328	>328
pink salmon	-	-	-
chum salmon	-	-	-
coho salmon	-	-	-
sockeye salmon	-	-	-
Chinook salmon	-	-	-
Dolly Varden	<83	83–	-
burbot	<280	280–498	>498
slimy sculpin	<51	51–68	>68

Note: A hyphen or missing value indicates that we assigned individual fish to the indicated life stage based only on examination of morphological indicators of sexual maturity, not based on fork-length threshold values.

Appendix B2.–Fish-anomaly classes.

Code	Name	Description
AB	Absent	Absent eye, fin, tail.
BK	Blackening	Tail or whole body with darkened pigmentation.
BL	Blisters	In mouth, just under skin.
BS	Extensive black spot	Small black cysts (dots) all over the fins and body.
CO	Copepod	A parasitic infection characterized by a worm-like copepod embedded in the flesh of the fish; body extends out and leaves a sore/discoloration at base, may be in mouth gills, fins, or anywhere on body.
CY	Cysts	Fluid-filled swellings; may be either small or large dots.
DE	Deformities	Skeletal anomalies of the head, spine, and body shape; amphibians may have extra tails, limbs, toes.
EF	Eroded fins	Appear as reductions or substantial fraying of fin surface area.
EG	Eroded gills	Gill filaments eroded from tip.
EX	Exophthalmia	Bulging of the eye.
FA	Fin anomalies	Abnormal thickenings or irregularities of rays
FU	Fungus	May appear as filamentous or "fuzzy" growth on the fins, eyes, or body.
GR	Grubs	White or yellow worms embedded in muscle or fins.
HM	Hemorrhaging	Red spots on mouth, body, fins, fin bases, eyes, and gills.
IC	Ich	White spots on the fins, skin or gills.
LE	Lesions	Open sores or exposed tissue; raised, granular, or warty outgrowths.
LI	Lice	Scale-like, mobile arthropods.
MU	Mucus	Thick and excessive on skin or gill, or as long cast from vent.
NO	None	No anomalies present.
OT	Other	Anomalies or parasites not specified.
SA	Scale anomalies	Missing patches, abnormal thickenings, granular skin
SO	Shortened operculum	Leaves a portion of the gill chamber uncovered
TU	Tumors	Areas of irregular cell growth which are firm and cannot be easily broken open when pinched. (Masses caused by parasites can usually be opened easily.)
WR	Leeches	Annelid worms which have anterior and posterior suckers. They may attach anywhere on the body.

Source: McCormick and Hughes 1998.

Appendix B3.–Fish-passage barrier classes.

Code	Name		Description
EBD	Ephemerally Beaver Dam	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a beaver dam. Used where the location of the barrier to movement is known within 100 m.
EDJ	Ephemerally Debris Jam	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a debris jam. This category is restricted to small scale (<10 m) features that do not dramatically alter the overall channel type. Larger mass-wasting created barriers fall in the EGD category. Used where the location of the ultimate barrier to movement is known within 100 m.
EGD	Ephemerally Hydro-Geomorphically Dynamic	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by current hydrological or geomorphic conditions but where evidence indicates that these landscape-scale conditions are in flux over brief (decades) geologic time. Used in areas of recent or ongoing geomorphic alteration (e.g., glacial advance or retreat, mass wasting, tectonic movements, dynamic channel formation). Used where the location of the barrier to movement is within 100 m.
ELF	Ephemerally Low Flow	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by low stream flow, but where evidence indicates that at higher stream flow, fish could ascend further up the channel. Used where the location of the barrier to movement is known within 100 m.
EOT	Ephemerally Other	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a non-permanent barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
ESS	Ephemerally Spring Source	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by the emergence of ground water from an unconfined substrate. Compare to GSL. Used where the location of the barrier to movement is known within 100 m.
GLK	Geologically Lake Shore	Fixed,	Where the upstream movements of a given species appear, based on sufficient sampling or on-site analysis, to be limited by the perimeter of a geologically stable lake shore. Used where the location of the barrier to movement is known within 100 m.
GOT	Geologically Other	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by a geologically fixed barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
GSL	Geologically Stream Limit	Fixed,	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be limited to the presence of surface water, and where that presence of surface water appears to be fixed in space and stable in time (compare to ELF). Spring-fed headwall pools are examples. Used where the location of the barrier to movement is known within 100 m.

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Code	Name	Description
GWG	Geologically Waterfall/High Gradient	Fixed, Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by a waterfall, cascade, or other similar geologically fixed barrier. Used where the location of the barrier to movement is known within 100 m.
HCU	Human, Culvert	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a culvert through a roadbed, a railroad bed, a runway, or through any other type of fill. This code includes culverts of all materials (e.g., metal, plastic, wood) and shapes (e.g., round, arched, bottomless) Used where the location of the barrier to movement is known within 100 m.
HDB	Human, Debris	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by debris placed or deposited in the stream as the direct result of human activities but where that material was not intentionally placed to impound, filter, or divert stream flow. Examples include woody debris from logging activities, and debris flows from failed road prisms. Used where the location of the barrier to movement is known within 100 m.
HDM	Human, Dam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a dam, weir, head gate, or other cross channel structure that impounds, filters, or diverts stream flow. This code includes structures of all materials (e.g., earth, concrete, rip rap, metal, wood). Used where the location of the barrier to movement is known within 100 m.
HOT	Human, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a human-created structure other than those listed immediately above. Used where the location of the barrier to movement is known within 100 m.
NAP	Not applicable	No fish observed. See downstream stations.
NON	None	No barrier exists at survey station.
SBU	Specific Unknown	Barrier Where a given species is collected at a downstream station and not at an upstream station but where no specific barrier is known between the 2 stations. Used where the distributional limits are not known within 100 m.
UNK	Unknown	No information exists upstream of a sample station. Often where a species is collected at a station and no additional sampling or survey occurs upstream.

Appendix B4.–Water color, substrate, and stream-stage classes.

Water-color classes.

Code	Description	Definition
CLR	Clear	Transparent water, or nearly so.
FER	Ferric	Rust- (orange) stained.
GHT	Glacial, High Turbidity	High turbidity waters (visibility \leq 30 cm (12 in) typical of streams originating directly from glaciers (e.g., Matanuska River).
GLT	Glacial, Low Turbidity	Low turbidity waters (visibility $>$ 30 cm) typical of systems with large lakes (settling basins) below glacial discharge (e.g., Kenai River). These waters are frequently turquoise-colored.
HUM	Humic	Tea-colored water (tannic)
MUD	Muddy	Dark water with high suspended particulate load.

Substrate classes.

Code	Name	Intermediate-axis dimensions
BED	Bedrock	$>$ 4,096 mm. Solid rock—few or no discrete particles
BLD	Boulder	256–4,096 mm
CBL	Cobble	64–256 mm
GRV	Gravel	2–64 mm
SND	Sand	0.0625–2 mm
SCL	Silt/Clay	\leq 0.0625 mm
ORG	Organic	Incompletely decomposed organic material

Source: adapted (Bedrock and Organic classes added) from Cummins (1962), which is based on the Wentworth (1922) scale.

Stream-stage classes.

Code	Description
DNC	Dry, no defined channel
DDC	Dry, defined channel
LDF	Low, intermittent surface flow
LCF	Low, continuous surface flow
MED	Medium
HIH	High
WNC	Wet, no defined channel

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Embeddedness classes.

Code	Level of embeddedness ^a	Description
NEG	Negligible	Gravel, cobble, and boulder particles have <5% of their height covered by fine sediment ^b .
LOW	Low	Gravel, cobble, and boulder particles have 5-25% of their height covered by fine sediment.
MOD	Moderate	Gravel, cobble, and boulder particles have 25-50% of their height covered by fine sediment.
HIH	High	Gravel, cobble, and boulder particles have 50-75% of their height covered by fine sediment.
VHI	Very high	Gravel, cobble, and boulder particles have >75% of their height covered by fine sediment.

^a Embeddedness (*sensu* Armantrout 1998): Degree that gravel and larger sizes of particles (boulders, cobble, or rubble) are surrounded or covered by fine sediment (e.g., less than 2 mm).

^b <2 mm, i.e., sand, silt, or clay.

Note: If the dominant substrate type is sand, silt, or clay, the level of embeddedness will be rated as Very high. If the dominant substrate type is bedrock, the level of embeddedness will be rated as Negligible.

Source: modified from Bain (1999), which was adapted from Platts et al. 1983.

Appendix B5.—Fish species codes.

Code	Common name	Scientific name
ACI	sturgeon-unspecified	<i>Acipenser</i> sp.
ATG	green sturgeon	<i>Acipenser medirostris</i>
ATW	white sturgeon	<i>Acipenser transmontanus</i>
CAC	Arctic char	<i>Salvelinus alpinus</i>
CBT	brook trout	<i>Salvelinus fontinalis</i>
CDV	Dolly Varden	<i>Salvelinus malma</i>
CHR	char-unspecified	<i>Salvelinus</i> sp.
CLK	lake trout	<i>Salvelinus namaycush</i>
DAL	Alaska blackfish	<i>Dallia pectoralis</i>
ERC	trout-perch	<i>Percopsis omiscomaycus</i>
FAR	Arctic flounder	<i>Pleuronectes glacialis</i>
FLN	righteye flounders- unspecified	Pleuronectidae
FST	starry flounder	<i>Platichthys stellatus</i>
GAD	cod-unspecified	Gadidae
GAR	Arctic cod	<i>Boreogadus saida</i>
GBR	burbot	<i>Lota lota</i>
GPA	Pacific cod	<i>Gadus macrocephalus</i>
GRA	Arctic grayling	<i>Thymallus arcticus</i>
GSA	saffron cod	<i>Eleginus gracilis</i>
HAM	American shad	<i>Alosa sapidissima</i>
HER	herrings-unspecified	Clupeidae
HPA	Pacific herring	<i>Clupea pallasii</i>
IDA	salmonid, unspecified	Salmonidae
KNS	ninespine stickleback	<i>Pungitius pungitius</i>
KSB	stickleback- unspecified	Gasterosteidae
KTS	threespine stickleback	<i>Gasterosteus aculeatus</i>
LAC	Arctic-Alaskan brook lamprey paired species	<i>L. camtschatica</i> / <i>L. alaskense</i>
LAK	Alaskan brook lamprey	<i>Lampetra alaskense</i>
LAR	Arctic lamprey	<i>Lampetra camtschatica</i>
LMO	Atlantic salmon	<i>Salmo salar</i>
LMP	lamprey-unspecified	<i>Lampetra</i> sp.
LPC	Pacific lamprey	<i>Lampetra tridentata</i>
LRV	American river lamprey	<i>Lampetra ayresii</i>
LWB	western brook lamprey	<i>Lampetra richardsoni</i>
MIN	lake chub	<i>Couesius plumbeus</i>
NOS	longnose sucker	<i>Catostomus catostomus</i>
OEU	eulachon	<i>Thaleichthys pacificus</i>
OLS	longfin smelt	<i>Spirinchus thaleichthys</i>
OPS	pond smelt	<i>Hypomesus olidus</i>
ORM	rainbow smelt	<i>Osmerus mordax</i>
OSM	smelt-unspecified	Osmeridae
OSS	surf smelt	<i>Hypomesus pretiosus</i>
PIK	northern pike	<i>Esox lucius</i>
SAM	Pacific salmon- unspecified	semelparous <i>Oncorhynchus</i> sp.
SCK	Chinook salmon	<i>Oncorhynchus tshawytscha</i>
SCM	chum salmon	<i>Oncorhynchus keta</i>

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Code	Common name	Scientific name
SCO	coho salmon	<i>Oncorhynchus kisutch</i>
SPI	pink salmon	<i>Oncorhynchus gorbuscha</i>
SSE	sockeye salmon	<i>Oncorhynchus nerka</i>
TCT	cutthroat trout	<i>Oncorhynchus clarkii</i>
TRB	rainbow trout	<i>Oncorhynchus mykiss</i>
TRT	trout-unspecified	iteroparous <i>Oncorhynchus sp.</i>
UCR	coastrange sculpin	<i>Cottus aleuticus</i>
UFH	fourhorn sculpin	<i>Myoxocephalus quadricornis</i>
ULP	sculpin-unspecified	Cottidae
UPR	prickly sculpin	<i>Cottus asper</i>
UPS	Pacific staghorn sculpin	<i>Leptocottus armatus</i>
USH	sharpnose sculpin	<i>Clinocottus acuticeps</i>
USL	slimy sculpin	<i>Cottus cognatus</i>
WAK	Alaska whitefish	<i>Coregonus nelsonii</i>
WAR	Arctic cisco	<i>Coregonus autumnalis</i>
WBC	Bering cisco	<i>Coregonus laurettae</i>
WBD	broad whitefish	<i>Coregonus nasus</i>
WHB	humpback whitefish	<i>Coregonus pidschian</i>
WHC	humpback whitefish complex	<i>C. clupeaformis</i> / <i>C. nelsonii</i> / <i>C. pidschian</i>
WHF	whitefish-unspecified	Coregoninae
WIN	inconnu (sheefish)	<i>Stenodus leucichthys</i>
WLC	least cisco	<i>Coregonus sardinella</i>
WLK	lake whitefish	<i>Coregonus clupeaformis</i>
WPG	pygmy whitefish	<i>Prosopium coulteri</i>
WRN	round whitefish	<i>Prosopium cylindraceum</i>
YMA	shiner perch	<i>Cymatogaster aggregata</i>
YYP	yellow perch	<i>Perca flavescens</i>
QQQ	other species not listed	-
VVV	no collection effort	-
XXX	no fish collected or observed	-
ZZZ	general fish observation, no species information	-

Appendix B6.–Riparian vegetation communities (Viereck et al. 1992).

Code	Key	Class	Description
I	Trees > 3 m tall with canopy cover of \geq 10%. If not, go to II.	Forest	Single stemmed woody plants at least 3 m tall at maturity and at least 10% cover.
IA	> 75% of tree cover contributed by coniferous species. If not, go to IB.	Coniferous Forest	Dominated by coniferous (needleleaf) tree species (Sitka, White, and Black Spruce; Western and Mountain Hemlock; Western Redcedar; Alaska-Cedar, Silver and Subalpine Fir, Pacific Yew, Lodgepole Pine, and Tamarack.
IA1	Tree canopy of 60 - 100% cover. If not, go to IA2.	Closed Coniferous Forest	Forest community has a 60 - 100% total tree canopy coverage.
IA1a	Sitka Spruce dominates overstory and regeneration.	Closed Sitka Spruce Forest	Occupies wet sites in SE Alaska, primarily in alluvial flood plains, and in narrow coastal band in SC Alaska to Kodiak.
IA1b	Western Hemlock dominates overstory; other species < 25% of overstory.	Closed Western Hemlock Forest	Widespread in SE Alaska, often with a Sitka Spruce component.
IA1c	Sitka Spruce and Western Hemlock each contribute > 30% cover. Sitka Spruce constitutes most of overstory, Western Hemlock usually provides most of understory.	Closed Sitka Spruce-Western Hemlock Forest	Occurs on moist sites throughout SE Alaska and in coastal band in SC Alaska.
IA1d	Western Hemlock dominates. Sitka Spruce > 25% cover but < Western Hemlock.	Closed Western Hemlock-Sitka Spruce-(Western Redcedar) Forest	Widespread in SE Alaska and in coastal band in SC Alaska (Redcedar may be present S of 57° N).
IA1e	Western Hemlock and Alaska-Cedar dominate (each contributes 25 - 75% of canopy cover).	Closed Western Hemlock-Alaska-cedar	Occurs on a variety of upland sites from sea level to subalpine throughout SE Alaska.
IA1f	Mountain Hemlock dominates canopy cover.	Closed Mountain Hemlock Forest	Occurs near tree line, normally on saturated soil, throughout SE Alaska and in narrow subalpine band in SC Alaska.
IA1g	Western Hemlock and Western Redcedar dominate (each contribute 25 - 75% of canopy cover). Alaska-cedar and Mountain Hemlock may also be significant.	Closed Western Hemlock-Western Redcedar Forest	Occurs on low-producing, poorly drained sites in southern SE Alaska.
IA1h	Silver Fir and Western Hemlock dominate (each contributes 25 - 75% of canopy cover). Sitka Spruce and Western Redcedar may also be important.	Closed Silver Fir-Western Hemlock Forest	Limited distribution in southernmost SE Alaska.

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Code	Key	Class	Description
IA1i	Subalpine Fir dominates canopy cover. Other important species include Sitka Spruce, Mountain Hemlock, and Alaska-cedar.	Closed Subalpine Fir Forest	Occurs in scattered locations near tree line in SE Alaska.
IA1j	White Spruce dominates canopy cover. May include scattered Paper Birch or Balsam Poplar.	Closed White Spruce Forest	Widespread in SC and Interior Alaska, generally on well-drained, permafrost-free soils.
IA1k	Black Spruce dominates canopy cover. White Spruce and Paper Birch may be present.	Closed Black Spruce Forest	Widespread in SC and Interior Alaska, generally on poorly drained organic soils, often over permafrost-free soils.
IA1l	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Closed Black Spruce-White Spruce Forest	Occurs in Interior Alaska near the northern and western limits of trees. Also on terraces and bases of south-facing slopes.
IA2	Tree canopy of 25 - 60% cover. If not, go to IA3.	Open Coniferous Forest	Forest community has a 25 - 60% total tree canopy coverage.
IA2a	Sitka Spruce dominate overstory. Other species < 25% of canopy cover.	Open Sitka Spruce Forest	Often occurs in alluvial deposits and glacial moraines and outwash in SE Alaska and in narrow coastal band in SC Alaska to Kodiak.
IA2b	Western Hemlock and Sitka Spruce dominate overstory (each contributes 25 - 75% of canopy cover).	Open Western Hemlock-Sitka Spruce Forest	Occurs from low to mid-elevations in SE Alaska.
IA2c	Mountain Hemlock dominates overstory. Other trees < 25% of canopy cover.	Open Mountain Hemlock Forest	Primarily on high mountain slopes in SC and SE Alaska.
IA2d	Dominated by various combinations of Alaska-cedar, Western Hemlock, Mountain Hemlock, Sitka Spruce, Lodgepole Pine, Western Redcedar, and Pacific Yew.	Open Mixed Conifer Forest	Stands with 3 - 5 overstory conifer species common on level or gently sloping wet sites in SE Alaska.
IA2e	White Spruce dominates overstory. Other species < 25% of canopy cover.	Open White Spruce Forest	On well-drained sites and near tree line in Interior, SW, NW, and SC Alaska.
IA2f	Black Spruce dominates overstory. Other species < 25% of canopy cover.	Open Black Spruce Forest	Extremely common on poorly drained, cold sites in Interior and SC Alaska.
IA2g	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Open Black Spruce-White Spruce Forest	Occurs mostly near tree line in Interior Alaska.
IA2h	Black Spruce and Tamarack codominate (each contributes 25 - 75% of canopy cover).	Open Black Spruce-Tamarack Forest	On wet lowland sites with permafrost in Interior Alaska.

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Code	Key	Class	Description
IA3	Tree canopy of 10 - 25% cover.	Coniferous Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IA3a	Lodgepole Pine dominates overstory. Other species < 25% of canopy cover.	Lodgepole Woodland	Pine Generally on boggy, poorly-drained sites in SE Alaska.
IA3b	Sitka Spruce dominates overstory. Other species < 25% of canopy cover.	Sitka Woodland	Spruce On poorly drained sedge peat in SE and coastal SC Alaska.
IA3c	White Spruce dominates overstory. Other species < 25% of canopy cover.	White Woodland	Spruce Common and northern and elevational treelines.
IA3d	Black Spruce dominates overstory. Other species < 25% of canopy cover.	Black Woodland	Spruce In Interior, SC, SW, and NW Alaska on wet, boggy sites, often with sphagnum mosses, and on dry upland sites frequently with lichens.
IA3e	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Black Spruce-White Spruce Woodland	In Interior, SC, SW, and NW Alaska, often near the northern, western, and elevational limit of trees.
IB	> 75% of tree cover contributed by broadleaf species. If not, go to IC.	Broadleaf Forest	Dominated by broadleaf (all deciduous trees except for tamarack) tree species (Red Alder, Black Cottonwood, Balsam Poplar, Quaking Aspen, Paper Birch).
IB1	Tree canopy of 60 - 100% cover. If not, go to IB2.	Closed Forest	Broadleaf Forest Forest community has a 60 - 100% total tree canopy coverage.
IB1a	Red Alder dominates overstory. Other species < 25% of canopy cover.	Closed Forest	Red Alder Forest Occupies moist sites and disturbed areas in SE Alaska.
IB1b	Black Cottonwood dominates overstory. Other species < 25% of canopy cover.	Closed Forest	Black Cottonwood Forest Generally along streams in SE and SC Alaska.
IB1c	Balsam Poplar dominates overstory. Other species < 25% of canopy cover.	Closed Forest	Balsam Poplar Forest Occurs most frequently on floodplains in Interior, SC, and SW Alaska and in isolated stands on the northern slope of the Brooks Range.
IB1d	Paper Birch dominates overstory. Other species < 25% of canopy cover.	Closed Forest	Paper Birch Forest Occurs on many upland sites, both with and without permafrost, in Interior and SC Alaska.
IB1e	Quaking Aspen dominates overstory. Other species < 25% of canopy cover.	Closed Forest	Quaking Aspen Forest Occurs on warm, well-drained upland soils in Interior and SC Alaska.

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Code	Key	Class	Description
IB1f	Paper Birch and Quaking Aspen codominate (each contributes 25 - 75% of canopy cover).	Closed Paper Birch-Quaking Aspen Forest	Found on moderately warm sites in Interior and SC Alaska.
IB1g	Quaking Aspen and Balsam Poplar codominate (each contributes 25 - 75% of canopy cover).	Closed Quaking Aspen-Balsam Poplar Forest	Occurs on floodplains in Interior Alaska.
IB2	Tree canopy of 25 - 60% cover. If not, go to IB3.	Open Broadleaf Forest	Forest community has a 25 - 60% total tree canopy coverage.
IB2a	Paper Birch dominates overstory. Other species < 25% of canopy cover.	Open Paper Birch Forest	Occurs on dry to moist sites in Interior, SC, and W Alaska. On dry sites lichens are important in understory; on moist sites, shrubs are dominant.
IB2b	Quaking Aspen dominates overstory. Other species < 25% of canopy cover.	Open Quaking Aspen Forest	Primarily on extremely dry sites on steep south-facing slopes in Interior and SC Alaska.
IB2c	Balsam Poplar or Black Cottonwood dominate overstory. Other species < 25% of canopy cover.	Open Balsam Poplar (Black Cottonwood) Forest	Occurs as open clumps near tree line in Interior, SC, SW, and NW Alaska and in isolated groves on north slope of Brooks Range (Black Cottonwood restricted to SC and SE Alaska).
IB3	Tree canopy of 10 - 25% cover.	Broadleaf Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IB3a	Paper Birch (may be multistemmed) dominates overstory. Other species < 25% of canopy cover.	Paper Woodland	Birch On dry sites, such as old sand dunes and coarse gravel deposits, in NW and northern Interior Alaska.
IB3b	Balsam Poplar dominates overstory. Other species < 25% of canopy cover.	Balsam Woodland	Poplar Reported from the Susitna R. floodplain. May occur on slopes near tree line.
IB3c	Paper Birch and Quaking Aspen codominate (each contributes 25 - 75% of canopy cover).	Paper Birch-Balsam Poplar Woodland	Reported from the Susitna Valley.
IC	Broadleaf or coniferous species both contribute 25 - 75% of tree cover.	Mixed Forest	Broadleaf or coniferous species contribute 25 - 75% of tree cover.
IC1	Tree canopy of 60 - 100% cover. If not, go to IC2.	Closed Mixed Forest	Forest community has a 60 - 100% total tree canopy coverage.

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Code	Key	Class	Description
IC1a	Paper Birch and White and/or Black Spruce dominate overstory.	Closed Spruce-Paper Birch Forest	Primarily in Interior and SC Alaska where it tends to occur on cool wet sites when black spruce is included in mixture
IC1b	White Spruce, Paper Birch, and Balsam Poplar/Black Cottonwood dominate overstory.	Closed White Spruce-Paper Birch-Balsam Poplar (Black Cottonwood Forest)	Reported from the Susitna Valley.
IC1c	White and/or Black Spruce, Paper Birch, and Quaking Aspen dominate overstory.	Closed Spruce-Paper Birch-Quaking Aspen Forest	Reported from Interior Alaska.
IC1d	Quaking Aspen and White and/or Black Spruce dominate overstory.	Closed Quaking Aspen-Spruce Forest	Most common in Interior and SC Alaska on warm, well-drained sites--an intermediate successional phase.
IC1e	Balsam Poplar and White Spruce dominate overstory.	Closed Balsam Poplar-White Spruce Forest	On floodplains In Interior, SC, SW, and NW Alaska where it is an intermediate successional stage.
IC2	Tree canopy of 25 - 60% cover. If not, go to IC3.	Open Mixed Forest	Forest community has a 25 - 60% total tree canopy coverage.
IC2a	Paper Birch and White and/or Black Spruce dominate overstory.	Open Spruce-Paper Birch Forest	On a variety of upland sites in Interior, SC, SW, and NW Alaska.
IC2b	Quaking Aspen and White and/or Black Spruce dominate overstory.	Open Quaking Aspen-Spruce Forest	Reported from the Porcupine River area in Interior Alaska.
IC2c	White Spruce, Paper Birch, and Balsam Poplar dominate overstory.	Open Paper Birch-Balsam Poplar-Spruce Forest	Reported from Susitna Valley.
IC2d	White Spruce and Balsam Poplar dominate overstory.	Open Spruce-Balsam Poplar	Reported from Susitna Valley.
IC3	Tree canopy of 10 - 25% cover.	Mixed Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IC3a	Paper Birch and White and/or Black Spruce dominate overstory.	Spruce-Paper Birch Woodland	Reported from Susitna Valley.
II	Erect to decumbent woody shrubs with cover \geq 25% OR dwarf trees (< 3 m tall) with cover \geq 10% cover. If not, go to III.	Scrub	Scrub communities are composed of combinations of dwarf trees, and tall, low, and dwarf shrubs.

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Code	Key	Class	Description
IIA	Dwarf trees (< 3 m tall) with cover \geq 10% cover. If not, go to IIB.	Dwarf Tree Scrub	Community dominated by dwarf trees (< 3 m tall), usually shrublike. Shrubs may be absent or abundant.
IIA1	Dwarf tree canopy of 60 - 100% cover. If not, go to IIA2.	Closed Dwarf Tree Scrub	Dwarf tree canopy of 60 - 100% cover.
IIA1a	Mountain Hemlock dominates overstory. Sitka Spruce may be present.	Closed Mountain Hemlock Dwarf Tree Scrub	Occurs at tree line in SE Alaska. On wind-exposed sites may form mat 0.3 m tall.
IIA1b	Subalpine Fir dominates overstory. Mountain Hemlock and Sitka Spruce may be present.	Closed Subalpine Fir Dwarf Tree Scrub	Forms dense stands at elevational tree line in SE Alaska. On highly exposed sites may form prostrate mat 0.15 m tall.
IIA2	Dwarf tree canopy of 25 - 59% cover. If not, go to IIA3.	Open Dwarf Tree Scrub	Dwarf tree canopy of 25 - 59% cover. Shrubs may be absent or abundant, usually common.
IIA2a	Black Spruce dominates overstory. Dwarf tamarack and paper birch may also be present.	Open Black Spruce Dwarf Tree Scrub	Found on very cold and/or wet soils in Interior, SC, and W Alaska.
IIA2b	Mountain Hemlock dominates overstory. Sitka Mountain-ash may be present.	Open Mountain Hemlock Dwarf Tree Scrub	Common on peatlands and sometimes on exposed ridges in SE Alaska.
IIA3	Dwarf tree canopy of 10 - 25% cover.	Dwarf Tree Scrub Woodland	Dwarf tree canopy of 10 - 24% cover. If other vegetation types are lacking, dwarf tree cover can be as low as 2%.
IIA3a	Black Spruce dominates overstory. Other tree species usually not present.	Black Spruce Dwarf Tree Woodland	Common in Interior, SC, and W Alaska on very cold or wet sites.
IIB	Shrubs > 1.5 m tall and \geq 25% cover dominate. If not, go to IIC.	Tall Scrub	Woody plants other than trees > 1.5 m tall and \geq 25% cover dominate.
IIB1	Shrub canopy cover > 75%. If not, go to IIB2.	Closed Tall Scrub	Shrub canopy cover > 75%.
IIB1a	Willow species dominate overstory (< 25% other canopy species).	Closed Tall Willow Shrub	Characteristic of floodplains and common throughout Alaska except for Aleutian Is. and Arctic coast.
IIB1b	Alder species dominate overstory (< 25% other canopy species).	Closed Tall Alder Shrub	Common throughout most of state on steep slopes, floodplains, and stream banks.
IIB1c	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Closed Tall Shrub Birch Shrub	Generally found in taiga openings in Interior Alaska near tree line.
IIB1d	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Tall Alder-Willow Shrub	Occurs on floodplain terraces and drainages on slopes throughout most of Alaska except Aleutian Is. and Arctic Coastal Plain.

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Code	Key	Class	Description
IIB1e	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Tall Shrub Birch-Willow Shrub	Not common but present on Seward Peninsula.
IIB1f	Standing water present most or all of growing season. Alder (usually) and willow typically dominate.	Closed Tall Shrub Swamp	Common in Interior, SC, and SE Alaska on sites with poorly drained soil and hummocky microrelief with depressions containing standing water. Typically dominated by alder or willow.
IIB2	Shrub canopy cover 25 - 74% OR $\geq 2\%$ IF little or no other vegetation cover present.	Open Tall Scrub	Shrub canopy cover 25 - 74% (or $\geq 2\%$ if little or no other vegetation present).
IIB2a	Willow species dominate overstory (< 25% other canopy species).	Open Tall Willow Shrub	Occupies a variety of sites, from dunes to river banks. Most common in Interior, W, SC, and Arctic Alaska.
IIB2b	Alder species dominate overstory (< 25% other canopy species).	Open Tall Alder Shrub	Found throughout state, but not as abundant as closed alder communities.
IIB2c	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Open Tall Shrub Birch Shrub	Occurs at and above tree line, especially in Alaska Range.
IIB2d	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Tall Alder- Willow Shrub	On floodplain terraces and steep slopes near tree line in Interior and N Alaska.
IIB2e	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Tall Shrub Birch-Willow Shrub	Occurs near tree line especially in Alaska Range and W Alaska.
IIB2f	Standing water present most or all of growing season. Alder (usually) and Willow typically dominate.	Open Tall Shrub Swamp	Occurs on floodplains and drainages in Interior and SC Alaska.
IIC	Shrubs 0.2 - 1.5 m tall and $\geq 25\%$ cover dominate. If not, go to IID	Low Scrub	Woody plants other than trees 0.2 - 1.5 m tall and $\geq 25\%$ cover dominate.
IIC1	Shrub canopy cover > 75%. If not, go to IIC2.	Closed Low Scrub	Shrub canopy cover > 75%.
IIC1a	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Closed Low Shrub Birch	Thickets not common but do occur on Seward Peninsula and Interior Alaska.
IIC1b	Willow species dominate overstory (< 25% other canopy species).	Closed Low Willow Shrub	Common in Interior, W and N Alaska along streams and lakes.
IIC1c	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Low Shrub Birch-Willow Shrub	Occupies alluvial deposits in N and W Alaska.
IIC1d	Ericaceous (e.g., Copperbush Cladothamnus pyrolaeiflorus) species dominate.	Closed Low Ericaceous Shrub	Near tree line in SE Alaska (Copperbush Cladothamnus pyrolaeiflorus).

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Code	Key	Class	Description
IIC1e	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Low Alder-Willow Shrub	Reported from SE Alaska on poorly drained soils.
IIC2	Shrub canopy cover 25 - 74% OR $\geq 2\%$ IF little or no other vegetation cover present.	Open Low Scrub	Shrub canopy cover 25 - 74% (or $\geq 2\%$ if little or no other vegetation present).
IIC2a	Mixed shrubs and tussock-forming sedges dominate (in arctic and alpine regions beyond tree line).	Open Low Mixed Shrub-Sedge Tundra	One of the most extensive tundra units in Alaska; centered in N and W Alaska.
IIC2b	Mixed shrubs and tussock-forming sedges dominate (in subarctic and subalpine regions within tree limit).	Open Low Mixed Shrub-Sedge Bog	Occurs in lowland areas of Interior and SC Alaska.
IIC2c	Shrub Birch and Ericaceous species codominate (each contributes 25 - 75% of canopy cover) on wet non-peat soils. Hydrophytic sedges and Sphagnum are absent.	Open Low Mesic Shrub Birch-Ericaceous Shrub	Mesic slopes and alpine areas in Interior and SC Alaska and in N and W Alaska. Hydrophytic sedges and Sphagnum mosses generally absent.
IIC2d	Shrub Birch and Ericaceous species codominate (each contributes 25 - 75% of canopy cover) on wet peat soils. Peat-forming sedges and/or mosses are present.	Open Low Shrub Birch-Ericaceous Shrub Bog	Common on peat mounds and ridges of poorly drained lowlands in all Alaska except SE Alaska and Aleutian Is. Hydrophytic sedges and Sphagnum mosses generally present.
IIC2e	Ericaceous species dominate (< 25% other canopy species). Wet peat soils.	Open Low Ericaceous Shrub Bog	Common in maritime climates of SE and SC Alaska and Aleutian Is. Hydrophytic sedges and Sphagnum mosses generally present.
IIC2f	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Low Shrub Birch-Willow Shrub	Occurs in poorly drained lowlands and on moist slopes in N, Interior, SC, and SW Alaska
IIC2g	Willow species dominate overstory (< 25% other canopy species).	Open Low Willow Shrub	Occurs on moist uplands in N, Interior, and SC Alaska
IIC2h	Willow species dominate overstory (< 25% other canopy species); sedges dominate understory (in arctic and alpine regions beyond tree line).	Open Low Willow-Sedge Shrub Tundra	Occurs on poorly drained lowlands of Arctic and W Alaska.
IIC2i	Willow species dominate overstory (< 25% other canopy species); graminoids dominate understory on peat soils (in subarctic and subalpine regions within tree line).	Open Low Willow-Graminoid Shrub Bog	Occurs in wet stream bottoms and depressions in Interior, SW, SC, and SE Alaska.

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Code	Key	Class	Description
IIC2j	Sweetgale and graminoids dominate on extremely wet (often standing water) on peat soils.	Open Low Sweetgale-Graminoid Bog	Occupies poorly drained lowlands and pond margins in SE, SC, and SW Alaska.
IIC2k	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Low Alder-Willow Shrub	Occurs near tree line in interior Alaska and on river terraces in Arctic Alaska.
IIC2l	Alder species dominate overstory (< 25% other canopy species).	Open Low Alder Shrub	Occupies moist areas, especially drainages, in most of Alaska, except SE and Aleutian Is.
IIC2m	Sagebrush and Juniper dominate.	Sagebrush-Juniper	Exists on steep south-facing bluffs in Interior and SC Alaska.
IIC2n	Sagebrush and grasses dominate.	Sagebrush-Grass	Occurs on south-facing bluffs in Interior and SC Alaska.
IID	Shrubs < 0.2 m tall and $\geq 25\%$ cover OR $\geq 2\%$ IF little or no other vegetation cover present.	Dwarf Scrub	Woody plants other than trees < 0.2 m tall and $\geq 25\%$ cover dominate.
IID1	Dryas species dominate. If not, go to IID2.	Dryas Dwarf Scrub	Dryas species dominant in dwarf shrub layer.
IID1a	Dryas species dominate.	Dryas Dwarf Shrub Tundra	Very wide-spread throughout the northern two-thirds of Alaska.
IID1b	Dryas species and sedges dominate.	Dryas-Sedge Shrub Tundra	Common on alpine sites throughout the northern two-thirds of Alaska.
IID1c	Dryas species and fruticose lichens dominate.	Dryas-Lichen Shrub Tundra	Occurs on windswept alpine sites, especially on the Seward Peninsula.
IID2	Ericaceous species dominate. If not, go to IID3.	Ericaceous Scrub	Ericaceous species dominant in dwarf shrub layer.
IID2a	Bearberry <i>Arctostaphylos</i> species dominate.	Bearberry Shrub Tundra	Occurs in alpine areas in Interior and Arctic Alaska, but most common in W Alaska.
IID2b	<i>Vaccinium</i> cranberry species dominate.	<i>Vaccinium</i> Shrub Tundra	Common in alpine areas of Interior, N, and W Alaska.
IID2c	Crowberry <i>Empetrum nigrum</i> dominates.	Crowberry Shrub Tundra	Characteristic of S. Alaska and Aleutian Is.
IID2d	Mountain-Heath <i>Phyllodoce aleutica</i> dominates.	Mountain Dwarf Shrub Tundra	Common on alpine slopes in SC and SE Alaska.
IID2e	Cassiope species dominate.	Cassiope Dwarf Shrub Tundra	Widespread on moist alpine sites throughout Alaska.
IID3	Willow species dominate.	Willow Dwarf Scrub	Willow species dominant in dwarf shrub layer.

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Code	Key	Class	Description
IID3a	Willow species dominate.	Willow Dwarf Shrub Tundra	Common in alpine areas throughout Alaska except for SE Alaska.
III	Herbaceous (non-woody) vegetation dominates with < 25% scrub and < 10% forest cover. If not, go to IV.	Herbaceous	Herbaceous (non-woody) vegetation with ≤25% shrub cover and <10% forest cover.
IIIA	Grasses and Sedges dominate (Rushes and Horsetails are treated as forbs). If not, go to IIIB.	Graminoid Herbaceous	Grasses, sedges, or rushes dominant.
IIIA1	Graminoids dominate on well- to excessively drained sites. If not, go to IIIA2	Dry Graminoid Herbaceous	Grasslands of well-drained, dry sites, such as south facing bluffs, old beaches, and sand dunes.
IIIA1a	Elymus species dominate.	Elymus	Occurs on beaches, dunes, gravel outwash flats, and dry slopes mostly in coastal areas, but occasionally in Alaska and Brooks Ranges and Interior Alaska.
IIIA1b	Fescue species dominate.	Dry Fescue	Occupies dry slopes in Interior, SC, and W Alaska.
IIIA1c	Medium height grasses dominate with conspicuous shrubs providing < 25% cover.	Midgrass-Shrub	Locally common on steep, south-facing slopes in Interior and SC Alaska.
IIIA1d	Medium height grasses and broad-leaved herbs dominate.	Midgrass-Herb	Occupies various sites in SC, SE, and Interior Alaska and Aleutian Is. from alpine meadows to stream banks.
IIIA1e	Hair-grasses Deschampsia species dominate.	Hair-Grass	Common in Aleutian Is. and along southern coast of Alaska. Often diverse stands with small numbers of a great many species.
IIIA2	Graminoids dominate or codominate on mesic sites.	Mesic Graminoid Herbaceous	Grasslands on moist sites, but usually not with standing water (tussocks often present).
IIIA2a	Bluejoint Calamagrostis dominates (includes lawns).	Bluejoint Meadow	Found throughout Alaska except for SE and Arctic Alaska. Occupies large areas in SC and SW Alaska. Includes installed and maintained lawns.
IIIA2b	Bluejoint Calamagrostis and herbs codominate.	Bluejoint-Herb	Widely distributed in southern half of state.
IIIA2c	Bluejoint Calamagrostis dominates with conspicuous shrubs providing < 25% cover.	Bluejoint-Shrub	Extensive in SW Alaska and probably also common in SC and Interior Alaska.
IIIA2d	Sedges in tussock growth form dominate (in arctic and alpine regions beyond tree line).	Tussock Tundra	Widely distributed throughout W, N, and Interior Alaska.
IIIA2e	Sedges and Grasses dominate in various combinations (in arctic and alpine regions beyond tree line).	Mesic Sedge-Grass Meadow Tundra	Usually of minor extent in arctic and alpine settings.

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Code	Key	Class	Description
III A2f	Sedges and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Mesic Sedge-Herb Meadow Tundra	Usually of minor extent in arctic and alpine settings.
III A2g	Grasses and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Mesic Grass-Herb Meadow Tundra	Occurs in small, limited areas. Reported from Arctic Slope but probably more widespread.
III A2h	Sedges dominate with conspicuous willow component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Willow Tundra	Widely distributed in tundra areas throughout Alaska except SC and SE; probably most abundant from Brooks Range north.
III A2i	Sedges dominate with conspicuous shrub birch component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Birch Tundra	Known from northern Alaska.
III A2j	Sedges dominate with conspicuous dryas component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Dryas Tundra	Widely distributed in tundra areas throughout Alaska except SE.
III A3	Graminoids dominate or codominate on wet (saturated or flooded most or all of growing season) sites.	Wet Herbaceous (emergent)	Grasslands on wet sites, standing water present for part of year; dominated by sedges or grasses; includes wet tundra, bogs, marshes, and fens.
III A3a	Sedges dominate (in arctic and alpine regions beyond tree line).	Wet Sedge Meadow Tundra	Found in very wet areas, generally underlain by permafrost, in every part of Alaska except SE and Aleutian Is.
III A3b	Sedges and Grasses dominate in various combinations (in arctic and alpine regions beyond tree line).	Wet Sedge-Grass Meadow Tundra	Largely confined to the Arctic Coastal Plain in very wet areas underlain by shallow permafrost.
III A3c	Sedges and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Wet Sedge-Herb Meadow Tundra	Found on very wet, poorly drained sites with standing water, such as oxbow lakes and alpine bogs. Apparently widely distributed throughout Alaska.
III A3d	Tall Sedges emerging from standing water (> 0.15 m deep) dominate.	Fresh Sedge Marsh	Found in SC and SE Alaska; may be found in Interior.
III A3e	Grasses emerging from standing water (> 0.15 m deep) dominate.	Fresh Grass Marsh	Common in ponds, slow-flowing streams, lake margins, and thermokarst pits in N and W Alaska. Depth of water ranges from seasonally flooded to 2 m.

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Code	Key	Class	Description
IIIA3f	Coarse, relatively tall Sedges in saturated or shallow flooded (≤ 0.15 m deep) soils dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge Wet Meadow	Common in very wet areas on floodplains, margins of ponds, lakes, and sloughs and in depressions in upland areas. Reported from W, SC, SE, Interior Alaska and Aleutian Is.
IIIA3g	Sedges in saturated or shallow flooded (≤ 0.15 m deep) soils dominate with conspicuous shrub component providing $< 25\%$ cover (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Shrub Wet Meadow	Occupies upper parts of coastal marshes in SC and SE Alaska.
IIIA3h	Salt-tolerant Grasses (e.g., Puccinellia) dominate.	Halophytic Grass Wet Meadow	Commonly occupies tidal mud flats along entire Alaska coast.
IIIA3i	Salt-tolerant Sedges (e.g., Carex) dominate.	Halophytic Sedge Wet Meadow	Commonly occupies tidal mud flats along entire Alaska coast.
IIIA3j	Delicate, low Sedges on bog peats dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Bog Meadow	Develops on peat deposits, sometimes forming quaking sedge mats, in filled lakes, ponds, and depressions throughout the southern two-thirds of Alaska.
IIIA3k	Mosses (e.g., Sphagnum) dominate with delicate, low sedges present and usually codominant on peat soils (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Moss Bog Meadow	Occurs on peat soils, including seepage slopes, raised bogs, slope bogs, early stages of flat bogs, and floating bogs in SE and SC Alaska and Aleutian Is.
IIIB	Forbs (broad-leaved herbs), Rushes (Juncaceae), Horsetails (Equisetaceae), and Ferns dominate. If not, go to IIIC.	Forb Herbaceous	Vegetation dominated by forbs (broadleaf herbs, ferns, rushes, or horsetails).
IIIB1	Forbs dominate on dry sites (often sparsely vegetated pioneer communities). If not, go to IIIB2.	Dry Forb Herbaceous	On dry sites, usually rocky and well-drained; mostly tundra sites.
IIIB1a	Open Herb communities colonizing previously unvegetated non-alpine sites.	Seral Herbs	Found throughout Alaska on floodplains, riverbanks, and eroding bluffs.
IIIB1b	Wide variety of herbs and sedges dominate on sites covered by late melting snow beds.	Alpine Herb-Sedge (Snowbed)	Includes a wide-variety of types below late-lying snowbanks in mountainous areas throughout Alaska.
IIIB1c	Sparse herb communities on alpine rock outcrops, talus and blockfields.	Alpine Herbs	Occur as sparse vegetation on talus and blockfields, and in some well-vegetated herbaceous meadows in alpine valleys throughout Alaska.
IIIB2	Forbs dominate on mesic soils.	Mesic Forb Herbaceous	On moist sites but without standing water, mostly within forested areas.

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Code	Key	Class	Description
IIIB2a	Mixture of herbs dominate.	Mixed Herbs	Occur on mesic slopes and streambanks throughout most of Alaska.
IIIB2b	Fireweed <i>Epilobium angustifolium</i> dominates.	Fireweed	Occurs on disturbed areas in SC and Interior Alaska.
IIIB2c	Tall (0.5 - 1.5 m) Umbelliferae (e.g., <i>Heracleum</i> and <i>Angelica</i>) dominate.	Large Umbel	Occurs on moist to wet areas, often along drainages, in SE and SC Alaska and Aleutian Is.
IIIB2d	Ferns (e.g., <i>Athyrium</i> and <i>Dryopteris</i>) dominate.	Ferns	Restricted to localized areas in SE and SC Alaska and Aleutian Is.
IIIB3	Forbs dominate on wet (saturated or flooded most or all of growing season) sites.	Wet Forb Herbaceous (emergent)	On wet sites, usually with standing water for part of year.
IIIB3a	Herbs (e.g., <i>Equisetum</i> , <i>Menyanthes trifoliata</i> , and <i>Potentilla palustris</i>) emerging from standing water (> 0.15 m deep) dominate.	Fresh Herb Marsh	Found in ponds, sloughs, and oxbow lakes in SC, SW, SE and Interior Alaska.
IIIB3b	Herbs on saturated or shallow flooded (≤ 0.15 m deep) non-peat soils dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Herb Wet Meadow	Found in seepage areas, ephemeral pools, pond margins and upper edges of coastal marshes on Aleutian Is. and in W, SC, and SE Alaska.
IIIB3c	Broad-leaved Herbs on saturated or shallow flooded (≤ 0.15 m deep) peat soils (often floating mat) dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Herb Bog Meadow	Commonly forms floating mats or occurs along margins of bog ponds in Interior, SC, and SE Alaska. Also occurs in wet areas above streams in Aleutian Is.
IIIB3d	Halophytic Herbs dominate on tidal areas inundated \geq a few times/month by salt water.	Halophytic Herb Wet Meadow	Occurs on a variety of wet substrates on beaches and seaward parts of coastal marshes along entire Alaska coastline.
IIIC	Bryophytes (mosses and liverworts) and/or Lichens dominate. If not, go to IIID.	Bryoid herbaceous	Vegetation dominated by mosses or lichens.
IIIC1	Bryophytes (mosses and liverworts) dominate. If not, go to IIIC2.	Bryophyte	Vegetation cover dominated by mosses.
IIIC1a	Bryophytes (e.g., <i>Gymnocolea</i> , <i>Scapania</i> , and <i>Nardia</i>) dominate on wet sites. Vascular plants are virtually absent.	Wet Bryophyte	Occurs on a wide variety of small and localized, mostly wet sites in the southern part of Alaska.
IIIC1b	Bryophytes (e.g., <i>Racomitrium</i> , <i>Grimmia</i> , and <i>Andreaea</i>) dominate on non-wet sites. Vascular plants are virtually absent.	Dry Bryophyte	Occurs on gravelly slopes, sand dunes, and mounds. Cover usually is sparse.
IIIC2	Lichens dominate.	Lichen	Vegetation cover dominated by lichens.

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Code	Key	Class	Description
IIIC2a	Crustose Lichen species dominate.	Crustose Lichen	Occurs on extremely harsh, dry, windblown rocky sites with little or no soil development primarily in alpine regions throughout Alaska.
IIIC2b	Foliose and Fruticose Lichen species dominate. Other plant types are absent or nearly so.	Foliose and Fruticose Lichen	Occurs on dry fellfields and exposed ridges.
IIID	Plants with floating or submerged leaves dominate. Plants may also have emergent leaves and flowers.	Aquatic (nonemergent) Herbaceous	Dominant vegetation growing submerged in water or floating on water surface. Emergent (often specialized) leaves may occur.
IIID1	Aquatic communities in fresh water.	Freshwater Aquatic Herbaceous	Vegetation submerged or floating in fresh water.
IIID1a	Pondlilies Nuphar and Nymphaea dominate.	Pondlily	In fairly large ponds with mineral substrates. Widely distributed throughout SE, SC, W, and Interior Alaska.
IIID1b	Common Marestalk Hippuris vulgaris dominates. Standing water may dry up for several weeks during growing season. Emergents are absent or nearly so.	Common Marestalk	Found in oxbows, tundra ponds, and sluggish sloughs in SE, SC, W, and N Alaska.
IIID1c	Aquatic Buttercup Ranunculus species dominate or codominate.	Aquatic Buttercup	Occurs in shallow ponds and flooded gravel pits in SC, W, and N Alaska.
IIID1d	Burreed Sparganium species dominate.	Burreed	Occurs in shallow ponds and lakes in SE, SC, W, and N Alaska.
IIID1e	Water Milfoil Myriophyllum spicatum dominates.	Water Milfoil	Found in shallow ponds in SC, W, and Interior Alaska.
IIID1f	Pondweeds Potamogeton species dominate.	Fresh Pondweed	Present in small ponds and pools throughout Alaska.
IIID1g	Water Star-Wort Callitriche species dominate.	Water Star-Wort	Reported from shallow seasonal pools with rock bottoms on Amchika Is.
IIID1h	Aquatic Cryptogams (e.g., mosses Fontinalis, liverwort Scapania, lichen Siphula, and quillwort Isoetes) dominate.	Aquatic Cryptogam	Poorly described but probably widely distributed in shallow lakes and ponds throughout Alaska.
IIID2	Aquatic communities in brackish water.	Brackish Water Aquatic Herbaceous	Vegetation submerged or floating in brackish water.
IIID2a	Four-Leaf Marestalk Hippuris tetraphylla dominates.	Four-Leaf Marestalk	Occurs on deltas, tidal flats, and bays along the Alaska coastline.
IIID2b	Brackish water-tolerant Pondweed Potamogeton, Wigeongrass Ruppia spiralis, or Horned Pondweed Zannichellia palustris dominate.	Brackish Pondweed	Occurs in permanent shallow (0.10 - 0.15 m deep) brackish ponds in SE, SC, and SW Alaska.

-continued-

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Code	Key	Class	Description
IIID3	Aquatic communities in marine water.	Marine Herbaceous	Aquatic Vegetation submerged or floating in saltwater.
IIID3a	Eelgrass <i>Zostera marina</i> dominates.	Eelgrass	Occupies subtidal and low intertidal sites with clear water in bays, inlets, and lagoons from SE Alaska to the Seward Peninsula.
IIID3b	Marine Algae dominates.	Marine Algae	Found on subtidal and intertidal sites, often in exposed rocky areas on the SC, SE, and Aleutian coasts.
IV	< 2% vegetative cover.	Unvegetated	Less than 2% vegetative cover; either natural or anthropogenic.

Appendix B7.–Vegetation disturbance classes.

Code	Description
A	Anthropogenic Disturbance
AA	Unique
AA1	Timber Harvest
AA1a	0-1 year post-harvest
AA1b	1-5 year post-harvest
AA1c	10-20 year post-harvest
AA1d	20+ year post-harvest
AA2	Construction
AA2a	0-1 year post-construction
AA2b	1-5 year post-construction
AA2c	10-20 year post-construction
AA2d	20+ year post-construction
AA3	Enhancement/Restoration
AA3a	Bank Stabilization
AA3b	Riparian Thinning
AA3c	Fisheries Related
AA3d	Rip-Rap
AB	Repeated Seasonal
AB1	Foot Traffic
AB1a	Anglers
AB1b	Non-anglers
AB2	Vehicle Traffic
AB2a	Non-Recreational (road vehicle)
AB2b	Recreational (ATV, snowmachine)
AC	Permanent
AC1	Pervious Surfaces
AC1a	Urban/Commercial Landscaping
AC1b	Agricultural
AC1c	Gravel
AC1d	Other
AC2	Impervious Surfaces
AC2a	Parking Area
AC2b	Paved Trail/Walkway
AC2c	Concrete Wall/Abutment
N	Natural Disturbance
NA	Water/Flood
NA1	Slumping/Undercutting
NA1a	Wood Inputs
NA1b	Sediment Inputs

Appendix B7.–Page 2 of 2.

Code	Description
NA2	Sediment deposition from tributary
NB	Windthrow
NC	Glacial Retreat
ND	Fire
NE	Mass Wasting
NE1	Avalanche
NE2	Landslide
NE3	Debris Torrent
NE4	Natural Tree Mortality

APPENDIX C

Appendix C1.–Headwater target stream location information

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
H001	65.51347	-143.38015	90	16	223	242
H002	67.97438	-145.42439	97	195	152	323
H003	65.62687	-146.49040	73	99	105	304
H004	65.67070	-141.66138	119	49	88	363
H005	67.46060	-145.86844	64	167	86	230
H006	66.41761	-145.36986	11	100	75	187
H007	65.90215	-141.31448	120	67	74	361
H008	67.36324	-144.39264	60	146	73	239
H009	66.95233	-148.38606	90	186	64	176
H010	66.16277	-144.06655	44	65	63	79
H011	65.95997	-146.00550	47	94	61	217
H012	64.95994	-142.94602	129	25	59	304
H013	67.04969	-144.52995	39	127	59	225
H014	65.92127	-143.71234	62	46	125	144
H015	67.45185	-143.94882	71	150	54	184
H016	65.89119	-147.79463	85	139	53	117
H017	66.50903	-148.43771	88	172	53	87
H018	67.27072	-144.27610	56	139	52	238
H019	67.71225	-147.34079	97	203	52	274
H020	67.39428	-145.69260	58	161	65	208
H021	67.40249	-144.85475	59	152	61	227
H022	67.76162	-144.90593	83	176	48	361
H023	64.64364	-143.16171	146	46	45	280
H024	65.78824	-147.86273	90	140	44	101
H025	65.65811	-143.78922	75	31	204	223
H026	66.40602	-144.47768	25	85	48	67
H027	67.55184	-143.74315	80	156	42	171
H028	66.93216	-147.06601	55	157	42	129
H029	65.56232	-145.39611	69	67	41	363
H030	66.36182	-144.18685	33	79	59	75
H031	64.16519	-143.83596	171	82	37	201
H032	67.28389	-145.84457	52	156	71	215
H033	65.06979	-144.87339	104	53	35	156
H034	65.94540	-147.53367	76	133	35	91
H035	65.08144	-144.06149	108	31	34	196
H036	66.03735	-146.93290	59	120	34	151
H037	67.41788	-147.45393	84	189	33	258
H038	66.79404	-144.77928	21	113	45	231
H039	66.16751	-141.14898	118	82	59	346
H040	64.93363	-144.92803	113	58	33	161

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
H041	67.85344	-146.63271	96	201	33	294
H042	65.46967	-146.27613	81	91	104	303
H043	66.07519	-147.68592	75	140	31	63
H044	65.64516	-147.92809	98	140	31	87
H045	66.87595	-141.89889	95	114	30	258
H046	66.19189	-146.73461	48	119	30	106
H047	67.33558	-143.47353	72	140	49	180
H048	67.93694	-145.69332	95	195	140	311
H049	65.84074	-141.40211	120	62	68	343
H050	65.94649	-147.10150	67	122	28	121
H051	65.05730	-142.13622	137	34	28	208
H052	67.69185	-144.76692	79	171	119	290
H053	66.50133	-148.83358	99	181	52	86
H054	66.98623	-148.54219	94	191	27	143
H055	65.19172	-141.14147	151	59	27	239
H056	64.78756	-142.79121	142	37	27	257
H057	67.26452	-144.91967	49	144	51	217
H058	64.76866	-143.96218	130	44	26	251
H059	65.96426	-145.53043	42	82	52	208
H060	66.84900	-143.20814	60	107	26	143
H061	67.00186	-142.17484	90	120	25	106
H062	65.90080	-142.69354	86	43	55	330
H063	64.21754	-144.13465	166	81	25	206
H064	65.33787	-143.88177	94	22	25	363
H065	65.86294	-148.33592	99	154	25	89
H066	65.79064	-144.88613	55	60	25	302
H067	66.11341	-145.67570	33	91	25	180
H068	65.76091	-147.64697	87	133	24	259
H069	65.15378	-143.87775	105	24	23	384
H070	66.57091	-141.32223	109	101	23	268
H071	65.04465	-142.53623	131	25	23	194
H072	67.67728	-143.25127	94	164	29	158
H073	65.62072	-145.15275	65	62	30	353
H074	65.53619	-146.63848	81	102	22	344
H075	66.59414	-143.47698	50	89	71	90
H076	67.53072	-147.30576	87	192	26	248
H077	65.66961	-142.77243	94	27	205	224
H078	64.67733	-141.49870	170	65	20	274
H079	66.03490	-147.48240	72	134	21	78
H080	67.18100	-145.52680	43	146	56	200
H081	66.01216	-146.68335	55	113	19	203

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
H082	67.92883	-144.92295	94	188	46	360
H083	65.62206	-145.55830	66	73	72	272
H084	66.25469	-141.34145	112	83	18	262
H085	65.67407	-142.42277	101	33	76	351
H086	67.19070	-144.56051	47	136	50	217
H087	67.36303	-146.38577	63	168	84	228
H088	67.18843	-143.38546	67	130	36	166
H089	66.21804	-145.23501	24	87	73	185
H090	66.98310	-145.69999	31	136	33	177
H091	65.38902	-145.12040	81	58	17	390
H092	67.95941	-145.94937	98	199	29	290
H093	64.46551	-145.53303	145	91	17	142
H094	66.99767	-145.31095	30	132	23	194
H095	66.73920	-147.81963	71	165	34	146
H096	64.33821	-144.51113	156	78	16	206
H097	64.79980	-142.42809	147	41	46	292
H098	65.15923	-145.79352	98	78	16	129
H099	66.65046	-141.66614	100	102	16	243
H100	67.40839	-142.33501	99	147	16	129
H101	66.63193	-144.06307	34	95	16	71
H102	65.89082	-144.69724	49	60	16	249
H103	64.49997	-143.83541	149	60	16	243
H104	67.69683	-146.39209	84	188	16	267
H105	66.08821	-142.04474	96	62	56	343
H106	65.56353	-145.72611	70	77	81	281
H107	67.69404	-145.09757	78	174	114	284
H108	66.67720	-147.67179	67	159	34	146
H109	66.41567	-141.09582	116	96	15	260
H110	65.96682	-147.39355	72	130	31	87
H111	65.21478	-146.30765	98	92	15	128
H112	64.34296	-143.80211	160	70	15	246
H113	64.94891	-144.18564	116	39	17	179
H114	65.12135	-145.53496	100	71	14	411
H115	66.94064	-144.01792	43	116	14	169
H116	66.71890	-146.89184	46	144	21	109
H117	65.75570	-143.84446	69	37	14	92
H118	65.17244	-144.74273	97	47	18	378
H119	65.83190	-148.04504	93	145	39	95
H120	66.40226	-148.79970	99	178	31	66
H121	66.40824	-144.02958	36	80	77	96
H122	66.30310	-143.96166	41	73	62	78

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
H123	66.17983	-143.20619	63	60	107	126
H124	65.82118	-145.05174	52	65	55	254
H125	66.80866	-147.79103	71	167	32	144
H126	66.36206	-141.73094	99	83	35	322
H127	67.58607	-147.24623	88	194	41	263
H128	65.05513	-142.80410	126	20	13	190
H129	66.77542	-148.39034	87	180	13	118
H130	67.55792	-144.53348	71	160	13	305
H131	66.39919	-147.46940	62	144	13	51
H132	64.73062	-144.21716	130	51	14	176
H133	65.60180	-142.54253	102	27	12	202
H134	65.45913	-146.63630	86	102	18	339
H135	67.70077	-145.29247	78	176	127	297
H136	66.51728	-143.21546	57	84	12	165
H137	64.71416	-144.31832	131	54	12	170
H138	67.78518	-146.66245	92	197	46	268
H139	64.83164	-141.97240	153	47	21	266
H140	64.81338	-145.84726	122	86	12	125
H141	66.11498	-142.69718	78	57	154	174
H142	64.55377	-145.12723	139	78	16	141
H143	66.96069	-147.38138	64	165	32	145
H144	67.33174	-143.25177	76	140	11	108
H145	65.47462	-144.90473	76	52	24	347
H146	65.94100	-145.91897	47	91	60	216
H147	65.65579	-142.93398	91	25	207	226
H148	65.53817	-143.14459	93	16	221	240
H149	66.77133	-146.64831	40	142	21	108
H150	65.32864	-145.95976	88	82	11	426
H151	65.62863	-147.20764	85	119	10	253
H152	63.97446	-144.09487	183	97	25	188
H153	65.92941	-145.42131	44	78	52	208
H154	67.08923	-146.56954	51	156	58	202
H155	65.08151	-143.72594	112	23	10	235
H156	66.00128	-146.84019	59	116	33	150
H157	65.99836	-148.26326	92	154	19	83
H158	65.27441	-143.69316	100	16	10	146
H159	64.28947	-144.37502	160	79	17	199
H160	66.86225	-142.07347	90	112	27	254
H161	64.63696	-143.89533	139	51	26	261
H162	66.43143	-143.10032	61	78	109	128
H163	64.82657	-145.60649	121	79	23	151

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
H164	67.23389	-146.42652	56	162	67	211
H165	66.96853	-147.55460	69	169	36	149
H166	67.75166	-144.30871	86	172	24	337
H167	66.85577	-142.34480	83	109	22	102
H168	65.81914	-142.38593	96	42	74	348
H169	65.86215	-141.68725	112	57	57	331
H170	66.13076	-146.33705	42	108	20	137
H171	66.55807	-147.79146	70	158	9	70
H172	67.03582	-145.16476	33	132	27	193
H173	64.85678	-144.26011	122	45	12	173
H174	66.84764	-142.61445	76	108	16	97
H175	66.35405	-142.14084	88	78	20	307
H176	65.82738	-143.85273	65	41	9	88
H177	65.75081	-141.59162	118	54	88	363
H178	64.82541	-144.72818	121	57	14	176
H179	66.79450	-145.72943	20	126	9	152
H180	67.23556	-145.12434	46	144	44	211
H181	65.96486	-148.05484	88	148	46	110
H182	64.83857	-142.50835	143	37	46	291
H183	65.93255	-142.37978	92	48	40	314
H184	65.56628	-142.02150	115	37	81	356
H185	66.50145	-143.58797	47	84	77	96
H186	65.59567	-143.09142	91	20	217	236
H187	66.34999	-143.01182	65	72	114	133
H188	65.60599	-141.17456	133	60	8	237
H189	67.82913	-144.51473	90	178	32	345
H190	66.86834	-146.00397	29	135	19	163
H191	67.80297	-146.91161	96	201	48	270
H192	66.10285	-143.79612	52	58	109	128
H193	67.92809	-144.00688	100	182	25	338
H194	66.75226	-148.09712	79	172	12	117
H195	64.46187	-143.86799	151	62	10	241
H196	65.49874	-145.02285	74	56	31	353
H197	65.01369	-143.92605	114	31	13	238
H198	64.32133	-144.12576	159	74	12	243
H199	65.72686	-143.54138	76	31	196	215
H200	65.14063	-144.39049	102	38	15	375

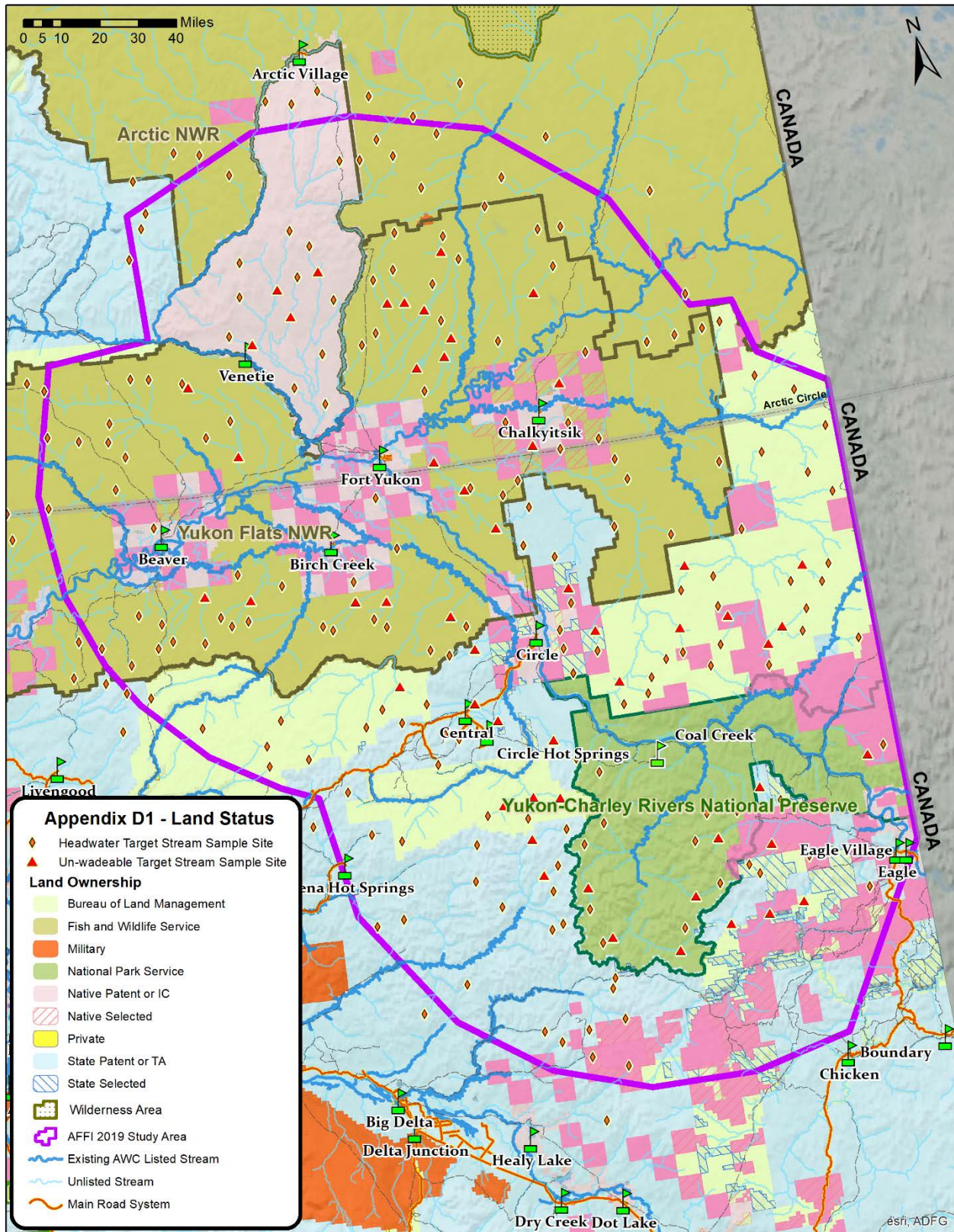
Appendix C2.–Un-wadeable target stream location information

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
C001	65.60122	-143.38682	85	22	214	305
C002	67.24539	-146.05441	52	157	80	118
C003	65.70162	-141.83839	114	46	79	421
C004	67.30796	-144.43496	56	143	68	141
C005	65.97888	-143.71302	60	49	120	210
C006	64.95828	-142.74058	133	27	51	360
C007	66.03852	-145.67817	38	88	49	205
C008	67.29520	-145.64075	51	154	68	106
C009	66.24346	-144.29620	35	73	41	128
C010	66.91570	-147.00999	54	156	39	127
C011	64.56337	-143.23310	150	52	35	333
C012	66.88483	-144.82297	25	119	33	105
C013	65.80539	-143.53229	72	36	189	279
C014	67.09933	-144.67495	40	131	41	113
C015	67.13784	-145.95769	44	149	70	108
C016	66.91348	-144.54486	31	118	21	135
C017	65.91710	-141.55374	113	62	60	402
C018	65.06249	-144.38010	107	40	21	90
C019	66.40265	-144.53704	23	86	31	118
C020	66.02589	-145.39528	37	81	45	201
C021	66.52352	-144.78312	14	96	22	112
C022	65.99114	-142.62480	84	50	47	388
C023	65.20082	-144.07695	100	28	16	282
C024	65.59861	-144.71654	69	50	16	244
C025	67.14359	-145.01621	41	137	38	110
C026	65.76230	-142.76124	90	33	198	289
C027	66.18552	-145.66671	28	94	11	167
C028	65.77752	-142.31079	99	40	69	411
C029	64.92088	-144.31984	117	44	10	79
C030	65.20252	-144.58583	96	43	13	278
C031	66.98005	-144.45781	36	121	20	134
C032	67.13755	-144.85367	41	135	40	112
C033	66.53193	-143.83872	40	87	56	147
C034	64.90244	-142.28191	143	38	37	346
C035	64.65249	-143.80079	139	49	23	320
C036	67.04964	-146.35441	45	150	62	100
C037	65.52400	-144.53105	75	43	10	239
C038	66.63578	-146.60649	37	134	10	97
C039	65.64695	-141.99124	112	41	74	416

Target Site (Ranked)	Latitude	Longitude	Dist. to Fort Yukon (mi)	Dist. to Coal Crk (mi)	Dist. to AWC (mi)	Dist. to Saltwater (mi)
C040	65.21875	-144.31610	97	35	8	274
C041	64.63182	-142.75446	152	48	103	103
C042	64.64507	-142.40433	156	51	87	87
C043	64.66783	-142.08784	160	54	80	80
C044	65.70044	-145.37293	60	70	64	170
C045	67.10171	-143.60956	59	125	26	188
C046	66.08943	-146.64041	50	114	23	140
C047	64.85063	-143.95074	124	40	22	307
C048	65.12181	-142.29870	131	28	20	262
C049	64.75679	-143.01961	141	38	19	312
C050	65.16833	-141.29445	149	55	18	293
C051	65.80204	-144.64964	56	55	16	199
C052	66.12037	-147.05964	59	125	15	104
C053	65.42094	-144.05755	86	28	14	258
C054	66.74959	-143.50044	51	100	13	197
C055	65.93744	-144.82667	45	65	11	150
M1	64.77663	-144.62638				
M2	64.86798	-143.49801				
M3	64.90761	-141.53598				
M4	65.45128	-142.25044				
M5	65.75743	-145.62240				
M6	65.94794	-142.02678				
M7	66.28888	-146.02130				
M8	65.88089	-143.10866				
M9	66.86436	-145.19098				
M10	66.97274	-146.12766				

APPENDIX D

Appendix D1.-2019 study area land status map.



APPENDIX E

The following outline, used by permission, accompanies the video *Staying safe in bear country*, which will be mandatory viewing for all field crew members.

Main Messages of the Video

STAYING SAFE IN BEAR COUNTRY

Safety in Bear Country Society, 2001

BEAR'S CHARACTERISTICS, BEHAVIOR AND SOCIETY

MIND OF BEARS

Bears are intelligent.
Curious
Individuals
More predictable than most people think.

PHYSICAL TRAITS

Amazing noses and ears and eyes are good.
Strong and fast, good swimmers.
Black bears are great at tree climbing, but grizzlies are not bad.

BLACK VS GRIZZLY BEARS

Grizzly distribution more limited but locally can be the most abundant.
Grizzlies more likely to attack when threatened.
Black bears rarely attack defensively.
Grizzlies more dangerous than blacks, but risks from either much less than people tend to fear.
Humans are more tolerant of black bears.

BEAR SOCIETY

Flexible social structure that allows bears to function at low densities or at concentrated food sources with reduced chance of injury.
Bears do fight but more often use avoidance, restraint, and posturing to prevent injury.

THREE MAJOR ASPECTS OF BEAR SOCIETY

Body language and vocalizations to communicate with each other
Dominance hierarchy or pecking order
Personal space

-continued-

BEARS' MOTIVATIONS

Bears have varying motivations for what they do.

- Food and the search for it dominate a bear's life
- Mating and raising offspring
- Investigating novel stimuli; curiosity
- Establishing and asserting dominance

From a safety standpoint it's important to understand the difference between "defensive" and other motivations, especially ones that might lead to "predatory" attack. It is also important to understand the psychology of bears as they grow up. There's a big difference in the mentality of a recently weaned 2 to 4 year old bear versus an adult female with cubs or an adult male.

BEAR-HUMAN INTERACTIONS

Most bears have previous experience around people and learn from each interaction. Humans usually don't even know they came close to a bear, **BEARS USUALLY AVOID PEOPLE**. Two major categories of bear-human interactions where bears don't avoid or even approach people: Defensive and Non-defensive.

DEFENSIVE INTERACTIONS

- Bear thinks you are a threat to itself, its cubs or its food.
- Usually you approached it and entered into its personal space, surprising or crowding it.
- Most likely will appear agitated and stressed.
- Closer you are to it before it becomes aware of you, more likely it is to react defensively.
- Almost always stop short of contact, fight/flight is triggered.
- Defensive response that results in an attack (physical contact) almost always involve grizzly bears surprised at close range, on a carcass or protecting young. The few defensive attacks by black bears have been females protecting cubs (but these are very rare).

NON-DEFENSIVE INTERACTIONS

A number of different non-defensive motivations that may appear similar to each other:

- Curious bear
- Human-habituated bear
- Food-conditioned bear
- Dominance-testing bear
- Predatory bear

AVOIDING BEAR ENCOUNTERS OR REACTING DURING ONE

AVOID BEARS WHENEVER POSSIBLE

LET BEAR YOU CANNOT AVOID KNOW YOU ARE HUMAN by talking and slowly waving your arms. Try to give the bear your scent

AVOID BEARS THAT ARE AWARE OF YOU AND UNCONCERNED

NEVER APPROACH A BEAR

-continued-

LEAVE AREA YOU ENCOUNTERED A BEAR

IF YOU HEAR VOCALIZATIONS OR SEE UNATTENDED CUBS...be extremely cautious and leave the area silently the way you came.

Review of your response during bear encounters:

Identify yourself as human to bears you cannot avoid by talking and slowly waving your arms. Try to give the bear your scent.

Increase your distance from the bear, even if it appears unconcerned.

Do not run, it could invite pursuit.

If a bear approaches you:

Stand your ground!

Quickly assess the situation. Is the bear behaving defensively or in some other way?

Remain calm, attacks are rare.

Do not run unless you're absolutely sure of reaching safety.

Group together. Prepare your deterrent

If the bear is approaching in a defensive manner:

Stand your ground. Try to appear non-threatening.

Don't shout at the bear. Talk to the bear in a calm voice.

If the bear stops its approach, increase your distance.

If the bear resumes its approach, stand your ground, keep talking calmly, and prepare to use your deterrent.

If the bear cannot be deterred and is intent on attack, fall to the ground as close to contact as possible and play dead.

When the attack stops, remain still and wait for the bear to leave. If an attack is prolonged or the bear starts eating you, it is no longer being defensive.

If the bear approaches in a non-defensive manner:

Talk to the bear in a firm voice.

Try to move away from the bear's travel path; that may be all it wants you to do.

If the bear follows you with its attention directed at you. Stop! Stand your ground and prepare to use your deterrent.

Act aggressively toward the bear. Let the bear know you will fight if attacked. Shout! Make yourself look as big as possible. Stamp your feet as you take a step or two toward the bear. Threaten the bear with whatever is at hand. A bear that is initially curious or testing you may become predatory if you do not stand up to it. The more the bear persists, the more aggressive your response should be.

If the bear attacks, use your deterrent and fight for your life. Kick, punch, or hit the bear with whatever weapon is available. Concentrate your attack on the face, eyes, and nose. Fight any bear that attacks you in your building or tent.

Remember:

If an attack (that is, physical contact is made) is defensive... Play dead. (Don't play dead before you have used all possible means, such as deterrents to prevent an attack).

-continued-

If the attack is predatory... Fight back.

HELPING SOMEONE BEING ATTACKED

You may be able to drive away an attacking bear from someone else, but if you do this you risk drawing the attack to yourself.

DETERRENTS AND PREVENTING PROBLEMS

DETERRENTS

BEAR SPRAY

Used to deter bears at close range.

It is not 100 percent effective or a substitute for avoiding an encounter.

Use only approved bear sprays.

Carry it ready to use and keep it handy in your tent at night.

Exercise caution

FIREARMS

Make sure it's adequate

Practice

Mentally rehearse the situations where you would use it.

DETERRENTS IN GENERAL

Know their capabilities and limitations.

Can be useful but should not give you a false sense of security.

Training and practice are essential.

Observe regulations governing their transport and use.

Consult with local authorities.

PREVENTING BEAR PROBLEMS

Most of bear safety is prevention.

LEARN ABOUT BEARS

AVOID ENCOUNTERS

Move away undetected from bears that are unaware of you or distant.

STAY ALERT

Be aware of your surroundings.

-continued-

Look for signs of recent bear activity.

DON'T SURPRISE BEARS

Warn bears of your presence.

TRAVEL IN A GROUP

Groups are noisier and easier to detect and several people are more intimidating to a bear.

KEEP CHILDREN CLOSE

DOGS

Keep it on a leash or leave it at home. The exception is a specially trained dog, but most dogs are not.

CHOOSE CAMPSITES CAREFULLY

Don't camp on bear travel routes

Use local knowledge of bears and recommended camping practices.

DON'T ATTRACT BEARS OR REWARD THEM WITH FOOD

Keep a clean camp free of attractants.

OTHER DETECTION/DETERRENT OPTIONS

Trip wires, motion detectors and compact electric fences can be useful

FIRST AID

Be proficient in first aid.

Carry sufficient medical supplies.

COMMUNICATION

Inform others of your plans.

Communication can save lives.

For 2019, all electrofishing crew leaders are required to have attended an approved electrofishing course. Other electrofishing crewmembers will receive an electrofishing orientation (see Appendix E3) and be directly-supervised by the crew leader at all times while electrofishing. All crewmembers will be certified in 1st Aid and adult CPR.

The following was adapted from McCormick and Hughes, 1998:

Because fishes are collected using electrofishing units, safety procedures must be followed meticulously at all times. Primary responsibility for safety while electrofishing rests with the electrofishing team leader. Electrofishing units have a high voltage output and may deliver a dangerous electrical shock.

While electrofishing, avoid contact with the water unless sufficiently insulated against electrical shock. Use chest waders or hip boots with nonslip soles and watertight rubber (or electrician's) gloves. If they become wet inside, **stop fishing until they are thoroughly dry. Avoid contact with the anode and cathode at all times due to the potential shock hazard.** If you perspire heavily, wear polypropylene or some other wicking and insulating clothing instead of cotton.

While electrofishing, avoid reaching into the water. If it is necessary for a team member to reach into the water to pick up a fish or something that has been dropped, **do so only after the electrical current has been interrupted and the anode is removed from the water.** Do not resume electrofishing until all individuals are clear of the electroshock hazard.

Avoid operating electrofishing equipment near unprotected people, or non-target animals. Discontinue activity during thunderstorms or heavy rain.

Team members should keep each other in constant view or communication while electrofishing. Although the electrofishing team leader has authority, each team member has the responsibility to question and modify an operation or decline participation if it is unsafe.

Appendix E3.–Acknowledgment of electrofishing orientation.

Acknowledgment of Electrofishing Orientation

I have received instruction and orientation about Electrofishing from my employer. As a result, I understand and accept the following conditions:

1. Electrofishing (EF) is an inherently hazardous activity in which safety is the primary concern. The electrical energy used in EF is sufficient to cause death by electrocution.
2. During operations, it is critical to avoid contact with the electrodes and surrounding water. The EF field is most intense near the electrodes and can extend 5-10 m outward.
3. The electrodes are energized by the power source, a generator or battery, and controlled by safety switches; these switches must remain off until the signal is given to begin EF.
4. The power source has a main switch that must be turned off immediately if an emergency occurs.
5. The electrodes are usually metal probes suspended in the water. If direct current is issued from a boat, the anodes (+) are in front of the boat to catch fish and the cathodes (-) may be suspended from the sides; both can produce electroshock. When a metal boat is the cathode, the boat is safe as long as all metal surfaces inside it are connected to the hull.
6. Moveable anodes on a boat are dangerous, especially on metal boats. All electrodes on a conventional EF boat should be in fixed position during operation.
7. Dry skin and clothing are good protection against electroshock. The body should be fully clothed during EF. Rubber knee boots are minimal foot protection, as are rubber gloves for the hands. A personal flotation device must be worn when the water is considered swift, cold, or deep. Ear protection is necessary for those working near the generator.
8. At least 2 members of the EF crew must have knowledge of CPR and first aid. A first aid kit and, in an EF boat, a fire extinguisher must be within immediate reach during an operation. Electroshock can cause heart fibrillations or respiratory arrest; CPR can cure only the latter. The EF crew must know the location of the nearest defibrillation unit.
9. A communication system, particularly hand signals, must be available to all members of an EF crew. When multiple anodes are used in a portable EF operation, the buddy system must be used. Above all, NEVER OPERATE ALONE.
10. Stunned fish should be removed from the EF field as soon as possible and not subjected to continuous electroshock by being held in the dip net. Using the anode as a dip net is unhealthy for fish and people and should be avoided.
11. An EF operation should proceed slowly and carefully; avoid chasing fish and other sudden maneuvers. Night activities require bright, bow-mounted headlights. Operations should cease during lightning or thunderstorms; use discretion during rain. Avoid EF too close to bystanders and pets or livestock.
12. All EF crewmembers must know who their leader is and recognize his or her authority as final in operational decisions. However, every crewmember has the right to ask questions or express concern about any safety aspect of an EF operation. A crewmember has the right to decline participation in an EF operation, without fear of employer recrimination, if he or she feels unsafe in such participation.

Signature of Employee

Date

I have discussed the above-named conditions with the employee and am satisfied that he or she understands them.

Signature of Supervisor

Date

*Adapted from Reynolds (1996), with permission.

APPENDIX F

Introduction:

This appendix was adapted from material provided by Coastal Helicopters and Greens Creek Mine, and is used by permission. The purpose of this information is to provide employees with safe practices in and around helicopters.

Pre-Flight Briefing

1. The aircraft pilot is in charge of all passengers. The pilot is responsible and accountable for all aspects regarding the safe operation and performance of the aircraft in flight or on the ground.
2. Transport of Cargo: Field Gear is controlled by and at the discretion of the pilot. Always inform the pilot about any weapons or other potentially hazardous items to be taken on board the aircraft, especially aerosol deterrents such as “Bear Pepper Spray”. Items such as these should be isolated and transported in sealed containers.
3. Passengers riding in the front seat should never ride with items larger than a map board in their hand. Bulkier items should be stowed in the cargo bay or on the rear seats.
4. Have daily supplies and equipment needs planned ahead of time, so loads can be properly stowed prior to boarding the aircraft.
5. Know the location and operation of seat belts, harnesses, doors and hatches that may have to be operated during an emergency.
6. Know and understand the use of the intercom system.
7. Know the location and operation of all emergency and survival equipment on board appropriate for the type of flight operation conducted. This includes the fire extinguisher, emergency fuel shut-off, and the ELT (emergency locator transmitter) and emergency floatation devices.
8. Smoking and open flames are not permitted within 100 feet of the aircraft, fuel tanks or landing sites containing either.

Personal Protection for Flight

1. Hearing protection is mandatory.
2. Natural fiber clothing (wool, cotton, etc) offer better protection than synthetics in case of fire.
3. PFDs should be worn for extended overwater flights.

Approaching and Departing the Helicopter

Always keep your eyes on the ship during landings and takeoffs. When performing these critical tasks, your observations and awareness will protect you and others from unnecessary risk while the helicopter is in operation.

NEVER TURN YOUR BACK TOWARD THE AIRCRAFT!

-continued-

- Always wait for the pilot's acknowledgement, command or signal before approaching or departing the aircraft.
- Always approach and depart the aircraft the within the pilot's field of view.
- Crouch low when approaching or departing under the main rotor.
- In side-hill situations always approach and depart from the aircraft from the DOWNHILL SIDE.
- NEVER approach or depart the aircraft from the rear.
- Always stay alert when near the aircraft, but DON'T RUSH! Be deliberate and think your actions through (don't let the noise and air blast make you hasty!).
- Ensure that no loose objects can be sucked, blown, or thrown into the rotor system; ensure that loose personal items such as hats (including hard hats), jackets, clipboards, folders, maps, etc. are secure.
- Always check and then double check for loose exterior items or loads.
- To avoid contact with the main rotor blades, long pieces of equipment or tools (e.g., electrofishing poles, dip net handles) should be carried horizontally at or below waist level. Equipment or tools of this type should never be carried upright and/or over the shoulder.
- NEVER THROW OR TOSS anything from or toward the aircraft.
- Eye protection must be worn at all times near the aircraft. If suddenly blinded by dust, stop and crouch down or, better yet, sit down and wait for help.

Entering the Helicopter

1. When entering the aircraft, confirm the pilot acknowledges your approach, use caution, the doors are fragile (and expensive pieces of equipment). Do not put your weight on the doors and do not use the doors as handles for hoisting or lowering yourself into or from the aircraft. Close doors snugly so that all latches are engaged and check to ensure that interior loads will not damage the doors when shut.
2. Once in the aircraft, fasten your seatbelt and (if present) shoulder harness. Put on and secure the headset. Rear seat passengers should notify the pilot when they are secured that they are ready.
3. The pilot and passengers must ensure that all equipment on board in the cockpit is securely stowed before taking off.

Exiting the Helicopter

1. Wait until the pilot has giving you permission to exit the aircraft. Follow any special instructions that the pilot gives you.
2. When landed, remove the headset and seat/shoulder belts.

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3. Retrieve any equipment stored in the cockpit or cargo hold, being cautious of the main rotor at all times. Carry equipment and loads horizontally. Secure loose clothing, equipment etc.
4. Depart downhill if the landing site is on a hill and always walk around the front of the aircraft to avoid the area of lowest rotor clearance.
5. Enter or Exit on the Downhill Side
6. NEVER ATTEMPT TO WALK AROUND THE REAR OF THE AIRCRAFT TO AVOID LOW MAIN ROTOR CLEARANCE ON A HILL!
7. Use caution if the landing surface is slippery or wet.
8. Move as far away as possible from the helicopter to offer the maximum amount of take-off room possible. If it is a tight remote landing zone, the pilot may command you to crouch down next to the aircraft/skids as the take-off is performed.
9. If the helicopter departs the sampling site for fuel or other reasons, reconfirm the time and place for the next pick-up; have a contingency plan and alternate-landing zone in case the weather is down or the helicopter fails to show for a pick-up.

In-flight

1. Be extra eyes and ears for pilot. Observe your surroundings and airspace at all times. Watch for hazards while landing and taking off. Warn the pilot of any unusual circumstances regarding the safety of the aircraft.
2. Wear your seatbelt and shoulder harness at all times during the flight.
3. Ensure to keep communication over the intercom to a minimum so as not to distract the pilot.

Remote Landing Zone Sites & Operations

1. Each LANDING ZONE selected by the crew leader will be inspected and approved by the pilot before landing.
2. All landing sites are at the complete discretion of the pilot
3. Exit or enter a hovering aircraft one at a time in one smooth, unhurried motion.

Finding and Preparing Suitable Landing Zones:

Do.....

- a. Select a spot that is relatively flat and open. The clearing needs to be wide enough to allow safe approach and departure angles for the aircraft at all times.

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- b. The pilot has absolute final say on the appropriateness of the landing site. If the pilot cannot land there, search for an alternative suitable Landing Zones.
- c. Position yourself in such a way that you are not in the direct path of the aircraft and so that you have an accessible escape route should something go wrong.

Do Not.....

- d. Do not select a Landing Zones with abundant small trees or other hazards that could inadvertently obstruct the tail rotor.
- e. Do not select a Landing Zones with abundant loose material on the ground.
- f. Do not select a Landing Zones where the placement of the tail rotor will endanger other individuals or strike other objects.
- g. Do not demand the pilot to land at a site that is not desirable or presents unacceptable risks, give only suggestions and trust the judgment of the pilot.

Refueling Operations

1. No smoking or open flames are allowed within 100 feet of the aircraft or fuel storage tanks.
2. The aircraft and fueling tanks should be grounded to dissipate static electricity.
3. If a spill occurs, the helicopter company will follow its emergency spill response plan.
4. Ground power units should not be connected or disconnected during refueling.
5. Fuel servicing personnel should not carry lighters or matches when refueling.
6. At the first sight of lightning in the area, refueling operations should be suspended.
7. Refueling should not be conducted with passengers on board.

Slinging Equipment

1. Slinging will be an unusual event most often used to transport fuel drums to and from remote fuel stashes.
2. The pilot shall ensure that all persons are briefed before takeoff on all pertinent procedures to be followed (including normal, abnormal, and emergency procedures) and equipment to be used during the external-load operation.
3. Have all loads and pick-ups planned out ahead of time so that the operation can proceed smoothly.

-continued-

4. The pilot will determine the sites and both ends of the operations and of all loads being transported (must be well within the aircraft's lifting ability). All slings must be furnished by the aircraft company.
5. All verbal commands and hand signals will be reviewed and confirmed before operations take place.
6. The slinging of loads must be pre-planned so the load flies in the intended manner, and ensures that nothing will cause the load to hang up, get caught, or have articles come loose during flying. When an inbound load is spinning on the sling the pilot should set it down near the destination to stop the spinning, then bring it to the unload point. Do not attempt to grab a spinning load.
7. Helicopter slung loads will often build up static electricity that will give a shock to the individual unhooking the sling. Use either insulated gloves and/or have the pilot discharge the line first by touching the ground.
8. Never go underneath a slung load.
9. Do not reach for a load as you may over reach and lose balance. Let the pilot bring the load to you.
10. Always have an escape route in the event of sudden and unexpected movement of the load so that you can quickly get away from the area.

Flight Following Procedures

1. Pilots will abide by their company's procedures for flight following.

Flight Plan and Overdue Aircraft Procedures

1. Each morning at base camp, each team leader will fill out a daily flight plan, which will include the date, aircraft type, tail number, color, company name, pilot and crewmembers' names, destinations (target stream IDs) listed in the order to be visited, and time due back.
2. During the day, the team leader will check in with the base camp by radio or satellite phone, if any deviation from the flight plan occurs.
3. If a helicopter is overdue, base camp staff will initiate the following overdue aircraft procedures:
 - a. 10 minutes past due: Base camp personnel will begin a communications search. Attempt contact with the helicopter via radio and/or Iridium phone.
 - b. 30 minutes past due: Base camp personnel will continue attempting contact with the overdue helicopter. If the 2nd project helicopter and/or other teams are still out, also attempt contact with them to notify them of the overdue helicopter and obtain its last-known location. If airborne, the 2nd helicopter pilot will also attempt radio contact with the overdue helicopter.

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- c. 60 minutes past due:
 - i. Check in with helicopter company (Coastal Helicopters 800-789-5610 or 907-789-5600; Quicksilver Air 907-457-1941) to notify them of the overdue helicopter and see if they have been in contact with the pilot.

Obtain last-known location from helicopter company (Coastal has automatic flight following; Quicksilver uses a spot indicator activated by the pilot).
 - ii. Aircraft is declared “Missing”. Notify DPS Alaska State Troopers : MATCOM 907-352-5401 or State Troopers in King Salmon (907-246-3307) or Dillingham (907-842-5641) to activate Search and Rescue. Continue attempting to contact the helicopter. State Troopers will coordinate all search and rescue activities, including any search flights to be made by the second project helicopter.

Emergency Procedures

1. Respond and obey to all instructions or commands given by the pilot.
2. Passenger Position: The passenger’s body position is an important factor in a survivable accident. The "brace-for-impact" position is used to reduce secondary impact and flailing around. If contact with the aircraft interior is likely, the passenger should place his/her body against what the passenger will hit before the impact occurs. If a passenger is resting against the surrounding structure, he/she can "ride the structure down" during the crash, thus avoiding a secondary impact. In addition, this position will reduce the forces acting on the body and can help reduce the severity of injuries. If a passenger is in a seat equipped with a shoulder harness and a safety belt, the harness should be snug, not slack.
3. After a forced landing, follow the pilot’s instructions. Exit the aircraft immediately, unless there is danger from the rotor blades or directed not to do so by the pilot.
4. Emergency Water Landing. Passengers should follow the instructions of the pilot in the event of a forced landing in water. Use life vests when clear of the aircraft. If the life raft lanyard is dangling loose the pilot and passengers should exercise extreme caution not to accidentally pull the lanyard or allow it to become entangled with the aircraft.
5. If practical, retrieve the emergency and survival gear, and ensure that the ELT is transmitting.
6. If practical, and the pilot is incapacitated, activate the emergency fuel shutoff valve.
7. If available, activate a personal locator beacon.
8. Administer first aid to those in need.
9. Assess the situation: determine the need to evacuate the injured individuals, determine the nearest landing zone and the easiest route to safety).

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Evacuation Procedures

1. On an Iridium satellite phone, dial "911" and press "OK". The call will be routed to the nearest public safety location. You may also contact the DPS Alaska State Troopers : MATCOM 907-352-5401 or State Troopers in King Salmon (907-246-3307) or Dillingham (907-842-5641) for medical assistance, to request an air ambulance, or any other special medivac needs.
2. Be prepared to provide the following information:
 - a. Nature of the emergency and evacuation urgency (e.g., urgent evacuation—life or limb threat);
 - b. Number of victims and basic diagnosis of injuries (e.g., “internal bleeding and loss of consciousness”);
 - c. GPS coordinates for the injured person’s location;
 - d. Injured person’s full name, date of birth, and weight;
 - e. Name and weight of escort (if any) who will ride along in the medivac;
3. As an alternative to waiting for a medivac to arrive, if the accident occurred during daylight hours and an aircraft is available, coordinate with State Troopers to fly the victim to the nearest or most appropriate hospital (likely Dillingham or Anchorage). Contact the hospital emergency room at the contact number advised by the trooper ASAP to provide the ETA and to request an accepting physician.
4. Contact base camp personnel. Base camp personnel will contact the Field Supervisor. The Field Supervisor (or base camp personnel, if Field Supervisor cannot be reached) will contact victim’s emergency contact(s) listed on the project contact sheet.

This guidance is commensurate with material contained in the following aviation safety documents:

- Federal Aviation Administration – AC 61-13B - Helicopter Handbook.
- Federal Aviation Administration – AC 91-32B – Safety In and Around Helicopters
- United States Government – Interagency Helicopter Operations Guide

APPENDIX G

Appendix G1.–Anadromous Waters Catalog Nomination Form.



State of Alaska
Department of Fish and Game
Division of Sport Fish

Nomination Form
Anadromous Waters Catalog

Region USGS Quad(s)
 Anadromous Waters Catalog Number of Waterway
 Name of Waterway USGS Name Local Name
 Addition Deletion Correction Backup Information

For Office Use

Nomination # _____	_____	_____
Revision Year: _____	Fisheries Scientist	Date _____
Revision to: Atlas _____ Catalog _____	Habitat Operations Manager	Date _____
Both _____	AWC Project Biologist	Date _____
Revision Code: _____	Cartographer	Date _____

OBSERVATION INFORMATION

Species	Date(s) Observed	Spawning	Rearing	Present	Anadromous
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>

IMPORTANT: Provide all supporting documentation that this water body is important for the spawning, rearing or migration of anadromous fish, including: number of fish and life stages observed; sampling methods, sampling duration and area sampled; copies of field notes; etc. Attach a copy of a map showing location of mouth and observed upper extent of each species, as well as other information such as: specific stream reaches observed as spawning or rearing habitat; locations, types, and heights of any barriers; etc.

Comments: _____

Name of Observer (please print): _____
 Signature: _____ Date: _____
 Agency: _____
 Address: _____

This certifies that in my best professional judgment and belief the above information is evidence that this waterbody should be included in or deleted from the Anadromous Waters Catalog.

Signature of Area Biologist: _____ Date: _____ Revision _____
 02/08